RAMIRAN 2025
Book of abstracts

Wageningen, The Netherlands, 15-17 October 2025

About this publication

The abstracts in this volume were evaluated by members of the Scientific Committee and the Organising Committee, resulting in the selection and allocation in oral presentations and poster presentations. This volume of abstracts contains only those abstracts that are expected to be actually presented at the conference. The Organising Committee takes no responsibility for any error and omission or for the opinions of the authors.

This volume contains the selected abstracts as they were received. The Abstract Numbers in the TABLE OF CONTENTS are identification numbers. These abstract identification numbers are referred to from the Conference Programme Booklet, both for oral and poster presentations. For the oral presentations they are organised per parallel session.

Organising Committee

Gerard Velthof
Rima Porre
Mart Ros
Dorien Westerik
Mieke Tusveld
Malte Lessmann
Karin Nikolaus
Twan Cals
Rik Maasdam
Mieke Tusveld
René Rietra
Jordy 't Hull
Lotte Stokkermans

Scientific Committee

Christof Ammann	Agroscope Research Institute, Switzerland
Barbara Amon	Leibniz Institute for Agricultural Engineering and Bioeconomy, Germany
Zhaohai Bai	Center for Agricultural Resources Research, IGDB, CAS, China
María Pilar Bernal	CSIC, Spain
Anne Bhogal	ADAS, UK
Wim Bussink	Nutrient Management Institute, The Netherlands
Rachel Cassidy	Agri-Food and Biosciences Institute (AFBI), Northern Ireland
Daniele Cavalli	Research Centre for Animal Production and Aquaculture, CREA, Italy
Maria Luz Cayuela	CSIC, Spain
Patrick Dabert	INRAE, France
Stefaan De Neve	Ghent University, Belgium
Sofia Delin	Swedish University of Agricultural Sciences, Sweden
Jihane EL Mahdi	Wageningen livestock research, The Netherlands
Carole Epper	Agroscope, Switzerland
Brigitte Eurich-Menden	Kuratorium für Technik und Bauwesen in der Landwirtschaft e. V., KTBL, Germany
Carlo Grignani	Dep. Agricultural Forest and Food Sciences, Università di Torino, Italy
Peter Groot Koerkamp	Wageningen University - Agricultural Biosystems Engineering group, The Netherlands
Nadine Guingand	Ifip-institut du porc, France
Sasha Hafner	Aarhus University, Denmark
Nyncke Hoekstra	Louis Bolk Institute, The Netherlands
Yong Hou	China Agricultural University, China
Jan Huijsmans	Wageningen Plant Research, The Netherlands
Nick Hutchings	Aarhus University, Denmark
Riikka Keskinen	Natural Resources Institute Finland
Dominika Krol	Teagasc, Ireland
Hans Kros	Wageningen Environmental Research, The Netherlands
Thomas Kupper	Bern University of Applied Sciences, Switzerland
Jan Peter Lesschen	Wageningen University and Research, The Netherlands
Rik Maasdam	Wageningen Livestock Research, The Netherlands
Jochen Mayer	Agroscope, Dept Agroecology and Environment, Zürich, Switzerland
Julio Mosquera Losada	Wageningen Livestock Research, WUR, The Netherlands
Kurt Möller	Department of Fertilization and Soil Matter Dynamics, University of Hohenheim, Germany
Astrid Oberson	ETH Zurich, Switzerland
Hans-Werner Olfs	Department of Plant Nutrition & Crop Production, University of Applied Sciences Osnabrück, Germany
Katrin Oltmer	Wageningen Social & Economic Research, The Netherlands
Søren Petersen	Dept Agroecology/Aarhus University, Denmark
Rima Porre	Wageningen Environmental Research, The Netherlands
Romke Postma	NMI, The Netherlands
Giorgio Provolo	Dept. Agricultural and Environmental Sciences, University of Milan, Italy
Inge Regelink	Wageningen Environmental Research, The Netherlands
Mart Ros	Wageningen Environmental Research, The Netherlands
Lizzie Sagoo	ADAS, United Kingdom

Francisco Salazar	Instituto de Investigaciones Agropecuarias
Alberto Sanz Cobeña	Universidad Politécnica de Madrid/CEIGRAM
Sven Gjedde Sommer	Institute of Biology and Chemical Engineering
Peter Sørensen	Department of Agroecology, Aarhus University, Denmark
Rachel Thorman	ADAS, UK
Anne Trémier	INRAE UR OPAALE, Rennes, France
Tony van der Weerden	AgResearch, New Zealand
Wim van Dijk	WUR, Netherlands
Hendrik Jan van Dooren	WUR, Netherlands
Bart Vandecasteele	ILVO, Belgium
Matias Vanotti	United States Department of Agriculture (USDA), USA
Gerard Velthof	Wageningen Environmental Research, The Netherlands
Dorien Westerik	Wageningen Environmental Research, The Netherlands

Contents

Oral presentations

Parallel session 1

1. Effect of solutions to mitigate methane emissions during digestate storage: an experimental approach

Auvinet, N.[a*], Nunes G.[a], Guiziou, G.[a], Sarrazin, M.[a], Vallet, A[a], Girault, R.[a]

INRAE, UR OPAALE, Rennes, France [a]

Introduction

Anaerobic digestion has a beneficial effect in term of GHGs emissions by maximising methane production inside digestion tanks combined with biogas valorisation. However, after anaerobic treatment, digestates are stored before being spread on fields. During this storage, emissions still occur and GHGs, such as methane, are emitted to the atmosphere. Hence, to optimize the environmental balance of anaerobic digestion, it is necessary to identify solutions to mitigate methane emissions during digestate storage. In this context, the aim of the study is to evaluate the effect of solutions for mitigating methane emissions during digestate storage such as:

- (i) the effect of design parameters of the anaerobic digesteur (hydraulic retention time)

- (ii) the effect of the digestate management chain design (phase-separation and the addition of a first storage tank without heating and with biogas recovery, after this step, digestate is transfer to other storage tank without biogas recovery)

Methodology

Digestates were sampled on various agricultural anaerobic digestion plants (substrates, design, digestate post-treatment…). For each facility, a digestate sample was taken at the last step of the unit. For some facilities, another sample was also taken in the previous step to measure the impact, for example, of a digestate treatment. Storage pilots were filled with approximately $1m^3$ of digestate. Dynamic chambers covered the storage pilots in order to collect and measure the gaseous emissions. Methane emissions were monitored for 6 to 12 months. Carbon dioxide, ammonia and nitrous oxide were also monitored in addition to temperature of digestates and atmospheric conditions. In addition to these experiments, digestates were characterize in term of residual BioMethanogenic Potential (BMP). Residual BMPs were assessed on 46 digestates and 14 of them were used for pilot storage experiments.

Results and discussion

The cumulative methane emissions during digestate storage on pilots were from 1.4 to 2.8 $Nm^3/t_{Raw\ Matter}$ after the anaerobic digestion with a residence time above 100 days, while they were from 0.6 to 0.8 $Nm^3/T_{Raw\ Matter}$ after a longer residence time (>100 days) or after a first storage tank with biogas recovery (residence time of 2 to 3 months). During these storage experiments, residual methane emissions were about 20 to 50% of the ones measured by BMP at 38°C.

Hence, the results highlight that residence time inside anaerobic digestion tanks is a key factor in residual methane emissions during digestate storage as they are strongly correlated. GHG emissions could be lowered by a factor 2 by increasing the residence time from 70 to 100 days in anaerobic tanks.

A first digestate storage step of 2 to 3 months without heating but with biogas recovery helps to maximize biogas production and to minimize the residual methane emission during storage from 40 to 60%.

Phase separation can affect methane emissions during digestate storage but the results strongly depends on the efficiency of the process (screw press versus centrifuge in particular).

Conclusion

During digestate storage, methane emissions still occur and could impact the environmental balance of a facility. However, these emissions could be mitigated by increasing residence time in anaerobic digestion or by the addition of a first storage tank with biogas recovery.

Acknowledgements

We are very grateful to GRDF, ADEME and GRTGaz for their support and funding for the research programs CRUST and Predigem.

2. Reduction of methane emissions and changes in microbial composition through calcium cyanamide addition during storage of liquid cow manure – impact of additive dosage and storage temperature

Herrmann, C.[a*], Okiobe, S.T.[a], Schuster-Hankel, S.[a], Prochnow A, [a,b] & Theuerl, S.[a]

Leibniz Institute for Agricultural Engineering and Bioeconomy (ATB), Germany [a]; Albrecht Daniel Thaer Institute for Agricultural and Horticultural Sciences, Humboldt Universität zu Berlin, Germany [b]; *Corresponding author, email: cherrmann@atb-potsdam.de

Introduction

Methane (CH_4) is a severe greenhouse gas with an estimated contribution of 0.5°C to the net increase in global temperatures. Agriculture accounts for 55% of anthropogenic CH_4 emissions in Europe, with ruminant enteric fermentation and manure management and storage being by far the largest contributors. In order to abate GHG emissions from manure management, a number of additives have been investigated recently (Ambrose et al., 2023). First studies have shown that calcium cyanamide ($CaCN_2$) is a promising additive to mitigate CH_4 and other greenhouse gases (Reiter et al., 2024), but more detailed analyses on its efficacy and mode of action are required. The aim of this study was to fundamentally assess the effects of different $CaCN_2$ additive dosages during long-term cow manure storage with focus on CH_4 emissions and changes in microbial composition.

Methodology

Dairy cow manure samples were collected from the pumping pit of a free-stall dairy barn with slatted floors and hourly mechanical manure removal by scrapers. The $CaCN_2$ additive effects were tested in static chamber storage experiments of 2-Liter scale at four dosages of 100 to 400 mg cyanamide (CA)/kg manure over 140 days. Storage vessels were placed in cooling incubators at 5°C, 15°C or 25°C. During the storage experiments, manure samples were taken in four weeks intervals for chemical analyses of metabolites. Real-time high-throughput qPCR assays were performed to quantify the microbial composition of key methanogenic groups. Biochemical CH_4 potential (BMP) tests were conducted after 140 days of storage in order to analyse biomethane potential changes due to the storage without and with $CaCN_2$.

Results and discussion

The $CaCN_2$ additive effectively reduced CH_4 emissions, with duration and extent of CH_4 mitigation being dependent on additive dosage and storage temperature. At a single dosage of 300 and 400 mg CA/kg, CH_4 emissions were reduced by 87 to 99 % over 140 days at all temperatures. A dosage of 100 to 200 mg CA/kg was less effective with overall CH_4 emission reductions of 44 to 87 % at 5 and 15°C. At an elevated temperature of 25°C, CH_4 formation was reactivated in these variants after 41 to 118 days leading to a time-delayed emission curve similar to the control. Inhibition resulted in an accumulation of organic acids up to 16.4 g/kg, but acids were rapidly consumed after reactivation. Microbial analyses clearly indicated that at dosages above 100 mg CA/kg quantitative proportions of archaea and bacteria were significantly reduced. In line with the reactivation of CH_4 formation, proportions of archaea and bacteria increased again and partly exceeded values of the control without additive. Among key archaeal families, largest effects were found for acetate metabolizing *Methanosaetaceae* with permanent inhibition over the storage period. Emission reduction positively affected post-storage BMP yields. Considering mass losses, BMP yields decreased by up to 70 % without additive, while it was preserved at dosages of 300 to 400 mg CA/kg resulting in up to 3.4-fold higher BMP yields compared to control.

Conclusion

Calcium cyanamide is an easy-to-apply additive with high potential to effectively mitigate CH_4 emissions during manure management and long-term storage. Additive dosage can be optimized depending on storage conditions and storage duration. Owing to the preservation of organic compounds during storage, post-storage biomethane production can be enhanced, but shorter storage periods need to be considered further.

Acknowledgements

The work of this study was financially supported by the Federal Ministry of Food and Agriculture by decision of the German Bundestag, through the Fachagentur Nachwachsende Rohstoffe e.V. (FKZ 2220WD016A).

References

Ambrose, H.W., Dalby, F.R., Feilberg, A., Kofoed, M.V.W., 2023. Additives and methods for the mitigation of methane emission from stored liquid manure. Biosystems Engineering 229, 209-245.

Reiter, D., Winkler, S., Becher, J., Seilinger, S., Nüchter, A.G., Kappelsberger, B.V., 2024. Nutrient Preservation in Cattle Slurry via Emission Reduction during Storage with Calcium Cyanamide. ACS Agricultural Science & Technology 4(9), 872-881.

3. Real-time bioprocess monitoring of methane emissions from liquid manure storage systems in course of the year as a basis for simulation and modeling

Amon, T.[*a,d] ; Rawat, A. [a]; Song, Z. [a]; Herrmann, C.[a], Kabelitz, T.[a] ; Amon, B. [a,b]; Janke, D. [a], Mehmood, T. [a]; Vieira, S.[c]; & Overmann, J.[c]

Leibniz Institute for Agricultural Engineering and Bioeconomy (ATB), Germany [a]; University of Zielona Góra, Faculty of Civil Engineering, Architecture and Environmental Engineering, University of Zielona Góra, 65-417 Zielona Góra, Poland [b]; Leibniz Institute DSMZ-German Collection of Microorganisms and Cell Cultures GmbH, Germany [c] ; Freie Universität Berlin, Department of Veterinary Medicine, Institut of Animal Hygiene and Environmental Health, FU-Berlin Germany [d] *Corresponding author, email: TAmon@atb-potsdam.de

Introduction

The European Climate Law implements the EU's commitment to transition to a climate-neutral economy by 2050, with an interim target of reducing greenhouse gas (GHG) emissions by at least 55% by 2030. CH4 emissions from enteric fermentation and N2O emissions from soils are responsible for 48% and 31% of total agricultural GHG emissions, respectively. CH4 from liquid manure management is the third largest source of emissions at around 17%. It is estimated that around 1.4 billion tons of liquid manure are produced annually in the European Union (Köninger 2021). An European Commission impact assessment highlights the challenges of further reducing non-CO2 GHG emissions from agriculture (European Environment Agency 2023). Monitoring of methane emissions from liquid manure storage systems as a basis for simulation and modeling. Comparison of mechanistic and data-based modelling approaches.

Methods (Experimental setup)

To measure methane emissions from liquid manure storage tanks, an experimental setup based on VDI 4630 was developed for continuous operation under laboratory conditions. The system includes four gas-tight, thermostatted tanks with a maximum working volume of 10 liters each. The tanks have an internal diameter of 35 cm and a height of 10 cm, matching the typical diameter-to-height ratio of practical liquid manure storage tanks. Each tank is surrounded by an external insulating double wall. A temperature-regulating liquid (water) circulates between the inner and outer wall to maintain the desired substrate temperature. A cryothermostat precisely controls the substrate temperature inside the tanks on a daily basis. Substrate was added to the tanks through a feeding pipe located at the top of each container on every working day.

Results

In the presentation, we show that the complexity of on-farm conditions of the relevant drivers of the emission process, such as the continuous temperature change along the year, the daily feeding of the storage tank with fresh liquid manure as long-term processes and the substrate removal as a short-term process, can be measured and simulated in laboratory real-time bioprocess monitoring, leading to reproducible results. We further show that dynamic adaptations of relevant parts of the microbiome to the changing environment conditions of the liquid manure during storage can be detected and that these are important parameters for the prediction of CH_4 emissions. We compare our experimental observations with the recently published equation of Petersen et al. (Petersen et al., 2024) as well as with the IPCC Methodology Tier 2 (IPCC, 2006).

References

European Environment Agency, 2023. Trends and Projections in Europe 2023. Publications Office of the European Union.
IPCC, 2006. IPCC guidelines for national greenhouse gas inventories. OECD.
Köninger, J., Lugato, E., Panagos, P., Kochupillai, M., Orgiazzi, A., Briones, M.J., 2021. Manure management and soil biodiversity: Towards more sustainable food systems in the EU. Agricultural Systems 194, 103251.
Petersen, S.O., Ma, C., Hilgert, J.E., Mjofors, K., Sefeedpari, P., Amon, B., Aarnink, A., Franco, B., Dragoni, F., Groenestein, K., Gyldenkaerne, S., Herrmann, C., Hutchings, N.J., Kristensen, I.S., Liu, J., Olesen, J.E., Rodhe, L., 2024. In-vitro method and model to estimate methane emissions from liquid manure management on pig and dairy farms in four countries. J Environ Manage 353, 120233.
Verein Deutscher Ingenieure, 2016. VDI 4630: Fermentation of Organic Materials : Characterisation of the Substrate, Sampling, Collection of Material Data, Fermentation Tests. Beuth Verlag.

Acknowledgements

This work is financially supported by the Federal Ministry of Food and Agriculture (BMEL) based on a decision of the Parliament of the Federal Republic of Germany, granted by the Federal Office for Agriculture and Food (BLE; grant number 28N206501 to-04 and 28N206506 to -10, joint project EmiMod).

4. Evaluating Methane Emissions from Pig Farms in South Korea Using IPCC Guidelines

Lee, SH[a*], Triolo JM[b,c]

Onespring, 4th Floor, Seojin Building, 38 Wolsan 1-gil, Hongseong 32229, Republic of Korea[a]; Department of Energy System Engineering, Gyeongsang National University, 501 Jinjudae-ro, Jinju 52828, Republic of Korea[b]; Future Convergence Technology Research Institute, Gyeongsang National University, 501 Jinjudae-ro, Jinju 52828, Republic of Korea[c]; *Corresponding author, email: shlee@onespring.co.kr

Introduction

Methane emissions from manure management are a major contributor to climate change. The IPCC guidelines provide standardized methodologies for estimating emissions, but applying default Methane Conversion Factors (MCFs) to complex manure management systems (MMS) can introduce uncertainties. South Korea's pig farming sector employs multi-step manure management systems involving solid-liquid separation, composting, and aerobic treatment. These systems do not always align with IPCC-defined categories, potentially leading to under- or overestimation of emissions. This study evaluates methane emissions from pig farms in South Korea using different IPCC-based methodologies to assess the impact of MMS variations. By comparing these approaches, we aim to improve national GHG inventory consistency and refine estimation methods.

Methodology

A total of 10 pig farms in Hongseong, recognized as the leading livestock region in South Korea, were surveyed to collect data on their manure management practices. The farms included in this study were mid- to large-sized farms, based on the average farm size in South Korea. Data collection focused on the number of livestock, manure emptying frequency, types of manure management systems used, and separation methods for solid and liquid fractions. These factors are crucial for methane emission calculations, as variations in manure handling influence methane production and emission rates.

Methane emissions from each farm were estimated using two methodologies: the Mass Flow Approach and the Simplified MCF-based Approach. Both approaches utilized IPCC default values for common manure management systems, including liquid/slurry, and pit storage below animal confinements, aerobic treatment, anaerobic treatment, and composting. The Mass Flow Approach adjusted volatile solids (VS) and maximum methane-producing capacity (B_o) at each manure processing stage to prevent double counting of emissions across multiple treatment steps. In contrast, the Simplified MCF-based Approach directly applied MCFs derived from emission factors reported in research studies, following the IPCC guideline equation to estimate methane production.

Results and discussion

Methane emission estimates varied depending on the methodology applied, with differences in estimated values ranging from 1.09% to 15.02% depending on the manure management system used at each farm. The level of variation was smaller when the primary manure management system (MMS) contributed more significantly to total methane emissions, whereas larger discrepancies were observed when the secondary MMS played a greater role in overall emissions. These results highlight the importance of considering manure flow through multiple management stages when estimating methane emissions for national GHG inventories. Proper allocation of volatile solids (VS) and maximum methane-producing capacity (B_o) values at each treatment stage may help reduce inconsistencies in methane emission calculations.

Conclusion

This study demonstrates that simplified methodologies may underestimate methane emissions when applied to multi-step manure management systems. The mass flow approach offers a more accurate framework by ensuring proper allocation of methane-producing potential across manure processing stages. These findings highlight the need to refine South Korea's national inventory reporting methods to improve comparability and accuracy in GHG emission estimations. Establishing standardized estimation protocols will enhance national climate reporting and support more effective methane mitigation strategies in the livestock sector.

Acknowledgement

This work was supported by the Livestock Environmental Management Institute (No. 20240706772-00 and R25TA00091586-00), and the Brain Pool program funded by the Ministry of Science and ICT through the National Research Foundation of Korea (RS-2024- 00410127).

5. Effect of pig slurry discharge frequency and combination with storage mitigation techniques on methane emission from house and storage

Guldberg, L.B. [a*], Adamsen, A.P. [a] & Hansen, M.J.[a]

Dept. of Biological and Chemical Engineering, Aarhus University, Denmark [a]; *Corresponding author, email: lbg@bce.au.dk

Introduction

Methane emitted from manure in animal houses and outside storages amount to ca 25% of total Danish agricultural GHG emission (Andersen M.N. et al. 2023). Frequent removal of slurry from the slurry system in pig houses and transfer to outside storages has proven to be an effective and straightforward strategy to reduce slurry related house emission of methane (Dalby, F.R. et al.,2023) and is now required as the norm in Denmark. However, net methane emission from pig house and following outside storage period for slurry has been discussed as potential methane emission from storages will increase with increased transfer of slurry with a high organic matter to the storage due to low house retention time. Abatement technologies for storages and stored manure represents a large potential to reduce methane emission from animal-based production and ensure the sustainability of livestock production. This potential is increased with increased implementation of frequent transfer of slurry from pig houses to outside storages. In this study, the effect on storage emission and net house-and-storage emission of the combination of frequent in-house discharge and transfer of pig slurry to outside storages combined with in-storage mitigation techniques is tested in a year-round continuous measurement campaign.

Methodology

A test facility with pilot scale (5-m^3) covered storages was built to test different slurry management strategies and in-storage mitigation techniques on well-defined pig slurry in triplicate sets of storages. Slurry for the storages was produced by finisher pigs in two experimental pig sections with two pens with 15 finisher pigs in each pen. The slurry was added to the storages ad hoc in a spring-to-spring storage season as the slurry was discharged from the pig house. The slurry was discharged from the slurry system below the floor and transferred frequent (weekly) from one section and infrequent (every 5-6 weeks) from the other section to the outside storages (n=3). In addition, storage of frequently discharged slurry was combined with in-storage mitigation techniques in a treatment versus control setup of storages (n=3). Pig house sections and storages were equipped with a mechanical ventilation system with a diffuse air inlet and an outlet with a controlled exhaust air flow rate. During housing and storage period, methane was measured in in- and outlet air from the pig house sections and storages using cavity-ring-down spectroscopy (CRDS). Furthermore, air exchange and climatic conditions were measured, and slurry samples were collected for later analysis.

Results and discussion

The last of four batches of pig and the associated emission from the house and storage periods, respectively will be finished in the coming spring. Initial preliminary results suggest a reduction in storage methane emission from slurry frequently discharged from pig houses and transferred to outside storage. The reduction of storage methane emission may be reinforced with additional reduction by combining with storage mitigation techniques. Preliminary results from the study on storage emission and net house-and-storage emission will be available for presentation at the conference.

Acknowledgements

The authors acknowledge Y. M. Lemes, A. H. Vazifehkhoran, A. J. Ward, B. Kunnoth, P. W. Hansen, H. G. Christiansen and P.S. Nielsen for their valuable help during the experiment and the Ministry of Food, Agriculture and Fisheries of Denmark for funding, GUDP project no 34009-21-1939.

References

Andersen M.N. et al., 2023. Viden- og forskningsbehov for forbedret grundlag for bedriftsspecifikke opgørelser af drivhusgasudledninger i landbruget. 69 sider. Rådgivningsrapport fra DCA – Nationalt Center for Fødevarer og Jordbrug, Aarhus Universitet. https://pure.au.dk/portal/da/publications/viden-og-forskningsbehov-for-forbedret-grundlag-for-bedriftsspeci

Dalby, F., et al. 2023. Simple Management Changes Drastically Reduce Pig House Methane Emission in Combined Experimental and Modeling Study. Environ. Sci. Technol. 57, 3990–4002.

6. Nitrous Oxide Emissions in Coffee and Cocoa Systems: Establishing Baselines for Sustainability

Lourenço, K.S[a*]; Lopes, M.A.[b]; Pulleman, M[c,d]; Giller,K.E.[a]

Plant Production Systems, Wageningen University & Research, Wageningen, The Netherlands [a]; Nestlé Institute of Agricultural Science, Lausanne, Switzerland [b]; Soil Biology Group, Wageningen University & Research, Wageningen, The Netherlands [c]; International Center for Tropical Agriculture (CIAT), Cali, Colombia [d]; *Corresponding author, email: kesia.lourenco@wur.nl

Introduction

Reducing food production's environmental impact requires benchmarking greenhouse gas (GHG) emissions from coffee and cocoa plantations. Tracking reductions is key to sustainability, as these crops support millions of smallholders and contribute to food security. Nitrogen (N) management is critical, particularly due to nitrous oxide (N_2O) emissions after organic and mineral fertilization. We aim to establish baseline GHG emissions as part of a global effort to reduce coffee and cocoa's carbon footprint and enhance soil health. Specifically, we assess how organic and inorganic fertilization affects N_2O emissions in coffee (Colombia, Mexico) and cocoa plantations (Ecuador, Ivory Coast). These findings will inform new emission factors (EF) and sustainability indicators for coffee and cocoa production.

Methodology

A standardized experimental design was implemented across all trials, consisting of four treatments with four replicates each. One treatment reflected current farmer practices (MF), ensuring real-world applicability. To establish a baseline, an unfertilized control (no mineral or organic inputs) was included. Two additional treatments were included: (1) Alternative Mineral Fertilization (AMF), optimized according to regional practices—either increasing or decreasing mineral fertilizer rates based on initial application levels; and (2) Local Improved Management (MF+C), which combined organic residues (different sources of compost) with adjusted mineral fertilizer inputs to enhance nutrient efficiency. GHG fluxes, including N_2O, CO_2, and CH_4, were quantified using PVC static chambers, following the methodology by Lourenço et al. (2024).

Results and discussion

N_2O emissions varied across countries, with higher N_2O EF observed in cocoa plantations (EF: 0.79% on average) compared to coffee (EF: 0.33% on average). The EF for treatments following farmers' management practices was highest in Ecuador (0.67%), Colombia (0.43%), and Mexico (0.03%) compared to the AMF. In Ivory Coast, however, the AMF resulted in the highest EF (EF: 1.46%), surpassing the farmers' practice (EF: 1.18%). The addition of compost as a complementary fertilizer had lower N_2O EF than mineral fertilizers, with EF values of 0.40%, 0.48%, 0.11%, and 0.02% for Ivory Coast, Ecuador, Colombia, and Mexico, respectively. CH_4 fluxes fluctuated daily, with both positive and negative values. However, cumulative CH_4 emissions showed no significant differences among treatments.

Conclusion

The magnitude of N_2O emissions varied significantly among locations, driven probably by differences in soil properties, climatic conditions, and fertilizer application intensity, highlighting the importance of optimizing fertilization strategies. The compost application had little effect on N_2O EF. In contrast, soils consistently acted as methane sinks across all regions, regardless of geographic location. These findings underscore the need for region-specific management practices to mitigate N_2O emissions while maintaining soil health and productivity.

Acknowledgements

The authors would like to thank all individuals involved in the experimental setup and for providing technical assistance throughout the study. I special thanks go to Catalina Trujillo, Leidi Sierra, and Matti .Barthel. This research was supported by Nestlé.

References

Giller, K.E., Pulleman, M., Sassen, M., Pronk, A., Pratihast, A., Velthof, G., Rahn, E., Barthel, M., Lourenço, K.S., Diaz, A., 2023. Ground Zero? Let's get real on regeneration: Report 1: state of the art and indicator selection, Wageningen University & Research, p. 67.

Lourenço, K.S., Suleiman, A.K.A., Pijl, A., Dimitrov, M.R., Cantarella, H., Kuramae, E.E., 2024. Mix-method toolbox for monitoring greenhouse gas production and microbiome responses to soil amendments. MethodsX 12, 102699. https://doi.org/10.1016/j.mex.2024.102699

Quiñones-Huatangari, L., Fernandez-Zarate, F., Huaccha-Castillo, A., 2022. Nitrous oxide emissions generated in coffee cultivation: A systematic review. Nature Environment and Pollution Technology. https://doi.org/10.46488/NEPT.2022.v21i04.023

7. Effect of integrating green manure, animal manure and mineral nitrogen fertilizer on N2O emissions in an irrigated maize crop

Iglesias, S.M.[1,2]*, Guardia, G.[1,2], García-Gutiérrez, S.[1,2], Montoya, M.[1,2], Monistrol, A.[1,2], Espín, G.[1], Salinas, J.[1,2], Vallejo, A. [1,2] & García-Marco, S[1,2].

Departamento de Química y Tecnología de Alimentos, Escuela Técnica Superior de Ingeniería Agronómica, Alimentaria y de Biosistemas, Universidad Politécnica de Madrid, Spain1; Centro de Estudios e Investigación para la Gestión de Riesgos Agrarios y Medioambientales (CEIGRAM), Universidad Politécnica de Madrid, Spain 2; *susana.igldiez@upm.es

Introduction

Excessive application of mineral nitrogen (N) fertilizers results in substantial N losses to the environment due to low crop N use efficiency (Zhang et al., 2021). The combined use of organic and mineral N sources is increasingly recognized as a sustainable agricultural practice as it improves soil quality and fertility (Liu et al., 2021). This approach reduces mineral N inputs, which could potentially mitigate nitrous oxide (N2O) emissions. The aim of this study was to evaluate the combined application of mineral (ammonium nitrate, AN) and organic nitrogen sources (vetch as green manure and sheep manure) on N2O and other GHG emissions and other soil/plant parameters in an irrigated maize (Zea mays L.) crop.

Methodology

The experiment was conducted from November 2023 to December 2024 at the experimental station "Centro Nacional de Tecnología de Regadíos" (CENTER, Madrid, Spain). It consists of 24 subplots arranged in a split-plot design with three replications. The main factor is the incorporation (+V) or its absence (-V) of vetch as green manure in a randomized block design. The second factor includes four fertilization treatments: (1) AN, (2) sheep manure (SM), (3) a combination of SM (50% N) and AN (50% N), and (4) a control without N from AN or SM (C). Vetch and basal dressing with manure were applied before maize sowing, while AN was used as top-dressing. The amount of N applied to the subplots as mineral fertilizer or in combination with SM was 215 and 85 kg N/ha in the -V and +V plots, respectively.

Greenhouse gases N2O, CO2 and CH4 were sampled with opaque manual static chambers, with higher sampling frequency (2-3 days per week) after basal and top-dressing fertilization and analyzed by gas chromatography. Soil sampling (0–10 cm) was conducted regularly to determine WFPS, mineral N and dissolved organic carbon (DOC). Olsen P and electrical conductivity (EC) were analyzed monthly. Maize was harvested at physiological maturity, and total grain yield and aboveground biomass were determined. Nitrogen (N) and carbon (C) contents in grain and biomass were also analyzed.

Results and discussion

Average daily N2O fluxes ranged from -1.2 to 7.3 mg N2O-N/d·m2 in EO+AN+V and AN-V subplots, respectively. Several emission peaks were observed throughout the experimental period, primarily following AN top-dressing and maize irrigation. Average cumulative fluxes, calculated at the end of the experiment, ranged from 4.6 to 58 mg N2O-N/m2 in C-V and AN-V subplots, respectively. Preliminary results indicate a significant interaction between vetch incorporation and fertilization treatments. The incorporation of vetch reduced emissions by 76% in SM+AN subplots, showing a significant effect, while in AN subplots emissions decreased by 56% without statistical significance. In subplots without vetch (AN-V and AN+SM-V), treatments showed significant differences only when compared to the control. Conversely, treatments in vetch-incorporated plots did not exhibit significant differences among them.

Conclusion

These findings suggest that combining vetch with specific fertilization strategies could enhance the mitigation of N2O gases. However, further analysis of soil and harvest data is needed to fully assess the effects on other greenhouse gases, soil health and crop productivity.

Acknowledgements

Funding project: PID2021-125007OB-I00 (MCIN/AEI/FEDER). Thanks to personal staff at CENTER Field Station and ETSIAAB_UPM.

References

Zhang, X., et al. 2021. Quantification of global and national nitrogen budgets for crop production. Nature Food 2, 529–540 https://doi.org/10.1038/s43016-021-00318-5

Liu, J., et al. 2021. Long-term organic fertilizer substitution increases rice yield by improving soil properties and regulating soil bacteria, Geoderma, 404, 115287. https://doi.org/10.1016/j.geoderma.2021.115287

8. Nitrogen processing in pasture urine patches and effect on N_2O emissions

Ammann, C.[a*] & Barczyk, L.[a]

Agroscope, Climate and Agriculture Group, Zurich, Switzerland [a]; *Christof Ammann, email: christof.ammann@agroscope.admin.ch

Introduction

Cattle excrete 75-95% of their nitrogen (N) intake. For dairy cows with a medium to high productivity, a large part of excreted N is in the form of urine. During grazing, urine patches on pastures experience a large local N input and thus form hotspots of potential nitrate leaching as well as emission of nitrous oxide (N_2O). While it is known that grazing, compared to in-house husbandry, is advantageous concerning NH_3 emissions (Voglmeier et al., 2018), the effect on N_2O emissions is still uncertain. To investigate the processing of N in pasture urine patches and its effect on N_2O emissions, we performed field experiments with controlled application of synthetic urine with typical patch sizes.

Methodology

Multiple urine applications were carried out between 2020 and 2023 on fenced-out areas of a pasture field in North-Eastern Switzerland (Barczyk et al., 2023). Two liters of standard synthetic urine was uniformly applied to circular areas of 0.12 m^2. In selected experiments, patches of urine with different volumes and/or N contents were additionally produced. The different application times during the grazing season allowed to study the influence of varying environmental conditions. Repeated measurements after application included ammonium and nitrate concentration in the soil profile, exchange of N_2O, and harvest N yield. The N_2O emission was measured by manual and automated chambers. The automated chamber system was similar to the one described by Flechard et al. (2005) and Ammann et al. (2020). It allowed measurements with a high temporal resolution of about 4 hours. In one application experiment, the emitted N_2O in the chamber headspace was analysed for its isotopic composition to identify the relevant source processes. The sampling of soil mineral nitrogen of urine treatments and untreated control plots in three depth layers took place at regular time intervals (weekly to biweekly) after urine application. The fresh soil was extracted with 0.01 M $CaCl_2$ solution, and resulting extracts were analyzed photometrically for their nitrate and ammonium concentrations.

Results and discussion

The observed N_2O emission time series were analysed for their temporal dynamics and corresponding driving parameters. An analysis using random forest modelling identified the time since urine application as most important predictor for the N_2O emission flux. On average, the emission was greatest one day after application, declining continuously until about 30 days later. This course was very similar to the one of the soil ammonium concentration, while the nitrate concentration increased at the same time. This suggests that processes based on ammonium substrate (i.e. nitrification and nitrifier denitrification) were predominantly responsible for the N_2O emissions. Furthermore, N_2O emission time series were considerably modulated by water-filled pore space and soil temperature.

Conclusion

Based on the very similar time course of N_2O emission and soil ammonium concentration in urine patches – in combination with observed N_2O isotopic signature – it is concluded that nitrification and nitrifier denitrification were the main sources of grazing related N_2O emissions at the study site.

Acknowledgements

This study was funded by the Swiss National Science Foundation (SNSF) under the project REFGRASS (Towards Representative N_2O Emission Factors for Grazing Systems in Switzerland, Nr. 184797).

References

Ammann C., et al. 2020. Effect of management and weather variations on the greenhouse gas budget of two grasslands during a 10-year experiment. Agric. Ecosyst. Environ. 292, 106814. https://doi.org/10.1016/j.agee.2019.106814

Barczyk, L., et al. 2023. N2O emission factors for cattle urine: efect of patch characteristics and environmental drivers. Nutr. Cycl. Agroecosyst. 127, 173–189. https://doi.org/10.1007/s10705-023-10290-0

Flechard, C.R., et al. 2005. Bi-directional soil/atmosphere N2O exchange over two mown grassland systems with contrasting management practices. Glob. Change Biol. 11, 2114–2127. https://doi.org/10.1111/j.1365-2486.2005.01056.x

Voglmeier, K., et al. 2018. Ammonia emission measurements of an intensively grazed pasture. Biogeosciences 15, 4593–4608. https://doi.org/10.5194/bg-15-4593-2018

9. Monitoring GHGs fluxes following slurry distribution in three alternative forage system managements

Allegrezza, M. [a*], Gabbrielli, M. [a], Vario, L. [a], Iderrami, H. [a], Perfetto, M. [a], Botta, M. [a], Acutis, M. [a], Ragaglini, G. [a] & Perego, A. [a]

Department of Agricultural and Environmental Sciences Università degli Studi di Milano, Milano, Italy [a]; [*]Corresponding author, email: marina.allegrezza@unimi.it

Introduction

The main greenhouse gases (GHGs) emitted directly from non-flooded agricultural soils are carbon dioxide (CO_2) and nitrous oxide (N_2O). N_2O accounts for approximately 6% of annual global GHG emissions in terms of CO_2 equivalents, and since anthropogenic N_2O emissions are largely associated with agricultural activities, their assessment is increasingly important for evaluating the mitigation potential of alternative soil and crop management practices (Chataut et al., 2023). The interactions between soil conditions, weather, and cropping system management—such as slurry application, tillage intensity, and crop residue management—affect GHGs emissions, C sequestration, and the overall soil GHGs balance. These factors determine whether a cropping system acts as a net source or sink of GHGs (Autret et al., 2019). The objective of this research is to compare agronomic strategies aimed at reducing GHGs emissions and increasing SOC stocks through different crop residue and soil management practices. The measured variables (GHGs fluxes, crop and soil-related variables) are used to calibrate ARMOSA (Perego et al., 2013), a process-based cropping system model. The calibrated model will enable the gap-filling of the missing GHGs fluxes data and the evaluation of 'what-if' management scenarios, allowing for the assessment of alternative practices at broader temporal and spatial scales.

Methodology

The field trial was established in september 2023 in Landriano (45°32'N, 9°26'E, Lombardy, Italy) to investigate a two-year silage crop rotation with double cropping (barley, soybean, and maize). Three management levels are being studied: (i) conventional – crop residue removal, slurry incorporation (25 cm), and plowing; (ii) semi-conservative – crop residue mulching, slurry incorporation (20 cm), and minimum tillage; (iii) no-tillage – crop residue mulching, slurry incorporation (15 cm), sod-seeding, and cover cropping. The Landriano monitoring station consists of a shelter housing gas analyzers (N_2O, CO_2-H_2O, CH_4), a multiplexer, a local processing unit, and 12 automatic chambers (ACs). Each AC operates on a 15-minute measurement cycle, thus obtaining eight measurements per AC per day. Additional variables such as soil organic carbon (SOC), soil mineral nitrogen (SMN), bulk density, crop aboveground-biomass (AGB), leaf area index (LAI), yield, and residue are frequently monitored through samplings. Simulated daily CO_2 and N_2O values were aggregated on the base of soil use to evaluate model performance using indices such as relative root mean squared error (RRMSE), coefficient of residual mass (CRM), and modeling efficiency (EF).

Results and discussion

Crops growth season were characterised by waterlogging due to frequent and intense rainfall events: the tested management did not influence barley (10.68 ±2.03 t DM ha^{-1}) and soybean (5.99 ±0.98 t DM ha^{-1}) productivity in terms of AGB accumulation. The statistical analysis of total cumulative CO_2, from December 2023 to February 2025, confirmed significant differences among the investigated management strategies: the semi-conservative system exhibited the highest CO_2 emissions (2237.82 ±779.77 g CO_2 m^{-2} *a*), followed by the conventional system (1644.25 ±744.78 g CO_2 m^{-2} *ab*), while the no-till system recorded the lowest emissions (1590.49 ±626.85 g CO_2 m^{-2} *b*). From September 2024 to February 2025, N_2O emissions were not influenced by management strategies: an average monthly cumulated emission of 2.83 ± 1.63 mg N_2O m^{-2} $month^{-1}$ was measured.

Acknowledgements

This study was carried out within the Agritech National Research Center and received funding from the European Union Next-Generation EUGeneration EU (PIANO NAZIONALE DI RIPRESA E RESILIENZA (PNRR)—MISSIONE 4 COMPONENTE 2, INVESTIMENTO 1.4—D.D. 1032 17 June 2022, CN00000022).

References

Chataut, G. et al., 2023. Greenhouse gases emission from agricultural soil: a review. J. Agr. Res. 11, 100533

Autret, B. et al., 2019. Can alternative cropping systems mitigate nitrogen losses and improve GHG balance? Results from a 19-yr experiment in Northern France. Geoderma 342, 20–33.

Perego, A. et al., 2013. The ARMOSA simulation crop model: overall features, calibration and validation results. Ital. J. Agrometeorol. 3, 23–38.

10. Impact of aeration management on the nitrogenous emissions linked to wastewater sludge composting

Crestey, E.[a,b], PoréeT.[b] , Paillet, F. b, Camacho, P. b & Trémier, A.[a*]

INRAE UR OPAALE, France [a]; Suez, CIRSEE, France [b] ; *Corresponding author, email: anne.tremier@inrae.fr

Introduction

In Europe, around 10 million tonnes of urban sewage sludge are produced yearly, requiring treatment, recovery, or disposal solutions. The main techniques include anaerobic digestion, composting, land application of raw sludge, and incineration, the choice of which varies according to local conditions. In France, about one third of sludge is composted before land application. Composting, an aerobic biological process for degrading organic matter, produces a stabilized, amending, and fertilizing agronomic product that closes the carbon and nitrogen cycles. However, when treating substrates with a high nitrogen content, such as sludge, gaseous emissions (NH_3/N_2O) can impact the environment and must therefore be limited. Beyond mixture physicochemical characteristics influencing emissions (Cretey et al., 2024), the type of aeration is recognized to influence ammonia and nitrous oxide emissions during composting. Thus, the study aimed to investigate the impact of aeration type on nitrogen emissions during sludge composting. To this end, two types of aeration were compared (passive and forced aeration).

Methodology

A mixture of dewatered sewage sludge, collected from an industrial composting site in North France, and bulking agents composed of green wastes and recycled green wastes, collected from the same industrial composting site, was studied. The recycled green wastes corresponded to the fraction superior to 2cm removed during the sieving of the mixture after the active degradation phase of composting. This mixture was composted in two types of a 300-liter composting pilot: a passive aeration reactor, in which an airflow of around 50 L/min swept over the surface of the mixture, and a forced aeration reactor, in which an airflow of between 4 L/min and 6 L/min was injected into the mixture to be composted from the base of the reactor. An infrared online analyzer assessed CO_2 and N_2O gaseous emissions, whereas ammonia was trapped in acid solutions and then measured. The composting mixtures were sampled during the trials to estimate dry matter, volatile matter, and Kjeldhal nitrogen content. The experiments lasted 90 days and represented the active and curing phases of composting.

Results and discussion

In these tests, 17.2% and 24.6% of the initial nitrogen was lost in gaseous form when forced and passive aeration were applied, respectively. Lower NH_3 emissions were observed with forced aeration: 16% of the initial nitrogen was emitted as NH_3 with passive aeration, compared with 4.2% with forced aeration. On the other hand, forced aeration led to higher N_2O emissions than passive aeration, with emissions corresponding to 8.6% of initial total nitrogen in passive aeration versus 13% in forced aeration. While biodegradation levels were comparable in both aeration conditions, the higher moisture content of the mixture, linked to the supply of humid air, probably enabled better conservation of ammoniac nitrogen in the mixture under forced aeration. However, the availability of ammonia nitrogen and oxygen during the maturation phase of composting probably increased nitrification processes and intermediate N_2O production.

Conclusion

The emission behavior presented above was observed for several types of sludge composting mixtures, highlighting interesting influences of the aeration type. Analyses of nitrite, nitrate, and ammonium concentrations in the composted mixture and of the microorganisms involved are underway to better understand nitrogen dynamics during these composting trials and the differences observed in terms of ammonia and nitrous oxide emissions. An in-depth study of the role of the humidity of the air injected during forced aeration would also be interesting to validate the hypotheses explaining the differences between the two aeration modes. Finally, it would be interesting to study an intermittent aeration method to take advantage of both types of aeration and minimize nitrogen losses.

References

Crestey, E., et al. 2024. Correlations between sewage sludge composting physicochemical parameters and emissions of greenhouse gases and ammonia: A statistical analysis. Journal of Environmental Management. 368

11. Manure processing in regions with intensive livestock farming: pros and cons

Regelink, I.C., [a*], Van Dijk, K[a] & Schoumans, O[a]

Wageningen Environmental Research, The Netherlands[a,] *Corresponding author, email: inge.regelink@wur.nl

Introduction

Manure processing is already common in regions with intensive livestock farming. There is a need for more advanced manure processing technologies to reduce losses of N to air and water. Processed manure in which N is >90% present in mineral form, is very similar to synthetic N. These products are referred to as RENURE (REcovered N from manURE) and can be used as replacement for synthetic N once this is legally approved by the European Commission.

Methodology

Installations for the production of three types of potential RENURE materials were monitored:

(i) mineral concentrate (MC) from pig slurry or digestate
(ii) ammonium-sulphate solution (ASS) from anaerobically digested dairy slurry
(iii) nitrified and biological acidified fertilizer from cow urine

Mass- and energy balances were derived from monitoring, agronomic properties were assessed in lab- and field experiments. The plants were situated in regions with intensive livestock farming in The Netherlands.

Results and discussion

Mineral concentrate is produced through solid/liquid separation followed by reverse osmosis. In this process, approximately 60% of total-N is recovered in MC and another 40% is recovered in the solid fraction. Mineral concentrate meets the RENURE criteria but is yet prone to NH_3 emissions due to its high pH. The remaining solid fractions of manure are typically exported to regions with a demand for organic fertilising products.

Ammonium-sulphate solution was produced through stripping using a small-sized installation on a dairy farm. About 30% of total N was recovered as ASS, which is a transparent solution with 5% N as NH_4SO_4 with a low risk for NH_3 emissions due to its low pH. Its high S content is however a point of concern when applied in large dosages.

Biologically nitrified urine was produced through aeration of cow urine in an membrane reactor. Bacteria converted NH_4 into NO_3 in a 50/50 ratio while simultaneously lowering the pH to 6.0, and hence substantially reducing risks for NH_3 emissions as compared to untreated urine which typically has a pH of 8.5. The process runs without any chemical additives buts its economic feasibility is poor as lower NH_3 emissions do not offer a direct financial benefit.

Effects of manure treatment on nitrate leaching and overall NH_4 emissions depend not only on the nitrogen use efficiency (NUE) of the RENURE products but more so on the NUE of the remaining organic manure fractions. Solid fractions can contribute substantially to NH_4 emissions when applied on grassland. Timely application of organic fertilisers is required to increase NUE of these products. Manure processing leads to the production of a pallet of new fertilising products with varying nutrient compositions increasing the complexity of farmers fertilising schemes.

Methane emissions from manure decrease when manure treatment leads to a faster removal of manure from the barn. In addition, CO_2 emissions associated with long-distance transport of surplus manure are being reduced but this benefit is partly counteracted by the fact that RENURE production is energy intensive. RENURE production is costly but economically feasible in regions with high costs for manure disposal such is The Netherlands.

Conclusion

No generic conclusions can be drawn as the overall emissions and costs strongly depend on the context.

References

Journal citation format:

Rietra et al. 2024. Environmental Effects of Using Ammonium Sulfate from Animal Manure Scrubbing Technology as Fertilizer. Applied Sciences 14(12) https://doi.org/10.3390/app14124998

Regelink, I., C. Brienza, I. Sigurnjak, L. Hermann and O. Schoumans (2021) Evaluation of five centralised anearobic digesters applying nutrient recovery and reuse. - A report within the H2020 project SYSTEMIC. Wageningen Environmental Research, Wageningen, the Netherlands. https://doi.org/10.18174/572617

FERTIMANURE, 2016. Dutch on-farm pilot for the production of bio-based tailor-made fertilisers - explanatory video

12. Region-specific management measures for crop and livestock production systems may achieve environmental targets cost effectively

Fang Q.[a]; Xu W.[a], Zhang T.[b], Dai G.[a], Zhang X.[a], Yu C.[c], Wang H.[a], Oenema O.[a,d], Hou Y.[a*]

State Key Laboratory of Nutrient Use and Management, College of Resources and Environmental Sciences, China Agricultural University, China [a]; Institute of Environment, Resources, Soil and Fertilizer, Zhejiang Academy of Agricultural Sciences, China [b]; School of Ecology, Hainan University, China [c]; Wageningen Environmental Research, Wageningen University & Research, the Netherlands [d]; *Corresponding author, email: yonghou@cau.edu.cn

Introduction

Securing food production and environmental safety is a grand challenge[1,2], notably because of the vast regional heterogeneity in systems and environment[3,4], which demands for region-specific and cost-effective best management practices (BMPs). China is an interesting case here as it has diverse socio-economic and environmental conditions at the subnational level. With 19% of the world's population and a rapidly developing economy, improvements of China's crop and animal production systems will have significant impacts also on the global food systems' sustainability. The purpose of our study was to explore how current crop and livestock production systems in China can stay within set environmental boundaries for GHG emissions and N and P losses to water bodies at regional level simultaneously.

Methodology

First, we built the CLEANER model (Crop and Livestock optimization, Emissions Abatement, and Nutrient Efficient Recycling) to analyse the food production capacity and environmental impacts of crop and livestock systems, without and with BMPs at provincial scales in China. Second, we derived regional-specific thresholds for the 31 mainland provinces, using scientific principles and regional properties, the impacts of the current crop and livestock production systems were assessed relative to the set boundaries and associated economic costs. Third, 6 BMPs along the crop-livestock production chain (BMP1- improved animal production efficiency; BMP2- methane inhibitor in feed; BMP3- improved manure management; BMP4- improved crop husbandry and balanced fertilization; BMP5- enhanced-efficiency nitrogen fertilizers; BMP6- deep fertilization) were defined and implemented in an integrated manner along the whole chain. Then two implementation levels (i.e., modest implementation at large farms only and full implementation in all farms) of integrated BMPs packages were explored. Finally, we explored optimal combinations of regional-specific BMPs based on cost and effectiveness of BMPs. These optimal combinations of BMPs turned out to be highly cost-effective to achieve adequate food supply within the set environmental targets.

Results and discussion

For the 2016-2018 baseline situation, nearly all provinces exceeded two or three environmental thresholds, which had been defined province-specific for hydrological nitrogen and phosphorus losses and greenhouse gas emissions. A uniform and full implementation of 6 packages of BMPs would allow 26/31 provinces to stay within the set regional environmental thresholds, but at the additional cost of 17% of total agriculture production costs. By contrast, province-specific combinations of BMPs decreased total hydrological nitrogen losses by 5.3 Mt (-64%) and phosphorus losses 0.7 Mt (-66%) in a cost-effective way (only 0.7% of total cost), while all provinces stayed within the set hydrological thresholds. We argue that greater attention has to be given to the spatial heterogeneity in the effectiveness and costs of BMPs, and to the development of region-specific policies and instruments.

Conclusion

Our study provided insight into the agronomic and environmental performances of crop and livestock production systems at sub-national level in China, as well as into the cost and effects of best management practices on these performances. Optimal combinations of region-specific BMPs turned out to be much more cost-effective than a uniform modest or full implementation of 6 BMPs packages along the crop and livestock production system. This region-specific approach recognizes the heterogeneity of production as well as environmental impacts in provinces.

References

[1] Clark, M. A., et al. 2019. Multiple health and environmental impacts of foods. Proc. Natl. Acad. Sci. U. S. A. 116, 23357–23362.

[2] Springmann, M. et al. 2018. Options for keeping the food system within environmental limits. Nature 562, 519–525.

[3] Chen, X. et al. 2024. Keeping Nitrogen Use in China within the Planetary Boundary Using a Spatially Explicit Approach. Environ. Sci. Technol. 58, 9689-9700.

[4] Chang, J. et al. 2021. Reconciling regional nitrogen boundaries with global food security. Nat. Food 2, 700-711.

13. Optimization of manure management options in view of crop nutrient demands, environmental benefits and costs

Sun, W.[a, b*], Ros, G. H.[a], Zhu, Q[b], Hou. Y[b] & de Vries, W.[a]

Wageningen University & Research , Earth Systems and Global Change Group, Wageningen, the Netherlands [a]; China Agricultural University, State Key Laboratory of Nutrient Use and Management, College of Resources and Environmental Sciences, National Academy of Agriculture Development, Beijing, China [b]; *Corresponding author, email: weikang.sun@wur.nl

Introduction

China's agricultural intensification, driven by the rising food demand, relies heavily on nitrogen (N) and phosphorus (P) fertilizers, causing soil acidification, ammonia (NH_3) and nitrous oxide (N_2O) emissions to air and leaching/runoff of nutrients to water, all of which threaten agricultural sustainability. Livestock production, which nearly tripled between 1980 and 2010, has worsened these impacts through ineffective manure management (Bai et al., 2016; Bai et al., 2018). Enhanced manure recycling offers a sustainable solution by reducing soil acidification, improving soil fertility, decreasing synthetic fertilizer dependence and mitigating environmental impacts when applied appropriately. Inappropriate use of excess manure application leads to soil P accumulation and associated risks for runoff and eutrophication in water bodies. Logistical, economic and technical barriers, such as transportation and treatment costs, along with mismatched N:P ratios compared to crop demand, limit effective manure use in agriculture. While manure management can offer solutions to adjust N:P ratios, their cost-effectiveness varies with the treatment technologies applied. The study therefore evaluates the effectiveness of manure management to align manure nutrient characteristics with regional crop nutrient demands, while balancing manure management costs and environmental benefits.

Methodology

The potential of manure management options to optimize N and P use was evaluated for a typical livestock production city Quzhou in China. Eleven manure management options were assessed based on different combinations of housing systems, storage and treatment techniques, considering their impact on nutrient retention and associated costs, such as investment and maintenance of manure process facilities. The crop-manure balance index (the ratio of manure nutrients to crop demands) was introduced to evaluate regional nutrient self-sufficiency. Levels of available nutrients after manure processing were quantified by calculating the difference between N and P excretion and nutrient losses occurring during the manure management chain. An optimization model was developed to allocate manure nutrients to various crops to find economically feasible and sustainable manure management options.

Results and discussion

The crop-manure balance index was 0.33 for N and 2.1 for P, indicating an N deficit that requires additional synthetic fertilizers and a P surplus at the city level. Nutrient retention across the eleven manure management options (meaning the nutrients becoming available for use) varied between 14% and 60%, with NH_3 emissions contributing significantly to losses. Environmental impacts were primarily driven by emissions during the housing and treatment stages, highlighting the need for targeted mitigation strategies. Crop-specific and city-averaged nutrient balances, treatment efficiency and economic feasibility will be presented.

Conclusion

This study demonstrates that the crop-manure balance index reveals a regional N deficit and P surplus whereas innovative manure management options can be applied to reconcile agronomic and environmental challenges. The current manure management in Quzhou city shows that only 14% to 60% of excreted nutrients are used, with significant N losses due to NH_3 emissions. While optimizing manure management options we showed that the nutrients reused in agriculture increase and nutrient losses can be minimized substantially, thereby balancing costs and environmental benefits.

Acknowledgements

We gratefully acknowledge the sponsors: China Scholarship Council (NO.201913043) and Hainan University.

References

Bai, Z., et al. 2016. Nitrogen, phosphorus, and potassium flows through the manure management chain in China. Environ. Sci. Technol. 50(24), 13409-13418.

Bai, Z., et al. 2018. China's livestock transition: Driving forces, impacts, and consequences. Sci. Adv. 4(7), p.eaar8534.

14. Are livestock manure and organic waste the key to nitrogen self-sufficiency in organic farming? From farm to territory case studies

Beline, F.[a*], Cristofaro, L.[a], Roy, D.[b], Bize, N.[c], & Harchaoui, S.[a]

INRAE UMR SAS, Rennes, France[a]; Agrobio35 Cesson-Sévigné, France[b]; FRAB, Cesson-Sévigné, France[c]; *fabrice.beline@inrae.fr

Introduction

Consumers and public authorities aim to promote organic farming (OF) but nitrogen (N) availability, an essential element for plant growth, could hinder its expansion. As mentioned by Barbieri et al. (2021), several studies identify N deficiency as the main factor limiting crop yields in OF systems, which are 20-25% lower than in conventional farming (CF). Moreover, OF depends on CF for land fertilisation through the use of livestock manure from CF as highlighted by Vergely et al. (2024) at French scale, with a dependence reaching up to 20% of N input. Could livestock manure and organic waste offer solutions to address N deficiency and reduce dependence? This will be examined using material flow analysis at scales ranging from individual farms to small territories.

Methodology

This study investigated N flows in OF, focusing on compartments such as soils with crops or grassland, livestock and manure. N inputs included biological nitrogen fixation, atmospheric deposition, manure or organic waste from CF or municipalities, and feed imports from outside the studied area. N outputs comprised exported crops, livestock production, manure and N losses (e.g., leaching, denitrification, and emissions of ammonia, N_2, and N_2O). Using mass balance models, agricultural statistics and literature, key indicators—such as N self-sufficiency, N use efficiency, surface N losses, N circularity index, and N productivity—were calculated, facilitating scenario comparisons. Various organic farms, both with and without livestock, were analysed to assess current situations and co-constructed scenarios with stakeholders for improving N self-sufficiency and developing OF. Additionally, similar modelling was performed at the territorial scale to evaluate the impact of inter-farms and agriculture-municipalities exchanges.

Results and discussion

In all cases based on actual situations, biological nitrogen fixation was the primary N input ranging from 32 to 125 $kgN.ha^{-1}.yr^{-1}$, contributing to an overall N self-sufficiency of 55-91%. However, external organic N inputs remained important in OF systems, ranging from 0 to 40 $kgN.ha^{-1}.yr^{-1}$, with an average of 22 $kgN.ha^{-1}.yr^{-1}$. High-population-density areas could provide up to 15–20 $kgN.ha^{-1}.yr^{-1}$ via organic waste, whereas rural areas could contribute less than 4 $kgN.ha^{-1}.yr^{-1}$. Ruminants supported N self-sufficiency by partially converting legume fodder into manure but also increased N losses. In high animal-density systems, feed imports requirements reduced overall self-sufficiency. Anaerobic digestion provided an additional strategy to improve N self-sufficiency while producing energy. While optimizing current systems yielded modest improvements, structural changes inspired by circular bioeconomy principles (Muscat et al., 2021) showed significant potential by minimizing losses and enhancing food production. These principles can be applied at both farm and territorial scales. However, such structural changes leading to increase vegetal to animal products ratio requires simultaneously diets transitions to avoid additional imports of animal products.

Conclusion

The results highlight the challenges of achieving N self-sufficiency in OF but also point to several pathways to address this issue at both farm and territorial scales. Structural changes are essential, particularly transitioning towards more extensive agricultural systems, including livestock farming adapted to territorial characteristics. Additionally, exploring alternative uses for fodder legumes, such as anaerobic digestion, presents a promising solution to enhance N self-sufficiency.

Acknowledgements

Authors thank the “Région Bretagne” for funding the CirculAB project and the Metaprogramme INRAE METABIO program for funding the Organic4organic and MethAB projects.

References

Barbieri, P., et al. 2021. Global option space for organic agriculture is delimited by nitrogen availability. Nature Food, 2(5), pp. 363-372.

Muscat, A., et al. 2021. Principles, drivers and opportunities of a circular bioeconomy. Nature Food, 2(8), pp. 561-566.

Vergely, F. et al. 2024. Contribution of livestock to organic agriculture: Modelling nitrogen flows at the national scale. Resources, Conservation and Recycling, 208, art. no. 107726.

15. Impact of manure separation techniques in dairy houses on environment, fertilization and economics

Galama, P.J.[a], van Dooren, H.J.C. [a*], Schep, C.A.[a], Ouweltjes, W.[a], de Boer, H.C.[a], & H.R. Kamstra-Brouwer[b]

[a] Wageningen Livestock Research, The Netherlands, [b] Dairy Campus, Leeuwarden, The Netherlands; * hendrikjan.vandooren@wur.nl

Introduction

Dairy cows produce feces and urine several time a day but at different moments and placed. However, housed in slurry based cubicle systems as the majority of dairy cows in The Netherlands, both fractions end up together in a slurry. When both fraction were kept separated as good as possible and removed from the surface of the walking floor or from the housing at all, this would probably reduce the slurry related emissions of methane and ammonia. Carbon rich feces is one of the sources of methane production and ammonia N rich urine is the source of nitrogen losses as ammonia, nitrous oxide and other nitrogen emissions. Both fractions individually could also contribute to more efficient use of nutrients for plant growth and soil fertility than the mixed slurry would do. Finally a well separated urine fractions could meet the EU RENURE (REcovered Nitrogen from manURE) criteria and replace part of the use of mineral fertilizer. The goal of the project was to evaluated three source segregation techniques that keep the urine and feces separated in dairy houses on the effect on ammonia and methane emission, nutrient losses during storage, the use as fertilizer and the economic implication.

Methodology

Three source segregation techniques were installed and investigated from the end of 2020 to the end of 2023 at research farm Dairy Campus in the Netherlands using three units of 16 lactating dairy cows each and compared to a conventional cubicle barn with slatted floor that acted as a reference. Emission of methane, ammonia, carbon dioxide and nitrous oxide were measured in all four units semi-continuously. The three techniques were:

- CowToilet (Hanskamp BV). The CowToilet is an automatic urinal combined with a concentrate feeder that cows use voluntarily. The urine collected is stored separately and feces and the remainer of the urine production is stored in the slurry pits under the slatted floor
- Permeable tiles floor (Zeraflex floor by A&S Techniek). Urine is drained by the permeable tile on the slatted floor into the pit. Feces is removed from the floor with a manure scraper and stored outside.
- Rubber floor (V17 Agro). A new type of a grooved rubber floor with drainage holes for liquid fraction and feces removal with a scraper.

Besides the effects on housing emissions, separation efficiency and of N, P, K and C-balances, measurement of nutrient losses during small scale storage of fractions and an economic analyses of the whole manure chain were performed.

Results and discussion

- CowToilet. The CowToilet collects around 35% of total urine production. Emissions of ammonia and nitrous oxide was reduced by 33% and 18% respectively, compared to the reference unit. The urine collected meets the RENURE criteria.
- Permeable tiles floor. Only combined with urine acidification the emissions of ammonia and nitrous oxide was reduced by 62% and 9% respectively compared to the reference barn. While total urine production is collected more fertiliser is replaced and slurry disposal costs decrease, but only when RENURE criteria are met.
- Rubber floor did not reduce ammonia and nitrous oxide emissions.

Results of methane emissions and economic analyses will be presented at the conference.

Conclusion

Both CowToilet and Zeraflex floor reduced ammonia emission but the latter only after additional acidification of the urine fraction. When RENURE criteria are met installation of these techniques is profitable

Acknowledgements

The project " Mestscheiding bij de bron in melkveestallen" was commissioned by the Ministry of LVVN and ZuivelNL, with in kind help of contributing companies.

Bio-based strategies in agriculture: perspectives for environmental pollution reductions

Ural-Janssen, A.[a*], Meers, E.[b], Ros, G.H.[a], Strokal, V.[c], & Strokal, M.[a*]

Wageningen University & Research, The Netherlands [a]; The University of Gent, Belgium [b]; The National University of Life and Environmental Sciences of Ukraine [c]; * corresponding authors, emails: aslihan.ural@wur.nl and maryna.storkal@wur.nl

Introduction

Agriculture has been contributing considerably to air and water pollution given nitrogen emissions to air in the form of ammonia, nitrogen oxides and nitrous oxide, and nitrogen and phosphorus emissions to water via leaching and runoff. Agricultural runoff being rich with nutrients enters rivers and is further exported to seas, affecting aquatic biodiversity. In many regions, agricultural crop and animal production is not sustainable, having substantial adverse impacts on climate and water quality. In Europe, existing policies facilitate the use of renewable resources such as bio-based fertilizers (BBFs) to support the circular economy and reduce environmental impacts. BBFs are often produced from processed organic waste such as animal manure, and sewage sludge. BBFs also facilitate nutrient recovery and re-use technologies to improve nutrient efficiencies. The integrative effects of BBFs to reduce both air and water pollution simultaneously are however not well studied, as well as their contribution to the spreading of antibiotics and pathogens.

Methodology

In this study, we synthesize the knowledge on the role of BBFs in agriculture and identify perspectives and lessons for air and water pollution reductions. For this, we systematically review the relevant literature. We used the ISI Web of Science (WoS) database for the period of 01.01.2014 - 31.12.2024. For each perspective, two separate search strings were developed and a combination of two search string blocks was conducted. After each combination of searches, we scanned the search results based on the title and abstract that were relevant to this study. For the articles that were judged as relevant, we then reviewed the full text to assess recent literature regarding each perspective (environment, agronomy, technology, scale, and policy) on the role of BBFs in air and water pollution control.

Results and discussion

We identified five main perspectives including (1) environment, (2) agronomy, (3) technology, (4) policy and socio-economy, and (5) scale and integration. BBFs may contain multiple pollutants that may increase environmental pollution (e.g., pathogens, heavy metals), and this should be considered before the adoption of BBFs in agriculture (perspective 1). In general, the agronomic efficiency of BBFs may be somewhat similar or different from synthetic fertilizers (perspective 2). There is no "golden" technology to process waste and produce BBFs. This implies that technologies vary greatly in terms of processes influencing their cost and implementation efficiency (perspective 3). BBFs are often subject to legal limitations for their production and adoption. This varies among regions in the world (perspective 4). Most of the knowledge base regarding the role of BBFs focused on agronomic effects and has been derived from small-scale lab and field experiments. The BBF implementation on a larger scale (e.g., continental, global) and its impact on air and water quality is still unknown(perspective 5). Models can help to explore the effects of upscaling BBFs in the world and assess their effects on air and water pollution reductions. BBFs are promising strategies to improve agricultural efficiencies. Their implementation should consider effects not only on agronomy but also on multiple pollutants, policy, and technology in time and space.

Conclusion

We derive five main conclusions. First, environment, agronomy, technology, policy, and scale are five perspectives identified. Second, bio-based fertilizers may have multi-pollutant issues. Third, the content variability of bio-based fertilizers could be overcome by precision techniques. Fourth, models can help understand the role of bio-based fertilizers in pollution control. Fifth, the upscaling of the application of bio-based fertilizers needs further research attention and the integration of other perspectives.

Acknowledgments

European Union HORIZON-CL6-2021-ZEROPOLLUTION-01 Grant Agreement No. 101060455 (NutriBudget project) and European Union HORIZON-MISS-2023-OCEAN-SOIL-01 Grant Agreement No. 101156867 (Path4Med)

Häni, C. et al. 2018. Accounting for Field-Scale Dry Deposition in Backward Lagrangian Stochastic Dispersion Modelling of NH3 Emissions. *Atmosphere* 9 (4), p. 146. DOI: 10.3390/atmos9040146.

Seitler, E. and Meier, M. 2023. Ammoniak-Immissionsmessungen in der Schweiz: 2000 bis 2022. FUB - Forschungsstelle für Umweltbeobachtung.

Valach, A. C. et al. 2023. Ammonia emissions from a dairy housing and wastewater treatment plant quantified with an inverse dispersion method accounting for deposition loss. *J. Air. Waste. Manag. Assoc.* DOI: 10.1080/10962247.2023.2271426.

16. Nitrogen use efficiency of digestate applied with high organic carbon materials on the growth and yield of spring barley.

van Midden, C.[ad*], Harris, J.[a], Sizmur T.[b], Shaw, L.[b], Morgan, H.[c], & Pawlett M.[a]
Cranfield University, UK [a]; University of Reading, UK [b]; Future Biogas Ltd, UK [c]; Agri-food & Biosciences Institute, UK [d,*].
Christina van Midden, email: Christina.VanMidden@afbini.gov.uk

Introduction Anaerobic digestate is produced during the anaerobic digestion of organic materials for biogas generation and can be used as a fertiliser. However, nitrogen is lost following the application of digestate to soil, resulting in environmental pollution (Nkoa, 2014) and a low proportion of nitrogen reaching the crop. This research aimed to improve the nitrogen use efficiency of digestate by combining it with materials containing a high content of organic carbon to stimulate soil microbial growth and nitrogen immobilisation.

Methodology Liquid digestate was applied (140 kg-N ha-1) in a pot scale glasshouse experiment with either glycerol, straw, or glycerol and straw combined (each treatment at 24 kg-C m3 digestate). Controls comprised of digestate (without additional carbon) and soil only. All pots were planted with spring barley. Soils and crops were sampled at 3 timepoints when the barley reached stem extension, start of grain fill and at harvest, with an additional soil sample 7 days following treatment application. Above-ground plant biomass was removed, dried and analysed for weight and nitrogen content. Nitrogen use efficiency was calculated for apparent crop recovery of applied nitrogen and difference in yield between fertilised and unfertilised treatments. Microbial immobilisation was measured by microbial biomass carbon and nitrogen, soil available nitrogen and three amino sugars (galactosamine, glucosamine and muramic acid) to represent soil microbial necromass. To measure the effect on nitrogen loss pathways, the static chamber method was used to measure N2O emissions in the first 2 months following application and ammonia volatilisation in the first week. After harvest, the pots were leached to determine post-harvest nitrate leaching risk.

Results and discussion Seven days from treatment application, the glycerol and glycerol with straw treatments had greater microbial biomass and muramic acid compared to digestate alone. As muramic acid is bacterial in origin (Glaser, Turrio, and Alef 2004), it indicates that the growth in microbial biomass and subsequent turnover into necromass is dominated by bacteria. Soil available nitrogen decreased by 95 mg-N kg-1 compared to digestate alone at this timepoint, but the majority of this nitrogen had remineralised by 30 days after treatment application. Despite the statistically significant ($p=0.002$) immobilisation, barley nitrogen use efficiency and yield were unaffected by treatments. This indicates that the immobilised nitrogen remineralised too rapidly to be of benefit to later key nitrogen demanding crop growth stages, and instead was utilised by the plant during its first key nitrogen demanding growth stage beginning at stem extension. The addition of straw, glycerol, and both in combination with digestate had no effect on N2O emissions, ammonia volatilisation, or post-harvest leaching, compared to the digestate control.

Conclusion The aim of this study was to assess the effects of adding organic carbon materials into digestate on plant nitrogen use efficiency. Whilst the addition of glycerol to digestate did result in nitrogen immobilisation, the period of immobilisation was too short for there to be any measurable effect on barley growth and nitrogen use efficiency. Yet the increase in biomass and turnover rate into necromass within a week of application demonstrates the effectiveness of transforming digestate supplied nitrogen into more stable organic nitrogen. This rapid immobilisation could reduce nitrate leaching from rainfall events occurring in the month after digestate application, which in turn could increase nitrogen supply to crops.

Acknowledgements This project was funded by the BBSRC and Future Biogas Ltd as part of the Food Systems DTP.

References

Glaser, B., Turrio, M-B. and Alef, K. (2004) 'Amino sugars and muramic acid— biomarkers for soil microbial community structure analysis' Soil Biology and Biochemistry, 36, pp. 399–407

Nkoa, R. (2014) 'Agricultural benefits and environmental risks of soil fertilization with anaerobic digestates: A review', Agronomy for Sustainable Development, 34(2), pp. 473–492. doi: 10.1007/s13593-013-0196-z.

Nicholson, F., et al. 2017. Nitrogen losses to the environment following food-based digestate and compost applications to agricultural land. Environ. Pollut. 228, 204–516.

Anon, 1986. The Analysis of Agricultural Materials. Ministry of Agriculture Fisheries and Food Reference Book, third ed. HMSO, London.

Davidson, E.A., 1991. Fluxes of nitrous oxide and nitric oxide from terrestrial ecosystems. In: Rogers, J.E., Whitman, W.B. (Eds.), Microbial Production and Consumption of Greenhouse Gases: Methane, Nitrogen Oxides and Halomethanes. American Society of Microbiology, Washington D.C, pp. 219–235.

WRAP, 2016.
http://www.wrap.org.uk/sites/files/wrap/WRAP_Digestate_and_compost_use_in_agriculture_for_farmers_growers_and_advisers.pdf

17. Optimisation of the fertilisation effect of digestates

Hansen, MN.[a*]

Affiliation, SEGES Innovation p/s, Denmark [a]; *Corresponding author, manh@seges.dk

Introduction

The Danish biogas sector has developed explosively the last decade, which means that today more than 35 percent of the total Danish production of livestock manure is digested at a biogas plant before used as a fertiliser in the plant production. An optimal plant utilisation of the nutrients content of biogas treated digestates is therefore important for Danish farmers to achieve an optimal plant production.

The fertiliser quality of digestates produced at Danish biogas plants has changed over the past years. The main reason is that that biomasses with a high dry matter content and low available nutrient content like for instance straw, deep litter and crop residues make up an increasing share of the biomasses co-digested at the biogas plants. These changes have caused production of digestates with lower fertilisation effects, mainly due a lower share of readily available nitrogen and a higher dry matter content, and thereby a higher risk of ammonia loss following land application.

SEGES Innovation has therefore performed a number of field trial studies to study how the fertilisation effects of dry matter rich digestates can be improved by different post treatment and land application technologies.

Methodology

The nitrogen utilisation and yield effects of digestates with different dry matter content were quantified by more than 20 field trials studies taking place in the period of 2021 to 2024. The field trial studies were based on 20 m long and 3 m wide experimental plots in cereal crops, where the different slurry types were land applied by experimental application technologies fitted the design of the experimental plots. All treatments and experimental plots were replicated four times. Different types of digestates and post treated digestates were land applied by different application technologies like trailing hoses, trailing shoes, and soil injection technologies. The fertilisation efficiency of the different type of digestates and treatments was quantified as nitrogen fertiliser equivalent (NFE), nitrogen uptake, and yield.

Results and discussion

Fertilisation with digestates with a low dry matter content resulted in NFE, yield effects and nitrogen uptake equal to fertilisation with slaughter pig slurry, while fertilisation with digestates with higher dry matter content caused lower crop yield and nitrogen uptake. Solid-liquid separation of the digestates increased the nitrogen utilisation and crop yield of the liquid fraction produced.

It was found that the dry matter content and viscosity of digestates can be reduced by screw press and decanter centrifuge technologies; however, the reduction is often lower than expected. Land application by use of trailing shoe and especially injection technologies increased nitrogen utilisation and yield compared to trailing hose application, while acidification by use of 1.7 l of sulphuric acid per ton of slurry only had minor effects on crop yield.

The lower fertilisation effects of digestates with a high dry matter content is expected to be due the slower infiltration of the slurry into the soil after application, which increases the ammonia emission potential. Pretreatment and land application ammonia abatement technologies therefore have a high potential for improving the fertilisation effects of digestates with high dry matter content.

Conclusion

The dry matter content of Danish digestates has increased considerably during the last decade. This and a steadily reduction in the share of plant available nitrogen has decreased its fertilisation effect. It was found that the fertilisation effect of dry matter rich digestates can be increased by use of separation technologies, and by use of ammonia abatement application technologies.

Acknowledgements

The projects were funded by the GUDP and the Promilleafgiftsfonden for agriculture.

18. The use of biochar as co-feedstock in anaerobic digestion: Effects on digestate separation performance

Tampio, E. [a*], Tiainen, S. [b], Heikkinen, K. [b], Hakala, E. [b], Honkala, N. [a], Laakso, J. [a] & Pyykkönen, V. [a]

Natural Resources Institute Finland (Luke), Finland [a]; Häme University of Applied Sciences (HAMK), Finland [b];

[*]Corresponding author, email: elina.tampio@luke.fi

Introduction

Anaerobic digestion plant operators seek ways to improve profitability while maintaining environmental sustainability. One potential approach is using biochar as a co-feedstock. Studies suggest that biochar can enhance anaerobic digestion by improving microbial activity, pH buffering, and adsorbing inhibitory compounds, leading to increased biogas production and reactor stability (Devi and Eskicioglu, 2024). However, results vary, and further research is needed to understand biochar's full potential as part of anaerobic digestion value chains.

On-farm digestate separation is commonly used to facilitate the handling of solid and liquid fractions. Enhancing this process could improve the overall efficiency of digestate management. In addition, producing manure-based biochar and using it in digesters promotes circular use of nutrients and carbon, aligning with circular bioeconomy goals. Additionally, biochar may reduce greenhouse gas emissions and contribute to carbon sequestration, making it an environmentally promising option (Verdi et al., 2024). In this study, the aim was to examine the use of horse manure-derived biochar as a co-feedstock in a digester processing cattle slurry and grass biomass. The focus was on its impact on digestate separability and the broader benefits of integrating pyrolysis and anaerobic digestion for regional manure management.

Methodology

Horse manure was pyrolyzed in a small-scale mobile unit at 350–550 °C for 3.5 hours. Prior to the experiments, the resulting biochar was ground. Laboratory-scale 5 L digesters were used to co-digest horse manure-based biochar with cattle slurry and grass biomass. Biochar was added at 0% (control), 1%, or 3% of the fresh mass of slurry and grass. During digestion and sample collection, the organic loading rate (OLR) was gradually increased from 4.5 to 7.8 kgVS/m³d by adjusting the share of grass feed, while process parameters were continuously monitored, confirming stable operation throughout the collection period. Digestate was separated into solid and liquid fractions using sieving (2 mm) and centrifugation to assess the effects of biochar on mass separability, total solids (TS), and nutrient distribution. Centrifugation was carried out using a Lemitec MD centrifuge at (10,000 rpm, differential speed 200 rpm, weir disc 52).

Results and discussion

The pyrolysis of horse manure produced biochar with a TS content of 93%, while its carbon content was 68%TS. The addition of biochar as a co-feedstock in the digesters did not affect gas production, likely because the manure-derived biochar lacked characteristics favourable for enhancing biogas yield. This highlights the importance of biochar quality and its variability. The TS contents in the digestates were 8.3%, 9.1%, and 10.3% where the biochar additions (0%, 1%, and 3% as co-feedstocks to the reactors, respectively) resulted in increasing TS.

Separation of the digestate into solid and liquid fractions depended on the TS of the digestate. Sieving and centrifugation produced more liquid fraction with digestate having the highest biochar addition (3%), suggesting better particle degradation in the digester due to biochar addition. Compared to the control, biochar additions also resulted in 2.5 and 8.4% higher TS removal in the centrifuged solid fraction (with biochar additions of 1 and 3%), showing that more digestate TS was captured than what was added with the biochar. The centrifuged solid fraction had a high TS content (22%), compared to the control (15%) . Results on nitrogen and phosphorus separability are still pending.

The tested concept promotes regional circular material use. Horse stables facing manure management challenges could supply pyrolyzed manure to local farm-scale digesters, which, in turn, may benefit from the improved digestate solids separation.

Acknowledgements

The study is conducted under BioKanta-project, which is funded by the Regional Council of Häme from the European regional development fund (ERDF).

References

Devi, P., Eskicioglu, C., 2024. Effects of biochar on anaerobic digestion: a review. Environ Chem Lett. 22, 2845–2886.

Verdi, L., et al. 2024. Evaluation of biochar addition to digestate, slurry, and manure for mitigating carbon emissions. Agriculture 14, 162.

19. Ferti-Dig: a French approach to optimize the agronomic benefits of on-farm digestates through typology establishment and assessment of the effects on agroecosystems

Jimenez, J.[a*], Moreira, M.[b], Heurtaux, M.[c], Caradec, L.[d], Michaud, A.[d], Menasseri-Aubry, S.[d], Pérès, G.[d], Patureau, D.[a], Berger, S.[e], Desneulin, I.[e], Capowiez, Y.[f], Simon, T.[g], Haumont, A.[h], Génermont, S.[i], Houot, S.[i]
[a] LBE, INRAE, Univ Montpellier, France ; [b] Chambre d'Agriculture de Bretagne, France ; [c] ACTA, France ; [d] UMR SAS, INRAE, Institut Agro, France ; [e]SOLAGRO, France, [f]UMR EMMAH INRAE, France ; [g]Chambre d'Agriculture Grand Est, France: [h] AAMF, France ; [i]UMR ECOSYS, Université Paris Saclay, INRAE, AgroParisTech, France; *julie.jimenez@inrae.fr

Introduction

To address climate change, and optimize agricultural resources, anaerobic digestion (AD) has rapidly grown in Europe, particularly in France, supported by European and national policies (EBA, 2022). AD recycles organic waste into renewable energy (biogas) and generates digestates (biofertilizer). In France, 73% of AD plants are on-farm, producing digestates for agricultural use (ADEME, 2024). A major challenge is understanding digestates' agronomic properties to optimize their benefits for soil quality and crop growth and avoid harmful environmental and health impacts (Nkoa, 2014). This requires establishing references and characterizing the factors influencing digestates properties, which vary due to feedstocks, post-treatments, and AD conditions (Guilayn et al., 2019). The French "Ferti-Dig" project aims to contribute to this understanding by (i) classifying on-farm digestates based on a comprehensive physicochemical properties database, (ii) linking this typology with effects on soil and agronomic properties, and (iii) producing a user-friendly fertilization guide.

Methodology

To achieve the research objectives, two databases were created: (i) the physicochemical description of 608 digestates and associated AD plant conditions, and (ii) field-effect indicators from twenty field trials, including crop available nitrogen, soil biological, and physical indicators. Missing data were addressed by sampling and characterizing 30 additional digestates and conducting four field experiments in 2022 across two French regions with contrasted pedoclimatic conditions. Statistical analysis was then applied to the first database to propose a digestates typology and assess their impacts on agroecosystem indicators from the second database.

Results and discussion

Hierarchical classification of the physicochemical database identified seven groups of digestates, based on AD process conditions (wet or dry), post-treatments (phase separation and composting), and main feedstocks (cattle manure, vegetal biomass, pig slurries co-digested with agro-food or biowastes). Depending on the feedstocks, obtained digestates presented either more soil improver-like properties (high dry matter, low available nitrogen content, high C/N) as for cattle manure or more fertilizing properties (low dry matter, high available nitrogen content, low C/N) as in pig slurry co-digestion. Post-treatments exacerbated these properties. The typology is significantly correlated to certain indicators, such as agronomic properties (e.g., C and N mineralization on soil) and nitrogen fertilizer replacement value, with high variability explained by the type of crop fertilized, spreading methods, and pedoclimatic conditions. However, the available data were insufficient to conclude about the impact of the typology on indicators related to soil quality (microorganisms, structural stability). Moreover, the impact of farming practices and pedoclimatic conditions also added complexity to understanding the typology's effects. Based on the compiled database (https://doi.org/10.57745/M1JSU5), digestate fact sheets were created detailing properties, soil improver and fertilizer value, application practices, and regulatory alerts, and are included in a user guide accessible online: https://fertiliser-avec-des-digestats.fr.

Conclusion

The digestates typology was relevant for describing their soil improver and fertilizing potential. However, variability in field indicators highlights the need to consider agricultural practices and pedoclimatic conditions to ensure optimal crop growth and avoid environmental harm. Ferti-Dig made research data accessible through an online guide, aimed at becoming a reference on on-farm digestates in France.

Acknowledgments

This work was supported by ADEME and GRDF through the Ferti-Dig project (grant number 2106D0007, 2020-2024).

References

ADEME, 2024. https://www.sinoe.org/documents/consult-doc/idDoc/1342/actualite/1

EBA, 2022. https://www.europeanbiogas.eu/wp-content/uploads/2022/12/Statistical-Report-2022-Presentation_FINAL.pdf

Guilayn et al. 2019. First fertilizing-value typology of digestates: a decision-making tool for regulation. Waste management, 86, 67-69.

Nkoa, R. (2014). Agricultural benefits and environmental risks of soil fertilization with anaerobic digestates: a review. Agronomy for Sustainable Development, 34, 473-492.

20. Towards an improved policy framework for biowaste management: The LIFE BIOBEST project

Walk, Steffen[a*] (SW), Granjard, Aline[a] (AG), Dr. Siebert, Stefanie[a] (SI)

European Compost Network ECN e.V., Germany, email: walk@compostnetwork.info

Introduction

Since January 2024, the EU has mandated the separate collection of biowaste (European Commission, 2018), to support the target of recycling 65% of municipal solid waste by 2035. However, the latest EU Early Warning Report indicates that 18 of the 27 EU member states risk failing to meet the 2025 recycling target (European Commission, 2023). To achieve the 2035 target, an additional 40 Mio. Mg of biowaste must be collected separately per year (Gilbert & Siebert, 2022). The recycling of biowaste to compost and digestate is especially important for the EU green deal, including the strategies on bioeconomy, biodiversity and soil. Organic recycling strategies aim to increase soil health and structure and the application of compost has the potential to contribute to improving 16% of soils degraded by erosion (Gilbert & Siebert, 2022). The EU LIFE BIOBEST project (EU LIFE BIOBEST, 2023) aims at supporting the strengthening of the legal frameworks to close the biological cycle to enrich soils with high quality compost from separately collected biowaste.

Methodology

The project started with the analysis of regulatory barriers regarding the implementation of effective biowaste management. This included the analysis of existing documents as well as stakeholder engagement activities. Deriving from these barriers, guidelines were developed including the entire value chain from waste generation to product application. These guidelines were produced in conjunction with the identification of best practice examples for biowaste collection and treatment representing the diverse local circumstances in various EU regions.

Results and discussion

In a first step, key bottlenecks were identified, hindering improved biowaste management from the EU to the local level, among others, the lack of performance monitoring, data management, and adoption of best practices. Therefore, the project developed a set of guidelines approaching local actors as well as policy-makers. For example, the following guidelines were produced: Separate Collection, Production of high-quality compost and digestate, Economic incentives, Communication activities, Quality Standards for biowaste entering biological recycling facilities and the Comprehensive Guidance for effective biowaste management in the EU. These guidelines approach local entities, such as municipalities and plant operators but as well regional, national and EU-level actors influencing policy developments.

All publications can be found following the LINK.

Conclusion

The guidelines produced within the project were expected by the European Commission to guide the mainstreaming of best biowaste management practices in the EU in order to close the biological cycle. It is up to policy makers now to adopt the legal frameworks (among others the Waste Framework Directive and Landfill Directive) including the development of homogenised monitoring methodologies for quality and quantity assessment, the establishment of specific targets for biowaste management as well as the promotion and strengthening of reliable and new markets for compost and digestate. These aspects were demanded not only by the BIOBEST consortium but as well stakeholders of the largest national and EU-associations related the field who verified the produced documents.

Acknowledgements

The project is funded by the European Union in the EU LIFE programme under the Grand Agreement code LIFE21-PRE-ES-LIFE BIOBEST – 101086420.

References

EU LIFE BIOBEST. (2023). Project website. www.lifebiobest.eu

European Commission. (2018). Waste Framework Directive. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=uriserv:OJ.L_.2018.150.01.0109.01.ENG

European Commission. (2023). Waste Early Warning Report. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=COM%3A2023%3A304%3AFIN&qid=1686220362244

Gilbert, J., & Siebert, S. (2022). ECN DATA REPORT 2022 - COMPOST AND DIGESTATE FOR A CIRCULAR BIOECONOMY. https://www.compostnetwork

Parallel session 2

1. Manure removal frequency in dairy housing – impacts on ammonia and methane emissions

Janke, D.[a*], Sahu, H.[a], Mehmood, T.[a], Umar, W.[a], Dragoni, F.[a], Amon, T.[a, c] & Amon, B.[a, d]

Leibniz Institute for Agricultural Engineering and Bioeconomy (ATB), Germany [a]; Freie Universität Berlin, Institut of Animal Hygiene and Environmental Health, Germany [c]; University of Zielona Góra[c]; [*]Corresponding author, email: djanke@atb-potsdam.de

Introduction

Manure management is a critical influencing factor on ammonia (NH_3) and also methane (CH_4) emissions from livestock housing. From barns with plane floors, NH_3 typically emits from fresh urine puddles on these floors. When urine is removed, e.g. by scrapers or cleaning robots, it is expected that the NH_3 emissions drop. Consequently, best practice guidelines usually recommend to remove manure at least 12 times a day. An increase of manure removal frequency is acknowledged as a proper measure to mitigate NH_3 emissions. Surprisingly, only very little to no data from experiments carried out in commercial exist, that investigated these assumptions. Therefore, we aim to close this knowledge gap by systematically investigating the effect of the manure removal frequency on the NH_3 and also the CH_4 emissions within the Horizon Europe project "ECONUTRI".

Methodology

Experiments were done in a naturally ventilated dairy barn with around 50 cows near Potsdam, Germany. The barn had two plane walking alleys, each 25 m long and 4 m wide. The first floor was cleaned by a scraper, the second by a cleaning robot (LeLy collector). Scraper and robot cleaned the floor and pushed the manure through slats at the end of the walking alleys into the slurry pre-storage, from where, dependent on the level, it was pumped daily to an outside storage. Emissions were measured following the CO_2 balance method, according to the VERA protocol, with two CRDS (cavity ring-down spectroscope, Picarro G2508 and G2509) gas analyzers. The effect of removal frequency was tested in a case-control-in-time approach. The removal frequency of 12 time per day was set as "baseline". "High" was defined as a frequency of 16 times per day, "Low" as a frequency of 8 times day. Frequencies were altered every week, always in the manner *Baseline-High-Baseline-High…* or *Baseline-Low-Baseline-Low-..,* and the emission values for each week were measured. After comparing the case (either "High" or "Low") with the control ("Baseline") emission levels, the potential effect of removal frequency on NH_3 and CH_4 emissions is estimated.

Results and discussion

The measurements started in December 2024 and are ongoing until May 2025. Intermediate analysis shows no significant difference between the baseline and the "High" frequency. Results for the whole experiment will be presented at the conference.

Acknowledgements

This work was supported by the European Commission within the framework of the Horizon Europe innovation project "ECONUTRI: Innovative concepts and technologies for ECOlogically sustainable NUTRIent management in agriculture aiming to prevent, mitigate and eliminate pollution in soils, water, and air" (Grant Agreement Number 101081858).

2. Understanding methane emissions from dairy farm manure management

Jiafa Luo[1], Emma Joyce[2], Lily Ouyang[1], Bob Longhurst[1], Talia Grala[2], Qiuliang Lei[1], Amanda Judge[1], Mike Rollo[1], Cecile de Klein[1]

[1] Bioeconomy Science Institute, AgResearch Group, New Zealand ; [2] Farm Source, Fonterra, New Zealand

AgResearch and Fonterra collaborated to investigate how manure and effluent management at dairy farms influence methane (CH_4) emissions in New Zealand's greenhouse gas (GHG) inventory. The study analysed data from 8,454 Fonterra farms in 2022–2023, covering 3.77 million cows and various off-paddock facilities, including feed pads, stand-off loafing pads, and livestock housing.

About 34% of Fonterra farms use off-paddock facilities, with feed pads being the most common. The use of these facilities varies across regions and seasons. In some areas, like Southland and Otago, livestock housing is more common, while fewer farms in Canterbury and the Central Plateau use off-paddock facilities. In winter, cows spend the more time in these facilities, while usage is lowest in summer.

The study found that dairy manure is managed in different ways depending on the type of facility. Effluent from dairy sheds is mostly liquid and stored in ponds, where some of it turns into slurry. Manure from stand-off pads is mostly solid, while feed pads and livestock housing produce a mix of solid and liquid/slurry manure. Storage times for effluent are longest in winter and shortest in summer.

A revised manure management framework was developed to improve methane emission calculations. It shows that 6.55% of dairy manure is stored in effluent ponds, lower than the 7.1% currently assumed in the national GHG inventory. Solid manure storage is now included, which may reduce methane emissions because aerated conditions slow methane production. Using this new approach, methane emissions from dairy manure management could be reduced by 6.6%.

Further research is needed to confirm effluent storage times and refine methane emission factors for different manure storage systems. This will help improve the accuracy of methane emissions estimates from New Zealand dairy farms.

3. Greenhouse gas and ammonia emissions from two floor types of naturally ventilated dairy barns in Denmark

Bühler, M.[a*], Kai, P.[a] & Adamsen, A.P.S.[a]

Aarhus University, Department of Biological and Chemical Engineering, Gustav Wieds Vej 10D, 8000 Aarhus C, Denmark [a]; [*]Corresponding author, email: mb@bce.au.dk

Introduction

Greenhouse gas (GHG) emissions from agriculture, particularly from livestock production, contribute significantly to global climate change. Dairy farming is a major source of methane (CH_4) and nitrous oxide (N_2O) emissions. In livestock systems, naturally ventilated dairy barns present unique measurement complexities due to spatial gas distribution and the inability to directly measure the ventilation rate, leading to higher uncertainty compared to mechanically ventilated barns. Accurate quantification of emissions from these systems is critical for establishing accurate emission values as well as developing mitigation strategies aligned with climate targets. This study focuses on GHG and ammonia (NH_3) emissions from naturally ventilated Danish dairy cubicle barns with either slatted floors above continuous slurry channel systems, where slurry is frequently circulated by pumping (frequently stirred slurry channels) or drained solid floors with frequent scraping of the floors and limited slurry stored inside the barn (drained solid floor). The barns were housing 200 – 300 dairy cattle. We will present preliminary results from an ongoing measurement campaign ending October 2025.

Methodology

Emissions are determined with the tracer gas ratio method using carbon dioxide (CO_2) produced by animals and manure as a natural tracer gas. CO_2, CH_4, N_2O, and NH_3 concentrations are measured with Cavity Ring-Down Spectroscopy (Picarro G2509). The air is sampled via a sampling line consisting of a partly heated and insulated FEP or PTFE tube with multiple sampling points. The sampling line is mounted in the middle of the barn along the length of the barn at circa 4 m above ground. Thus, a representative air sample with an average barn air concentration is taken. Measured are four barns with frequently stirred slurry channels and four barns with drained solid floor. The barns are measured six times over the course of a year for at least 72 hours. Additionally, the feed and the slurry are analysed for each measurement campaign.

Results and discussion

The results presented in this abstract are preliminary and incomplete. Barns equipped with frequently stirred slurry channels have on average, emission values of 0.38 kg CH_4 livestock unit^{-1} (LU, 500 kg live weight) d^{-1} and 35 g NH_3 LU^{-1} d^{-1}. Conversely, the barns with drained solid floor exhibited 0.30 kg CH_4 LU^{-1} d^{-1} and 30 g NH_3 LU^{-1} d^{-1}. This indicates that the CH_4 emissions are ca. 30% and NH_3 emissions are about 20% higher per LU for cattle housed in barns with frequently stirred slurry channels. This is attributable to the longer storage period of slurry and larger soiled surface in barns with frequently stirred slurry channels in comparison to that of a drained solid floor, where manure is removed on a daily basis to an outside storage. A positive correlation between the ambient temperature and the emission of CH_4 and NH_3 was observed. The preliminary findings align with current literature data: however, a significant portion of the measurements are still ongoing (23 out of 48 campaigns are completed). Further, the data have not yet been corrected for dry matter and nitrogen intake, slurry composition, and animal space. Additionally, some barns housed calves, heifers, dry cows, and lactating cows, whereas in other barns only cows were present. In barns with not only cows present, the ratio in LU of cows to calves and heifers was up to 1:0.44. This variation complicates the comparison of data, particularly in the absence of standardisation of dry matter and crude protein intake. While the trend in the emission data is anticipated to be consistent, the relative difference between the two systems may persist until the project's conclusion in October 2025, as the absolute emission values are subject to change.

Conclusion

As this is an ongoing study with a scheduled conclusion in October 2025, the final results are not yet available but will be presented at the conference. Consequently, it is premature to draw any conclusions at this juncture.

Acknowledgements

The project is funded by the Danish Agricultural Agency, 33010-NIFA-21-766. The help of the technical staff at Campus Aarhus University Viborg is greatly acknowledged.

4. Effect of pH and crust formation on N_2O and NO emission from liquid cow manure (slurry) during storage.

Maasdam, E., van den Brink, P. F. H., van Eekert, M. H. A., Groenestein, C.M., Rijnaarts, H.H.M.

Email: rik.maasdam@wur.nl

Introduction

Storage of slurry (liquid manure) can contribute significantly to the emissions of N_2O (nitrous oxide) and NO (nitric oxide) in the agricultural sector. These emissions are most likely linked to the microbial conversions of ammonia through nitrification, denitrification and nitrifier denitrification. During denitrification both NO and N_2O are formed as intermediary products, leading to the assumption that emission of NO and N_2O will be in the same order of magnitude. While emission rates of N_2O from stored slurry have been studied on lab scale, pilot scale as well as in practice, linking these emission rates to the NO emission has not been done before. Moreover, correlations between storage conditions and N2O emission have been observed, but it is unclear if these parameters also influence NO emissions since these correlations could not be linked to one specific microbial conversion. Parameters known to influence N_2O emission are the presence of a natural crust layer on top of the stored slurry and the pH of the slurry during storage. The presence of natural crust increases oxygen availability in the top layer of the manure, and this likely facilitates a higher rate of nitrification and subsequent follow up processes, thus increasing N_2O emission (Hansen et al., 2009; Petersen et al., 2013). The optimum pH of the slurry for N_2O emissions seems to be in the range of 6.5 – 8.5 (Wang et al., 2023). This study aims to quantify the effect of the presence of natural crust and pH of the slurry on the emission pattern (emission rate over time) and total emission of both NO and N_2O in slurry during storage, to determine if NO emission is indeed linked to N_2O emission.

Methodology

Lab scale experiments were performed with dairy slurry and artificial slurry. Artificial slurry was created by combining urea solution with dairy feces in a 60/40 volume ratio, resulting in a N concentration similar to natural dairy slurry. The slurries were stored (incubated) over 45 days in 6 L reactors and continuously stirred to prevent crust formation. The pH was measured at a depth of 10 centimetre in the slurry. The gas phase in the headspace of the reactors was continuously refreshed with air and the outgoing airflow was analysed using gas chromatography and the GSD 350 O1C, OmniStar Gas analysis system to determine the concentrations of NO, N_2O, CH_4 and CO_2.

Results and discussion

Preliminary results for N2O emission from dairy slurry showed that no significant N_2O emission took place within the first 30 days of incubation. A peak emission of 2.0 mg N_2O-N/m^2/h was measured on day 47 after the start of the experiment. In contrast, on day 26 the artificial slurry had a peak emission of 5.5 mg N_2O-N/m^2/h. The emission decreased over time to 1.9 mg N_2O-N/m^2/h on day 47, comparable to the emission rate of the dairy slurry on day 47. The average pH over the duration of the experiment was 7.5 in the dairy slurry, but slightly higher (8.0) in the artificial slurry mix of feces and urea. Additional preliminary experiments indicated much higher emission rates during incubation of slurry when natural crust formation did occur. Currently, experiments are performed to determine how much pH and crust formation influence the NO and N_2O peak emission rates and pattern. Final results will include the emission ratio between N_2O and NO over the duration of the experiments.

5. Modelling Greenhouse Gas and Ammonia Emissions at building and manure storage level in three housing systems for laying hens

Carranza-Díaz, A.K.[a*], Godbout, S.[b], Fournel, S.[a]

Université Laval, Canada[a]; Institut de recherche et de développement en agroenvironnement (IRDA), Canada[b]; *Corresponding author, email: akcad@ulaval.ca

Introduction Reducing greenhouse gas (GHG) and ammonia (NH_3) emissions in agriculture is crucial for addressing climate change and air quality challenges. Accurate quantification models are essential to support effective environmental management (Zhao et al., 2014). However, research on emissions from commercial egg production remains limited. While some studies have focused on specific housing systems, such as cages or aviaries, comparative analyses across multiple systems are not standard. This study aims to develop a model for estimating GHG and NH_3 emissions from manure management at both the housing and storage site levels, using exclusively experimental production and environmental data collected at the laboratory level and validated at the commercial level.

Methodology This study is based on three projects conducted at the *Laboratoire sur le bilan agroenvironnemental des bâtiments d'élevage* (BABE, Québec, Canada) to model GHG and NH_3 emissions in three laying hen housing systems (conventional cages, enriched cages, and aviaries). Data preprocessing included dendrogram-based correlation to identify variable relationships, Pareto scaling to reduce bias from different measurement scales, and Principal Component Analysis (PCA) to select key variables explaining most variance. Emission modelling was performed in two stages: for building emissions, mixed linear regression and system-specific machine learning models were trained (80%) and validated (20%) using daily averages to minimize diurnal variations, while storage emissions were estimated using literature-based coefficients (Shepherd et al., 2015). The model was validated using data from 30 commercial farms in Québec (6 CC, 14 CE, 10 V), and its predictive performance was assessed using RMSE and R^2.

Results and discussion The PCA results identified the variables pH, indoor temperature, air exchange rate, hen body mass, egg production, and relative humidity as the most relevant for modelling emissions due to their significant loadings on the principal components. The mixed regression analysis performed on all systems showed a low explanatory capacity ($R^2 < 0.1$), suggesting system-specific effects and justifying individual system analysis to understand better the factors influencing emissions. The regression models applied to daily emissions showed variable performances across gases and systems. For CO_2 and CH_4, the best performances were observed in the CE system (R^2 of 0.68 and 0.63, respectively), while N_2O showed weak results, justifying a constant emission factor. Models for NH_3 showed better predictive capacity, with an R^2 of 0.87 in the V system. However, the validation of the models with data from commercial farms revealed poor predictive performance, likely due to the high variability in management practices, production scales, and environmental conditions.

Conclusion This study underscores the necessity of system-specific modelling for accurately estimating GHG and NH_3 emissions in laying hen housing and manure storage. The PCA facilitated the selection of key explanatory variables, optimising model performance. While system-specific regression models demonstrated moderate to high predictive capacity, particularly for NH_3 emissions, their generalizability to commercial farms was limited due to the high variability in real-world conditions. These results highlight the need for further model refinement, incorporating broader commercial-scale datasets and additional environmental and management parameters to enhance predictive reliability and support evidence-based mitigation strategies.

References

Shepherd, T. A., Zhao, Y., Li, H., Stinn, J. P., Hayes, M. D., & Xin, H. (2015). Environmental assessment of three egg production systems — Part II. Ammonia, greenhouse gas, and particulate matter emissions. Poultry Science, 94(3), 534–543. https://doi.org/10.3382/ps/peu075

Zhao, Y., Shepherd, T. A., Xin, H., & Li, H. (2014). Concentrations of ammonia, greenhouse gases and particulate matters in conventional cage, aviary, and enriched colony laying-hen houses. *2014 ASABE Annual International Meeting*, 1–14. https://doi.org/10.13031/aim.20141904027

6. Biochar for carbon dioxide removal: how biochar properties modulate soil C persistence and potential synergies with N_2O emissions reduction

Cayuela, M.L.[a*], Bruun, S.[b], Chiaramonti, D.[c], Contreras, F.[a], Mašek, O.[d], Mondini, C.[e], Petersen, H.I.[f], Sánchez-García, M.[a], Sánchez-Monedero, M.A.[a], Taghizadeh Toosi, A.[g]

[a]Department of Soil and Water Conservation and Waste Management, CEBAS-CSIC, Spain; [b]Department of Plant and Environmental Sciences. University of Copenhagen, Denmark; [c]Politecnico di Torino, Italy; [d]UK Biochar Research Centre (UKBRC), School of Geosciences, University of Edinburgh, UK; [e]CREA Research Centre for Viticulture and Enology, Italy; [f]Department of GeoEnergy and Storage, Geological Survey of Denmark and Greenland, Denmark; [g]Danish Technological Institute, Aarhus N, Denmark

[*]Maria Luz Cayuela, email: mlcayuela@cebas.csic.es

Introduction

Carbon persistence in soil is essential for the success of biochar as a Carbon Dioxide Removal (CDR) strategy, shaping policies aimed at climate change mitigation. Biochar, with its stable and long-lasting carbon fraction, stands out as a promising solution, meeting the stringent criteria of the most ambitious CDR frameworks. Its ability to sequester carbon in soils for centuries and millennia makes it a reliable tool for long-term climate change mitigation. Beyond its carbon sequestration potential, recent research and meta-analyses show overall reduction in soil nitrous oxide (N_2O) emissions in biochar amended soils.

Methodology

This overview synthesizes current research lines from the co-authors' own work and recently published literature, focusing on two key areas: (1) challenges for the accurate assessment of biochar stability in soil and (2) latest advances on the understanding of N_2O emissions reduction after biochar application in soil. A comprehensive assessment of methodologies used to evaluate biochar stability in soil has been conducted, highlighting current limitations and emerging approaches in the field. Synergies and trade-offs with N_2O emissions depending on biochar properties and environmental conditions will be summarized.

Results and discussion

Biochar possesses fundamentally different properties compared to other common soil amendments used in agriculture, often resembling geological organic carbon more than recently fixed carbon in biomass. This unique nature makes it an ideal candidate for long-term carbon sequestration, but it also presents significant challenges for accurately determining its long-term permanence in soil. For instance, field studies face difficulties in quantifying soil organic carbon in biochar-amended soils (Chiaramonti et al., 2024) and existing models struggle to reliably predict biochar persistence (Azzi et al., 2024). These challenges have spurred the development of new methodologies to better assess biochar stability and predict its permanence in soil (Ringsby and Maher, 2025; Rodrigues et al., 2023; Sanei et al., 2024). Simultaneously, biochar offers a distinct advantage over other carbon amendments: it exhibits a lower trade-off with soil N_2O emissions, at least in the short term. All meta-analyses conducted to date show an average decrease in N_2O emissions in biochar-amended soils (Kaur et al., 2023), though its effectiveness depends on both, biochar properties and the predominant N_2O formation pathway. Identifying scenarios where this dual benefit—enhancing soil carbon sequestration while minimizing N_2O emissions—is maximized would further reinforce biochar's role as a key player in climate-smart agriculture and global mitigation efforts.

Acknowledgements

This work was supported by the Project PID2021-128896OB-I00 funded by MCIN/AEI/ https://doi.org/10.13039/501100011033/ and ERDF A way of making Europe.

References

Azzi, E.S. et al. 2024. Modelling biochar long-term carbon storage in soil with harmonized analysis of decomposition data. Geoderma, 116761

Chiaramonti, D., et al. 2024. Assessment of long-lived Carbon permanence in agricultural soil: Unearthing 15 years-old biochar from long-term field experiment in vineyard. Biomass Bioenergy, 191, 107484.

Kaur, N., et al. 2023. How much is soil nitrous oxide emission reduced with biochar application? An evaluation of meta-analyses. GCB Bioenergy, 15, 24–37.

Rodrigues, L., et al., 2023. The importance of biochar quality and pyrolysis yield for soil carbon sequestration in practice. Eur. J. Soil Sci., 74:e13396.

Ringsby, J. and Maher, K. 2025. Do oversimplified durability metrics undervalue biochar carbon dioxide removal? Environ. Res. Lett. 20 034001.

Sanei, H. et al., 2024. Assessing biochar's permanence

7. Reducing nitrogen losses in broccoli cultivation through valorization of crop by-products

Ovelhey, H. L.[a*], Vorsatz, C.[b] & Daum, D.[a]

Osnabrück University of Applied Sciences, Germany [a]; Mählmann Gemüsebau GmbH & Co. KG, Germany [b]; [*]Corresponding author, email: h.ovelhey@hs-osnabrueck.de

Introduction

Broccoli is a high fertilizer-demanding vegetable crop requiring 300–360 kg nitrogen (N) ha^{-1} to achieve optimum yields. At harvest, nearly two-thirds of the total biomass remains on the field, containing up to 210 kg N ha^{-1}. The low carbon (C)/N ratio and high water content of the crop residues favor rapid N mineralization. However, 20–60% of the released N can be lost through nitrate (NO_3^-) leaching and gaseous N emissions. Denitrification of the released N, which is also promoted by easily decomposable organic material, predominantly leads to the formation of nitrous oxide (N_2O) and molecular nitrogen (N_2). Additionally, at high pH levels, ammonia (NH_3) volatilization may occur [1,2]. The removal of the total aboveground biomass could help mitigate these N losses and their adverse environmental impacts. Broccoli by-products, including leaves and stems, are edible and contain valuable nutrients such as glucosinolates, vitamin E, vitamin C, and β-carotene [3]. This study aims to evaluate a novel approach for reducing N losses and enhancing the agronomic value of broccoli cultivation by valorizing its by-products for industrial food processing.

Methodology

A field trial was conducted on a sandy soil at a conventional vegetable farm in northern Germany from November 2024 to February 2025. Different amounts of broccoli residues were added to the soil (no residues, lower stems, lower stems + leaves) in combination with two different N fertilizer levels (200 kg ha^{-1}, 300 kg ha^{-1}). The residues were harvested manually, mulched, and mechanically incorporated into the upper 15 cm of the soil. No subsequent crop was sown during the winter season. The study focuses on N_2O emission, a potent greenhouse gas, that also contributes to ozone depletion in the stratosphere. N_2O fluxes were monitored using a closed chamber system, with weekly gas measurements taken throughout the investigation period using a portable infrared laser-based gas analyzer. In addition, soil samples were collected in monthly intervals at depths of 30, 60, and 90 cm to assess the risk of NO_3^- leaching. Potential overall N losses will be estimated using a balance sheet approach.

Results and discussion

Preliminary results show that N_2O emission was highest under common vegetable cultivation practices that combined high N fertilization with the incorporation of crop residues. Removing leaves – and even more so, removing all aboveground biomass – considerably reduced N_2O emission. At lower N supply levels, N_2O emission remained relatively low, regardless of crop residue incorporation. This may be attributed to a significantly higher C/N ratio in leaves and stems under reduced N fertilization, likely limiting mineralization and, consequently, denitrification. However, reduced N application also resulted in a significant decline in inflorescence yield, making it less agronomically viable. The effects of different residue management strategies and fertilization levels on mineral N content in the soil and thus NO_3^- leaching risk are subject of ongoing analyses.

Conclusion

The findings of this study suggest that utilizing broccoli by-products for industrial food processing is a promising strategy to reduce N emissions in the post-harvest period. In contrast, lowering N fertilization during cultivation does not appear to be a viable option, as it decreases overall crop yield. Further research is needed to optimize N input levels in broccoli cultivation, ensuring that all plant components can be utilized as food while simultaneously minimizing N_2O emission and NO_3^- leaching.

Acknowledgements

The research project is funded by the German Federal Ministry of Food and Agriculture (Grant No. 2823KTF002).

References

1. Congreves, K., & Van Eerd, L. (2015). Nitrogen cycling and management in intensive horticultural systems. Nutr. Cycling Agroecosyst. 102, 299–318.
2. De Ruijter, F., et al. (2008). The fate of nitrogen from crop residues of broccoli, leek and sugar beet. Acta Hort. 852, 157–162.
3. Liu, M., et al. (2018). Comparative phytonutrient analysis of broccoli by-products: the potentials for broccoli by-product utilization. Molecules 23, 900.

8. A greenhouse gas balance under a forage cropping system in southwestern Japan

Koga N.[a*] & Goto S.[a]

[a]; Kyushu Okinawa Agricultural Research Center, NARO Japan; [*]Corresponding author, nkoga@affrc.go.jp

Introduction

In the context of global climate change, greenhouse gas emissions (CO_2, N_2O and CH_4) from agricultural soils should be reduced or captured in the soil. In southwestern regions of Japan, livestock farming including dairy farming is at its most active, and thus forage crops are produced. The typical forage cropping system in southwestern Japan is an Italian ryegrass (winter crop)-forage corn (summer crop) double-cropping system. In order to reduce greenhouse gas emissions from an entire livestock farming sector in Japan, we assessed greenhouse gas balances in a forage field where composted cattle manure and wood biochar were applied.

Methodology

A field experiment was conducted in Kumamoto, southwestern Japan from October 2022 to September 2025 (3 years of measurement period). The soil was an Andosol, which is derived from volcanic ash. The forage cropping system studied was an Italian ryegrass (winter crop)-forage corn (summer crop) double-cropping system. We used a randomized block design with four treatments (each was triplicated): no nitrogen application (NN), chemical fertilizer only (CF), CF + composted dairy cattle manure (CM) and CM + biochar (CM+BC). In each cropping, composted dairy cattle manure was applied at a rate of 20 Mg ha^{-1} on a fresh weight basis and biochar was applied at a rate of 2 Mg ha^{-1} on a dry weight basis. The biochar used was wood biochar pyrolyzed at 350 ^oC and its dry-weight basis carbon content was approximately 72%. For chemical fertilizer, N, P_2O_5 and K_2O were applied at rates of 200, 200 and 200 kg ha^{-1}, respectively. Greenhouse gas (CO_2, N_2O and CH_4) emissions from soil were measured by a closed chamber technique (Koga et al., 2022). Within each experimental plot, two different collars for rectangular gas exchange chambers, made of acrylic resin and shaded by silver adhesive tape, were installed in the ground. The first collar was installed in each planted plot to measure N_2O and CH_4 fluxes. The second collar was installed in each planted plot to measure soil CO_2 emissions (i.e., heterotrophic soil respiration) by the root exclusion method. The measurement of gas fluxes continued for 3 years. Metal plates were installed vertically in the soil to a depth of 30 cm around the collar so that plant roots could not enter the soil directly below the area covered by the chamber. Every cropping, dry matter production and dry weight-basis carbon content of cattle manure, biochar, above-ground residue biomass (i.e. stubble) and below-ground residue biomass (i.e. roots and part of stubble). The greenhouse gas balance was calculated based on the equation below. To calculate the CO_2-equivalent greenhouse gas balance, we used global warming potential over a 100-year time horizon of 1, 265 and 28 for CO_2, N_2O and CH_4, respectively.

Greenhouse gas balance (Mg CO_2-eq. ha^{-1} yr^{-1}) = C input from cattle manure, biochar, above and below-ground residue biomass – cumulative CO_2, N_2O and CH_4 emissions from soil

Results and discussion

In our experimental field on Andosol, N_2O and CH_4 emissions from soil were negligible on a CO_2-equvalent basis. Thus, the greenhouse gas balance was mostly explained by the carbon balance. The NN and CF plots were a slight carbon source to the atmosphere. On the other hand, the CM plot was a large carbon sink (47.3 Mg ha^{-1} for 2 years from October 2022 to September 2024). Furthermore, the co-application of cattle manure and biochar strengthened the carbon sink in soil (66.0 Mg ha^{-1} for 2 years). The cattle manure was maturely composted. This indicates that the organic carbon component in composted cattle manure was recalcitrant. Biochar addition did not increase CO_2 emissions; therefore, the carbon component was highly stable in soil. Our research project aims to reduce greenhouse gas emissions from an entire dairy farming system (CH_4 emissions from enteric fermentation of dairy cattle, N_2O and CH_4 emissions from management of animal wastes and greenhouse gas emissions from soil). Of these emission sources, only soils can be a carbon sink. It is expected that soils for forage crops can contribute to greenhouse gas emissions from livestock farming systems in Japan.

Acknowledgements

This work was supported by the MAFF commissioned project study on “Development of Technologies to Reduce Greenhouse Gas Emissions in the Livestock Sector” (Grant Number JPJ011299).

References

Koga, N., et al. 2022. Soil greenhouse gas emissions from an animal excrement-based forage cropping system. Nutr. Cycl. Agroecosyst. 123, 153-157.

9. The influence of long-term compost application on soil nitrous oxide emissions: A one-year budget

Baert, L. [a*], Sleutel, S. [b], Cornelis, W. [a], Maenhout, P. [c]

SENSE, department of Environment, faculty of Bioscience Engineering, Ghent University, Belgium [a];

SOFER, department of Environment, faculty of Bioscience Engineering, Ghent University, Belgium [b];

Plant Sciences Unit, Flanders Research Institute for Agriculture, Fisheries and Food (ILVO), Merelbeke, Belgium [c]

*Corresponding author: Lotte Baert, email: lotte.baert@ugent.be

Introduction

Regular compost application is a well-established practice to simultaneously improve multiple soil properties including soil carbon storage, soil chemical fertility and soil biological parameters. However, as source of C and N it may also stimulate soil nitrous oxide (N_2O) emissions, a potent greenhouse gas. The alongside beneficial effect on soil structure may on the other hand improve soil aeration, which should lower the risk for N_2O emission. This study investigates the impact of long-term application of compost on soil nitrous oxide emissions.

Methodology

In the BOPACT field trial, a long-term experiment run since 2010 by the Flanders research institute for Agriculture, Fisheries and Food (ILVO), compost has been regularly applied to an arable crop rotation. Soil borne N_2O emissions were monitored on a weekly basis between May 2023 and May 2024 on compost amended and unamended replicate plots. Potato was grown as main crop in 2023. Since this crop is cultivated on ridges, separate measurements were carried out on ridges and furrows. Afterwards, white mustard was sown as a cover crop. The soil moisture content was monitored continuously using soil moisture sensors installed at multiple depths.

Results and discussion

After potato planting, there was a significantly higher emission from the furrow parts of the field, but this effect declined rapidly and by the end of the growing season a larger emission was measured from the ridges. A significant share of the annual N_2O emission took place in autumn during the cover crop phase. This stresses the importance of continued measurement of greenhouse gas balances outside the growing period of the main crop. In general, large peaks in N_2O emissions corresponded to field management practices including ploughing and application of compost, mineral fertilizer and cattle slurry. Given the extensive dataset, a variety of field conditions were met during the observation period. Soil moisture- and temperature data allowed to interpret N_2O emission patterns during the monitoring campaign.

The cumulative N_2O emissions over one year were similar for treatments with and without compost. This encouraging result further supports the potential of compost as soil amendment, with no adverse trade-off effect on soil N_2O emission.

Conclusion

This intensively monitored field study suggest no significant difference in yearly cumulative nitrous oxide emissions after long-term compost application. Within-year variations in emissions were attributed to field operations and environmental conditions.

10. A coupled system that combines a cropping system model and a software tool to optimise manure redistribution at local and regional level

Gabbrielli, M. [a*], Allegrezza, M. [a], Botta, M. [a], Acutis, M. [a], Ragaglini, G. [a] & Perego, A. [a]

Department of Agricultural and Environmental Sciences Università degli Studi di Milano, Milano, Italy [a]; *Corresponding author, email: mara.gabbrielli@unimi.it

Introduction

The increasing intensification of crop and livestock production, along with the resulting farming specialization and high livestock density, presents growing challenges in achieving an optimal balance between economic profitability and environmental sustainability. In this context, an integrated system has been developed, combining a software tool (ReturN) for optimising manure redistribution between farms with a cropping system model (ARMOSA). This system supports stakeholders in identifying feasible solutions to maintain crop productivity while reducing environmental impact on a local or regional scale.

Methodology

ReturN was developed to evaluate the feasibility of redistributing manure from farms with a manure surplus (N surplus-farms) to farms with a manure deficit (N deficit-farms), where crop N requirements are primarily met with mineral fertilizers. The oppurtunity of manure redistribution was estimated using optimisation algorithms that consider the distance between surplus and deficit farms, as well as the costs and CO_2 emissions associated with manure transport and mineral fertilizer purchases in deficit farms. To determine the distance trade-off threshold for the feasibility of manure transport to N-deficit farms, the relative weighting of costs and emissions can be adjusted by the user. The tool generates a list of deficit farms that would benefit from receiving manure in terms of cost savings and CO_2 emissions reduction, as well as a decrease in mineral fertiliser use. For each deficit farm, the tool provides the imported N amount, associated costs, and emissions related to N importation. The tool was applied in three case studies at different scales: a regional case in Lombardy (Northern Italy) and local cases in Girona (Spain) and Mors (Denmark). ARMOSA, a process-based dynamic model (Perego et al., 2013), was used to assess crop productivity, soil organic carbon stock, crop N recovery, and N losses (NO_3 leaching, N_2O, and NH_4 emissions) in N deficit-farms before and after manure application. Additional assessments were conducted in deficit farms following manure redistribution optimization to evaluate the environmental benefits of alternative management practices aimed at reducing N losses. For each deficit farm, three different scenarios were simulated: (i) a baseline scenario with mineral fertilizer application only, (ii) an alternative scenario with manure application based on ReturN's optimisation and the EU Nitrate Directive, and (iii) a second alternative scenario with optimised management practices, including reduced fallow periods, residue incorporation, and cover cropping.

Results and discussion

The replacement of mineral fertilizers with manure led to variable effects on long-term average nitrate leaching in the simulated areas. Compared to the current scenario, the manure application scenario resulted in both increased and decreased leaching rates, depending on manure type, soil texture, and crop rotation. The optimised management scenario significantly reduced leaching due to increased soil cover. Additionally, a positive effect on soil organic carbon (SOC) stock was observed.

Conclusion

This integrated system can be applied to data available Europe-wide thus allowing the a priori evaluation, at different scales (local, regional, territorial), of the impact of moving manure on N use efficiency and soil carbon stock evolution, in a wide range of pedoclimatic conditions and cropping systems, in the framework of collaborative agreements for manure management.

Acknowledgements

The authors acknowledge the financial support for the PROENV project through the partners of the Joint Call of the Cofund ERA-Nets SusCrop (Grant N° 771134), FACCE ERA-GAS (Grant N° 696356), ICT-AGRI-FOOD (Grant N° 862665) and SusAn (Grant N° 696231).

References

Perego, A. et al., 2013. The ARMOSA simulation crop model: overall features, calibration and validation results. Ital. J. Agrometeorol. 3, 23–38.

11. Local urban biowaste recycling as fertilisers: a safe-by-design approach

Bisschops I.[a*], Arrizabalaga-Larrañaga A.[b], van Asselt E.D.[b], Bos M.G.E.[a], Hoffmans Y.[b], de Lange E.[b], Melchers T.C.[b], Safitri R.A.[b], Tao W.[b] & Schellens K.E.[b]

LeAF bv, the Netherlands [a]; Wageningen Food Safety Research, the Netherlands [b];

[*]Corresponding author, email: iemke.bisschops@wur.nl

Introduction The EU Green Deal strives for a 50% reduction of agrifood system nutrient losses by 2030, combined with a 20% reduced fertiliser use. Furthermore, the EU Waste Framework Directive specifies targets for waste recycling, with Member States having the binding obligation to recycle or prepare at least 60% of their municipal waste for reuse by 2030. The use of domestic and commercial biowaste (food waste) as fertilisers is a logical step combining both ambitions. However, closing this loop for nutrients will also introduce other biowaste components in the agrifood system. Useful ones such as organic matter, but also possible contaminants like pathogens, heavy metals and pesticides. The currently ongoing PPP project 'Circular Urban Food Production, safe by design' (see project website) is developing a safe-by-design approach to ensure food safety and regulatory compliance when reusing municipal (bio)waste as compost or other fertilisers.

Methodology The project is looking in detail at urban biowaste composition (focusing on food waste), different processes for fertiliser production and legal aspects. Samples of different biowaste inputs and process outputs are analysed, and the results will be integrated in a HACCP-like approach for evaluating the effects of using the outputs in the agrifood system on human health. In parallel the compliance of processes and products with the regulatory framework is evaluated, e.g. the fertiliser quality and application rules that are in place to protect environmental health. Biowaste conversion processes included in the project are worm hotels, commercial scale vermicomposting and anaerobic digestion to produce a nutrient solution for vertical farming. Kitchen waste grinders are evaluated as a novel collection system for the Netherlands. Centralised composting (sometimes preceded by anaerobic digestion) as currently performed in the Netherlands is used as the reference process. Samples are taken in different seasons and will be analysed for agronomic value, visual contamination (e.g. plastics, glass), heavy metals, pathogens, and organic pollutants (a.o. pesticides and PAHs). Critical control points will be identified for the different processing options. Analytical results will be complemented with available literature data if necessary.

Results and discussion At the current stage of the project, the regulatory framework has been mapped and legal limits for contaminant concentrations and nutrient content have been identified. A complex interaction of rules and regulations needs to be taken into account as different directives and regulations apply. The status of food waste as category 3 animal by-product (Regulation (EC) No 1069/2009) is important, requiring hygienisation. In addition, Dutch and EU fertiliser regulations have different characteristics. For example, digestate from biowaste can be used as input for CE certified fertilisers, whereas within Dutch law composting is the only viable option.

Processes have been mapped and prepared for identifying the critical control points. Literature data on constituents has been gathered and as soon as biowaste and product samples have been analysed, a thorough comparison and interpretation will take place. At the moment of writing this abstract, no publicly available data can be reported yet, but it is expected that most of the sampling results will be available at the time of the conference. Some contaminants are inevitably present in food waste (e.g. zinc and copper, as these are also micronutrients), whereas others are a direct result of human behaviour. The levels of contaminants in the biowaste are ultimately decisive in determining the fertiliser quality and related acceptable or unacceptable risks when using them in the agrifood chain.

Conclusion Various food safety hazards have been identified that potentially could be present in the incoming and outgoing biowaste materials. Based on the safe-by-design approach, conclusions are drawn on the impact of using fertilisers made from biowaste processing on food safety, which will be presented at the conference.

Acknowledgements

Project co-financed by Topsector Agri & Food. Partners: Wageningen Food Safety Research, LeAF bv, Amsterdam Institute for Advanced Metropolitan Solutions, Growy, Chef's Farm, Gemeente Amsterdam, StadsWormerij Amersfoort, Branche Vereniging Organische Reststoffen, Vereniging Afvalbedrijven, Normec Groen Agro Control, Rijkswaterstaat Afval Circulair, New Focus, Bureau van Leent.

12. Recirculating nutrients through black soldier fly larvae bioconversion of organic waste streams for improved plant performance

Lopes IG.[a*], Sani, MNH.[a], Lalander, C.[b], Yong JWH.[a]

Department of Biosystems and Technology, Swedish University of Agricultural Sciences, Sweden [a]; Department of Energy and Technology, Swedish University of Agricultural Sciences, Sweden [b]; *Corresponding author, email: iva.guidini.lopes@slu.se

Introduction

The bioconversion of waste streams using black soldier fly larvae (*Hermetia illucens*, BSFL) is a prominent technology that has been gaining momentum worldwide over the last couple of decades. It generates a larval biomass and an organic fertilizer (frass) that enables the recycling of nutrients back into the food production chain (Singh et al., 2019). Recently, we proposed a novel methodology called frass recirculation (Lopes et al., 2024) as a way of improving waste bioconversion efficiency and the quality of the resulting frass. The aim of this study was to evaluate this new technology from both a process efficiency and agronomic perspectives.

Methodology

A model feed substrate (chicken feed) was used to grow BSFL, and the resulting frass was recirculated back into the process through five subsequent rounds of bioconversion. After the first round, frass was collected and used as part of the feed substrate in the second round, generating a frass that was then used in the third round and so on. This process resulted in five frass fertilizers with increasing number of recirculations (which can be translated as longer retention times". These were evaluated for the presence of plants nutrients (N, P, K and others) and for their maturation and stability degree and used as a single nutrient source for the cultivation of pak choi (*Brassica rapa* subsp. chinensis) in comparison to a positive control with a commercial NPK fertilizer and a negative control. The experiment was conducted in a greenhouse in which temperature and humidity were set at 25 °C and 60% RH. Plants were evaluated for biomass accumulation (shoots), nutrient concentration and photosynthetic performance (Radzikowska-Kujawska et al., 2023).

Results and discussion

Frass recirculation did not impact the waste bioconversion efficiency (> 20%$_{DM}$ in all rounds of bioconversion) and the material reduction (> 50%$_{DM}$), and the five frass types obtained in the distinct rounds of bioconversion did not differ significantly in relation to their macronutrients concentration. In contrast, frass with a higher number of recirculation displayed a higher proportion of inorganic forms of N, especially NH_4^+, along with greater maturity and stability, as indicated by lower self-heating capacity reduced respiration and decreased phytotoxicity. The plants cultivated with non-recirculated frass (from the first round of waste bioconversion) displayed the lowest growth (54 ± 25 g/plant) and photosynthetic performance (CO_2 assimilation rate of 15 ± 8 µmol m^{-2} s^{-1}), while the growth of plants cultivated with frass recirculated four times (*i.e.* frass from the fifth round of bioconversion) was not significantly different from that of the positive control (261 ± 48 g/plant and 26 ± 2 µmol CO_2 m^{-2} s^{-1}). Interestingly, the concentration of N and K in the plants' shoots was higher in the plants cultivated with non-recirculated frass in comparison to the highly recirculated frass and the positive control, while P concentration remained unchanged amongst the treatments.

Conclusion

Frass recirculation significantly improved the quality of frass fertilizers in terms of nutrient concentration and maturity. Plants cultivated in recirculated frass generated higher productivity and metabolic performance in relation to non-recirculated frass.

Acknowledgements

The authors are thankful for the financial support provided by FORMAS (project number 2021-02001) and by the Carl Tryggers Foundation (project number CTS21:1483).

References

Singh, A., et al. 2019. An inclusive approach for organic waste treatment and valorisation using Black Soldier Fly larvae: A review. J. Environ. Manage. 251, 109569.

Lopes, I.G., et al. 2024. Recirculating frass from food waste bioconversion using black soldier fly larvae: Impacts on process efficiency and product quality. J. Environ. Manage. 366, 121869.

Radzikowska-Kujawska, D., et al. 2023. *Hermetia illucens* frass improves the physiological state of basil (*Ocimum basilicum* L.) and its nutritional value under drought. Plos One 18, e0280037.

13. Multicriteria assessment of organic waste application across diverse real-world cropping systems: a modelling study

Seheno Rinasoa [1*], Sabine Houot [1], Mariana Moreira [2], Anne Schaub [3], Hélène Lagrange [4], Bruno Huyghebaert [5], Florent Levasseur [1]

Université Paris-Saclay, INRAE, AgroParisTech, UMR EcoSys, 91120 Palaiseau, France [1] ; Chambre d'Agriculture Bretagne, 35042 Rennes, France [2] ; Chambre Régionale d'Agriculture Grand Est, 67300 Schiltigheim, France [3] ; ARVALIS, 31450 Baziège, France [4]; Walloon Agricultural Research Centre (CRA-W), 5030 Gembloux, Belgium [5] ; *Corresponding author: seheno.rinasoa@gmail.com

Introduction

Long term field experiments have shown that recycling organic waste (OW) in agriculture enhances soil fertility, reduces reliance on mineral fertilizers, and mitigates greenhouse gas (GHG) emissions. However, the long-term effects vary across soil types, climates, and cropping systems. Moreover, these effects might differ with real-world farmers' practices. In this context, this modelling study evaluates the agronomic and environmental impacts of OW application in France and Belgium, under different soil, climate and cropping systems, based on real-world farmers' practices.

Methodology

28 scenarios of OW use were defined in 10 case studies, based on local expert knowledge. The agronomic and environmental impacts were simulated with the PROLEG tool (Levavasseur and Houot, 2022), which integrates models for soil organic carbon (SOC) dynamics, nutrient fluxes, and GHG emissions. The impacts were simulated in both the short and long term (over 30 years).

Results and discussion

Results highlight that N supply increased immediately, mainly in scenarios with OW types rich in mineral-N, such as digestates and slurries, whereas a gradual increase was observed over 30 years in scenarios involving applications of manure or compost. The prolonged use of compost and manure progressively enhanced N availability, thereby intensifying both nitrate leaching and nitrous oxide emissions. OW applications also led to improved phosphorus (P) and potassium (K) balances, reducing mineral fertilizer dependence. However, complete fertilizer autonomy was never reached for N and rarely for P and K, even though some excess in P and K surpluses were observed (e.g., scenarios with slurry application). SOC sequestration peaked in the first years but declined over time, with the highest C inputs in scenarios with green waste compost and cattle manure. When emissions from OW storage and treatment were considered, long-term applications often resulted in net GHG increases.

Conclusion

Our results demonstrated the positive effects of OW application across various case studies based on real-world farming practices. They also highlighted the potential trade-offs such as increased N losses or GHG balance deterioration. These findings underscore the need for optimized OW management strategies that reconcile agronomic benefits with environmental risks, incorporating agroecological practices to ensure long-term sustainability.

Acknowledgements

This work was funded by the EJP Soil EOM4SOIL project.

References

Levavasseur, F., Houot, S., 2022. Predicting the short- and long-term effects of recycling organic wastes in cropping systems with the PROLEG tool. Soil Use Management 39, 535–556. https://doi.org/10.1111/sum.12856

14. From agro-food waste to exopolysaccharide-based biostimulants: a circular bioeconomy strategy to enhance soil health and plant resilience under saline stress

Garcia-Muchart, E.[a*], Mejias, L.[a] & Martínez-Avila, O.[a]

[a] BETA Technological Centre, University of Vic-UCC, Vic, 08500, Catalunya, Spain *Corresponding author, email: enric.garcia.muchart@uvic.cat

Introduction

The increasing challenges of soil degradation, climate change, and salinity stress threaten agricultural productivity and sustainability. To address these issues, biostimulants have emerged as promising alternatives to reduce conventional fertilizers, enhancing plant resilience and soil health while minimizing environmental impact (Chojnacka, 2015). Among them, bacterial exopolysaccharides (EPS) exhibit key properties such as water retention, soil aggregation, and stress mitigation (More et al., 2014). However, large-scale production remains costly due to the use of expensive substrates (Joulak et al., 2022). Solid-state fermentation (SSF) using agro-industrial by-products offers a sustainable and economically viable alternative, integrating EPS bioproduction into a circular bioeconomy framework. This study aims to evaluate the production, sustainability, and agronomic potential of an EPS-based biostimulant derived from SSF to improve plant tolerance under saline stress.

Methodology

EPS were produced through SSF in 6L packed-bed reactors connected to a mass flow controller under optimized conditions using *Burkholderia cepacia* as the bacterial strain and the solid agro-food by-product Ginger Juice as a substrate (Garcia-Muchart et al., 2024). Solid-liquid extraction was performed by agitating the fermented biomass in distilled water at 60°C. The sustainability assessment included energy, water, and chemical consumption analyses. Agronomic trials were conducted with plants subjected to varying levels of saline stress, comparing the EPS-based biostimulant to a commercial alternative applied both foliarly and to the soil. Additionally, stability experiments were performed under different storage conditions, and molecular characterization of EPS is being carried out through chemical and physical analyses.

Results and discussion

SSF process at bench scale maintained productivity levels similar to lab-scale studies, reaching up to 73 mg g^{-1} DM of EPS over five days. Sustainability analysis identified key process hotspots, such as energy use in inoculum preparation and aeration, which could be optimized through fed-batch operation to reduce environmental impact. Agronomic trials evaluated EPS effectiveness under saline stress based on plant growth and physiological responses. Preliminary evidence suggests that EPS-based biostimulants may enhance stress tolerance by improving soil structure and nutrient availability, something that corresponds with the molecular characterization of the obtained EPS and their functional properties.

Conclusion

This study integrates bioprocess optimization, sustainability assessment, and agronomic evaluation to explore the potential of EPS as an attractive biostimulant. Results demonstrate the feasibility of SSF for cost-effective EPS production with reduced environmental impact. The expected benefits of EPS in improving plant tolerance to saline stress reinforce its potential as a sustainable agricultural input.

Acknowledgements

This work was financed by AGRI-PROSUME project (PID2020-120568RB-I00/ AEI / 10.13039/501100011033) funded by the Ministerio de Ciencia e Innovación de España within the Proyectos de I+D+I 2020 call.

References

Chojnacka, K. 2015. Innovative bio-products for agriculture. Open Chem. 13(1), 932–937.

Garcia-Muchart, E., et al. 2024. Novel biostimulant bacterial exopolysaccharides production via solid-state fermentation as a valorisation strategy for agri-food waste. Environ. Sci. Pollut. Res.

Joulak, I., et al. 2022. Sustainable use of agro-industrial wastes as potential feedstocks for exopolysaccharide production by selected *Halomonas* strains. Environ. Sci. Pollut. Res. 29(15), 22043–22055.

More, T. T., et al. 2014. Extracellular polymeric substances of bacteria and their potential environmental applications. J. Environ. Manage. 144, 1–25.

15. New amendment: agro-environmental properties of hydrochar and post-treated hydrochar.

Bona, D.[a*], Bertoldi, D. [b], Zaccone, C.[c], Golinelli, A.[d], Mazzini, S. [e], Borgonovo, G.[e], Silvestri, S.[a], & Tambone, F.[d]

Research and Innovation Centre, Fondazione Edmund Mach, Italy [a]; Technology Transfer Centre, Fondazione Edmund Mach, Italy [b]; Department of Biotechnology, University of Verona, Italy [c]; Department of Agricultural and Environmental Sciences, University of Milano, Italy [d]; Department of Food, Environmental and Nutritional Sciences, University of Milano, Italy [e]
corresponding author: daniela.bona@fmach.it

Introduction

The hydrochar (HC) produced from the hydrothermal carbonisation at mild temperature (190-220°C) of several typologies of organic wet waste, among which agro-industrial waste, seems very promising as amendment/fertilizer. The aerobic post-treatment of HC improves its agronomic properties (Bona et al., 2022). The project "HYDRORG" founded by VRT (Fondazione Valorizzazione Ricerca Trentina) studied the agro-environmental properties and effect on soil of HC compared to compost (COM) and HC aerobically post treated (MIX) (Bona et al., 2023).

Methodology

The HC (190° C for 2 h) was produced at the HTC pilot plant using winery and dairy agro-industrial sludges. The HC properties have been compared to COM and MIX, obtained by mixing HC and COM in a ratio 1:1 (w/w), monitored in an aerated pile for 1 month, by measuring temperature, oxygen uptake (by dynamic respiration index), and water content. The Growth Index (GrI) has been assessed by testing the growth of *Lactuca sativa* L., at increasing doses. The three amendments were chemically characterised, studying the quality of carbon content by measuring dissolved organic carbon (DOC) by ^{1}HNMR liquid state, and the soil recalcitrant organic matter (ROC) fraction (alkaline extracted) by ^{13}C NMR liquid state. Finally, the short and long-term effects on soil have been considered. The HC, COM, and MIX were added to the soil and incubated at controlled conditions (25°C and 50% of WHC). The soils have been analysed considering the dynamic of nutrient (N,P,K, and Mg) and the evolution of organic carbon, by applying different analytical methods: thermal analysis of TOC400 and recalcitrant oxidable carbon (ROC) (UNI EN 17505:2024 method), soil respiration, DOC/ROC by ^{1}HNMR liquid state and ^{13}C NMR liquid state of soil alkaline extract, and POXC (permanganate oxidable carbon) (following the methods of Weil et al., 2003).

Results and discussion

The MIX aerated pile determines a faster decrease of oxygen uptake (from 1789 to 421 $mgO_2\,kg_{VS}^{-1}\,h^{-1}$). HC has a higher content of both TOC and TKN compared to other products (47 and 4.8 g kg^{-1}) HC has a higher content of P compared to COM (41 and 4.5 g kg^{-1} respectively) and the MIX has an intermediate value (12.9 g kg^{-1}). The K content was higher in the COM (14.2 g kg^{-1}). The HC induces toxicity on seed germination while COM does not show adverse effect (GrI always >1). And MIX30 was able to double the plant growth in comparison to COM (GrI always $\gg 1$). The analysis of DOC and ROC fractions showed the presence of aliphatic components, greater than aromatic ones in HC, with a higher proportion of less complex and thermally stable molecular compounds (Bona et al., 2023). COM, HC, and MIX were used for soil incubation at two agronomic doses (10 and 20 Mg/ha). After 1 month, the soil amended with HC differed from COM for P and N dynamics; MIX have an intermediate effect. The data suggest a role of HC and MIX as slow-release fertilizers. In the short-term the quantitative effect on TOC were negligible for all the amended soil compared to the Control, and the analysis of DOC and ROC demonstrated slightly differences due to the addition of different quality of organic carbon. These slightly differences were confirmed of the ratio TOC400/ROC. In the long-term the effect TOC400 are similar for all amended soil, but the analysis of POXC highlighted the presence of more active carbon of HC compared to other.

Conclusion

The chosen approach allowed to verify the effect of new organic fertilizers. The work contributes to the knowledge on their agro-environmental properties, aiming to more define the role in carbon storage, soil fertility management, and mineral fertilizers input reduction.

References

Bona, D., Scrinzi, D., Tonon, G., Ventura, M., Nardin, T., Zottele, F., ... & Silvestri, S. (2022). Hydrochar and hydrochar co-compost from OFMSW digestate for soil application: 2. agro-environmental properties. Journal of Environmental Management, 312, 114894.

Bona, D., Bertoldi, D., Borgonovo, G., Mazzini, S., Ravasi, S., Silvestri, S., ... & Tambone, F. (2023). Evaluating the potential of hydrochar as a soil amendment. Waste Management, 159, 75-83. https://doi.org/10.1016/j.wasman.2023.01.024

Weil RR, Islam KR, Stine MA, Gruver JB, Samson-Liebig SE. (2003). Estimating active carbon for soil quality assessment: A simplified method for laboratory and field use. American Journal of Alternative Agriculture, 18, 3–17.

16. Nutrient balance and Resource Optimisation in Regional Ecosystems through holistic, sustainable and zero-pollution solution - GREENHOOD

Laia Llenas Argelaguet, LLA[a], Ana Robles Aguilar, ARA[a], Enol Nieto Jiménez, ENJ[a], Lorenzo Proi[a], LPa, Lluís Bertrans Tubau, LBT[a], Laura Dejana, LD[a], Mabel Mora Garrido, MMG[a]

BETA Technological Center, University of Vic – Central University of Catalonia, Spain[a]

Introduction

The imbalanced nutrient flows across various EU regions are causing significant environmental and health challenges, accelerating biodiversity loss and intensifying GHG emissions, compromising food security and causing an estimated economic loss of 70 – 320 billion euros per year. Sustainable agriculture requires a unified approach, fostering collaboration among farmers, researchers, industry and policymakers. Holistic, regionally anchored strategies are essential to reducing nutrient losses while preserving soil health and fertility. The Horizon Europe GREENHOOD project promotes systemic solutions that prevent nutrient excess, reduce waste pollution, and enhance nutrient reuse—all supported by governance models that integrate circularity into regional development.

Methodology

The GREENHOOD project pioneers a comprehensive approach to address the global challenge of unbalanced nutrient flows in regional ecosystems. Operating across four European countries and one associated region, GREENHOOD focuses on re-balancing nutrient flows and reducing N/P emissions through five strategic approaches:

a) Estimation of maximum allowable nutrient inputs: Utilising optimised budgeting methodologies, including novel modelling tools and socio-economic data, to assess the impacts of new balancing practices.

b) Demonstration of effective nutrient management strategies: Leveraging insights from previous R&D experiences to develop and demonstrate solutions for nutrient excess prevention, reduction and recycling in key sectors such as agriculture, wastewater treatment, aquaculture and forestry.

c) Establishment of regional nutrient circular economy schemes: Creating schemes to close nutrient flow gaps between sectors like livestock-agriculture and aquaculture-agriculture, evaluating the agronomic performance and market uptake of bio-based fertilisers and by-products.

d) Participatory approach: Engaging diverse stakeholders through capacity building, governance labs and cross-regional exchange activities to ensure inclusive decision-making.

e) Innovative governance models: showcasing governance measures to incentivise the adoption of nutrient-balancing solutions, collaborating with regional administrators and supporting existing policies.

Results and discussion

The proposed oral presentation will showcase key insights from a comprehensive stocktaking analysis conducted across four key regions involved in the project: The Ebro River Basin (Spain), The Rhine, Meuse and Scheldt River Basins (Belgium and The Netherlands), The Archipelago Sea Basin (Finland) and the Trondheim Fjord Basin (Norway). This deep analysis will explore past and ongoing initiatives aimed at balancing nutrient flows in each region, offering a clear understanding of their effectiveness, scale, current bottlenecks, drivers and locks-in of implementation. Additionally, it will highlight the mechanisms -such as legislation, roadmaps, basin management strategies, and funding instruments used by public and private stakeholders to scale up successful solutions. Finally, the presentation will introduce the innovative solutions that GREENHOOD will test and demonstrate to improve the current scenario in each region.

Acknowledgements

GREENHOOD project, Co-Funded by the European Union. This project has received co-funding from the European Union's Digital Europe Programme under grant agreement Nº 101181712.

https://greenhoodproject.eu/

17. Current use of nitrogen, phosphorus and potassium fertilizers and their potential replacement by manure, sludge and biowaste in EU agriculture

Xu, D.[*], Ros, G. H.[a], Wang, M.[a] & De Vries, W.[a]

[a] Earth Systems and Global Change Group, Wageningen University, the Netherlands; [*]Corresponding author, email: donghao.xu@wur.nl

Introduction

Application of nitrogen (N), phosphorus (P) and potassium (K) to soil by mineral fertilizers and organic inputs (manure, sewage sludge and biowaste) differs among EU member states, ranging from inadequate P and/or K inputs to maintain soil fertility (i.e. mining the soil) to inefficient N applications leading to nutrient losses. Besides their supply of N, P and K organic resources also supply carbon, other major nutrients and trace elements thereby improving soil properties, such as bulk density, aggregate stability, infiltration capacity and water retention, and soil fertility (Fu et al., 2022). To assess required N, P and K fertilizer inputs in the EU-27+3 member states, it is crucial to assesses crop N, P and K demands, while accounting for all available N, P and K input sources coming from manure, biowaste and sewage sludge. In this study we thus assessed the current (mean of 2021-2022) and potentially available organic N, P and K inputs from manure, sewage sludge and biosolids at country level EU-27(+3) and identified their potential for replacing N, P and K fertilizers.

Methodology

We assessed both current and potential availability of N, P and K in manure, sewage sludge and biowaste by their production, and either the current losses (current supply) or the inevitable losses (potential supply), using Eurostat and FAO statistics and literature data on contents in and loss fractions of N, P and K in manure, sewage sludge and biowaste. The production N, P and K in manure was calculated by multiplying livestock numbers with N excretion rates in different animal types, corrected for gaseous N emissions and N leaching in livestock housing and manure storage systems, and P/N and K/N ratios in different manure types. The N, P and K in sewage sludge were estimated by multiplying the fraction of human population connected to sewage systems by the production of N, P and K by humans, which was calculated by multiplying the actual human intake of N, P and K and their excretion ratio versus intake. The production of N, P and K by biowaste was estimated based on the total amount of biowaste per country multiplied with their N, P and K contents.

Results and discussion

Results show that potential nutrients in : (i) manure are 5525 ktons N, 1375 ktons P and 4737 ktons K, of which 72%, 75% and 70% is currently applied in arable land, respectively (the rest applied in grassland), (ii) sewage sludge are 2698 ktons N, 523 ktons P and 572 ktons K, of which 5%, 18% and 3% is currently used in agriculture, respectively and (ii) biowaste are 795 ktons N, 159 ktons P and 477 ktons K, of which 51%, 32% and 46% is currently used in agriculture, respectively. If all nutrients could be used, it would replace 29% N, 50% P and 33% K applied as mineral fertilizer in agriculture. The potential for additional recycling sludge and biowaste is affected by minimum requirements on their quality, related to concentrations of heavy metals, pharmaceuticals, persistent organic contaminants and "emerging contaminants", such as microplastics and nanoparticles, their agronomic value, in terms of their N or P Fertilizer Replacement Value and their environmental risks due to emissions after soil application (Velthof et al., 2024).

Conclusion

If all nutrients could be used, it would replace 29% N, 61% P and 33% K applied as mineral fertilizer in agriculture. In some countries like Portugal, Austria, United Kingdom, Germany, Belgium and Netherlands, it would fully replace mineral P fertilizers but there is still a substantial need for N and K fertilizers. In Luxembourg, it would fully replace mineral P and K fertilizers but there is still a substantial need for N fertilizer. In Switzerland, it would fully replace the mineral fertilizers. The potential for enhanced recycling is mainly determined by their quality and agronomic value.

Acknowledgements

We thankfully acknowledge Fertilizers Europe for financing this research.

References

Fu, Y., De Jonge, L. W., Moldrup, P., Paradelo, M., and Arthur, E. (2022). Improvements in soil physical properties after long-term manure addition depend on soil and crop type. Geoderma 425:116062. doi: 10.1016/j.geoderma.2022.116062.

Velthof GL, Cals TCA, van 't Hull JP, Lesschen JP, Lessmann M, Porre RJ, Ros MBH, Rietra RPJJ, Schoumans OF, Veenemans L and Westerik D (2024) Managing organic resources in agriculture: future challenges from a scientific perspective. Front. Sustain. Food Syst. 8:1393190. doi: 10.3389/fsufs.2024.1393190.

18. Integrated dairy manure management systems to simultaneously reduce environmental impact and improve fertilizing value

EL Mahdi, J.[a,b]*, Groot Koerkamp, P.W.G.[a] & De Vries, J.W.[a,c].

[a] Agricultural biosystems engineering, Department of Plant Sciences, Wageningen University and Research, P.O. Box 16, 6700 AA Wageningen, the Netherlands

[b] Wageningen livestock research, Department of animal sciences, Wageningen University and Research, PO Box 338, 6700 AH Wageningen

[c] Applied Research Centre, VHL University of Applied Sciences, P.O. Box 9001, 6880 GB, Velp, Netherlands

*Jihane.elmahdi@wur.nl

Introduction

Animal manures are a valuable resource, providing essential nutrients such as nitrogen (N) and phosphorus (P) while contributing to long-term soil fertility. However, their management and use in the different parts of the manure chain remain a challenge due to environmental concerns, including greenhouse gas (GHG) and ammonia (NH_3) emissions and nutrient leaching. Addressing these challenges individually often leads to pollution swapping because of complex interactions between chemical and physical properties of the manures. Modelling studies have suggested that an integrated dairy manure management system—combining source segregation of faeces and urine, complementary treatments and optimized storage and application systems—can improve nutrient recycling efficiency while minimizing environmental trade-offs (De Vries *et al*., 2015; EL Mahdi et al., 2025). When considering the use of urine as RENURE, such systems can also reduce manure transport off-farm and the reliance on mineral fertilizers. This study aimed to validate these findings by using experimental data from laboratory scale to estimate N use efficiency (NUE) and environmental impacts through the whole manure management chain.

Methodology

The integrated system (IS) tested included source segregation of faeces and urine in the dairy cattle housing, acidification of urine, anaerobic digestion of faeces and acidification of the digestate, covered storage of the treated fractions, application to grass by shallow injection of the acidified digestate five times per year and deep injection of acidified urine ten times per year. In these different stages we measured the NH_3 and GHG emissions and quantified N input and outputs. We also measured the biogas yield from anaerobic digestion of the faeces and the required acid amount for acidification. This data served to calculate NUE of the system from excretion to grass uptake and the environmental impacts (climate change (CC) terrestrial acidification (TA) marine eutrophication (ME) particulate matter formation (PMF) and fossil fuel depletion (FFD)) through a consequential life cycle assessment approach (LCA). We also quantified P over application to grass, meaning P applied in excess to grass demand, with this IS. The reference system in this study was untreated slurry stored in-house and injected in grassland up to 170 kg ha^{-1}.

Results and discussion

The results showed that the IS doubled the NUE as compared to the reference slurry system and reduced the P over application to grass. In addition, the IS reduced all quantified environmental impacts as compared to the reference system: CC by 83%, TA by 25%, ME by 191%, PMF by 36% and FFD by 382%. These reductions originated mainly from a reduction of GHG and NH_3 emissions in storage, a reduction of NO_3^- leaching potential after field application, production of biogas and a higher use of farm N instead of mineral fertilizer N thanks to the saving of losses and the use of urine as RENURE.

Conclusion

The tested integrated system effectively reduced all environmental impacts and improved nutrient recycling on the farm. This validates the potential of an integrated systems approach to reduce all emissions and nutrient losses in the manure management chain without trade-offs to environmental impacts. However, it is essential to test this system on pilot and field scale to investigate its performance under practical conditions. Further, the costs should be quantified and compared to conventional manure management.

References

De Vries, J. W., Groenestein, C. M., Schröder, J. J., Hoogmoed, W. B., Sukkel, W., Groot Koerkamp, P. W. G., & De Boer, I. J. M. (2015). Integrated manure management to reduce environmental impact: II. Environmental impact assessment of strategies. Agricultural Systems, 138, 88-99. https://doi.org/https://doi.org/10.1016/j.agsy.2015.05.006

EL Mahdi, J. De Vries, J. W., Gort, G., & Groot Koerkamp, P. W. G. (2025). Source segregation and treatment of urine and faeces from dairy cattle reduces GHG and NH3 emissions in covered storage. Journal of Environmental Management, 374, 123895. https://doi.org/https://doi.org/10.1016/j.jenvman.2024.123895

19. Sustainable solutions for excess agricultural phosphorus management in Northern Ireland using pyrolysis of anaerobic digestate solids for biochar production.

Lyons, G.A[1]*., Johnston, C. R[1]. & Cathcart, A. M[1]., Doherty, R[2]., and Baral., K. R[1].

[1]Agri-Environment Branch, The Agri-Food & Biosciences Institute for Northern Ireland, Large Park, Hillsborough Co. Down, BT26 6DR; [2]School of Natural and Built Environment, Queens University Belfast, David Keir Building 39-123 Stranmillis Road, Belfast BT9 5AG. *Gary Lyons, email: gary.lyons@afbini.gov.uk

Introduction

Mapping of agricultural phosphorus (P) flows in N. Ireland (Rothwell et. al., 2020) indicated that an annual surplus of 6000 t exists beyond crop requirement, mainly due to imported feed P, resulting in serious environmental damage through water quality degradation. Solutions are required to remove excess P from the mainly grass based agriculture system for export, to facilitate the improvements in water quality over time which government departments are under pressure to deliver. This work examined biochar production from separated digestate solids and possible end uses.

Methodology

Digestate from the AFBI biogas plant (80% cattle slurry + 20% grass silage feedstock) was separated through a screw press and 12 t of separated fibre were dried to below 10% moisture content. The resulting 4 t of dried fibre was pelletised and thermochemically treated in a Biomacon C100–F Pyrolysis Boiler at 675 ± 5 °C for 30 m at a feed rate of 21 kg/h, producing renewable syngas and 1.23 t of biochar. The biochar was analysed to EBC standards for a number of parameters and then used for experiments on the following: agronomic trial work; addition to biogas reactors; filtration of landfill leachate; ammonia emission reduction from stored slurry; incorporation into non-structural concrete to reduce carbon footprint.

Results and discussion

Biochar analysis showed carbon and ash content of 55.4% and 42.3% respectively, pH 11.9, total nitrogen 11.1 g/kg, phosphate 40.6 g/kg, potash 41.6 g/kg, BET surface area 463.7 m^2/g, low levels of heavy metals (apart from copper and zinc), and Total 16 EPA-PAH levels below 0.5 mg/kg. Copper and zinc content were within EUFPR limit guidelines but only met EBC Basic Material usage category. Digestate biochar did not perform as well as other organic amendments in agronomic trials, with an average spring barley grain yield decrease of 12% over 3 years compared to control, meaning it should be considered as a soil conditioner and not a direct fertiliser. Biochar addition to anaerobic reactors increased biogas yield by up to 16% and resulted in faster substrate breakdown. Remediation of landfill leachate through biofilters containing mixtures of digestate biochar and peat, resulted in the significant reduction or complete removal of a range of toxic organic and inorganic pollutants, with the potential to be used for industrial remediation work. Other work demonstrated that the biochar effectively reduced ammonia emissions during storage of cattle slurry, with a 28% cumulative reduction during a 113-day trial. Incorporation of 20-40% by volume of digestate biochar into non-structural concrete mixes showed that compressive strength decreased with increasing biochar additions and that over time as the concrete cured, compressive strength increased for each treatment. All treatments produced compressive strength composites above the 12-15 MPa threshold required for safe usage. This could be a significant result if even 20% of cement in concrete could be replaced by biochar, resulting in huge carbon savings and improved performance.

Conclusion

Results from the experimental work provided valuable data and information on how manure derived biochars containing excess P could be exported from N. Ireland grass-based agriculture, for end uses which could reduce environmental damage through P loss to water bodies, produce renewable energy, mitigate environmental damage from ammonia emissions and toxic water pollutants, and help to decarbonise the construction sector. Syngas combustion provided renewable heat and 45% of this was required to sustain the pyrolysis process, with the remainder available to dry feedstock and heat buildings. The findings provide circular bioeconomy solutions for agri-environmental pollution issues.

Acknowledgements

We acknowledge project funding from the Centre for Advanced Sustainable Energy, Department for Economy N. Ireland.

References

Rothwell, S., et al. 2020, Phosphorus stocks and flows in an intensive livestock dominated food system, Res. Cons. Recyc. 163, 105065.

20. Development of a simple vegetable residue nitrogen dynamics model

Sharp, J.[a*], Van Houtte, C.[b] & Jenkins, H.[c]

The New Zealand Institute for Plant and Food Research Limited, New Zealand [abc]; [*]Corresponding author, email: joanna.sharp@plantandfood.co.nz

Introduction

One of the biggest gaps in grower-facing tools for nitrogen (N) budgeting in vegetable crops in New Zealand is accounting for the amount and timing of N mineralised from residues of the previous crop (Reid & Morton 2019). Vegetable production systems can have significant amounts of N returned as residues (e.g. Thiébeau et al. (2021)) and Chen et al. (2014) describe the short-term behaviour of soil inorganic N change following residue return as either mineralisation, immobilisation or immobilisation followed by mineralisation. These behaviours can be reproduced by complex mechanistic models (e.g. Justes et al. (2009)), however simple functional models, such as first-order kinetic models with low input data requirements that are better suited to grower-facing tools, are not able to reproduce the immobilisation-mineralisation behaviour of some vegetable crop residues (Chaves et al. 2004). The aim of this study was to develop and parameterise a simple functional model that can reproduce the three N dynamic behaviours that result from different vegetable crop residues, for inclusion into a grower-facing N balance tool (www.svstool.co.nz).

Methodology

The model developed is a double exponential, whereby net N mineralisation is predicted from terms estimating gross N mineralisation and gross N immobilisation. The model is similar in structure to previous double exponential decomposition models (e.g. Bruun et al. 2006), with the asymptotes and decomposition rates a function of the C:N of the residue. Temperature and moisture functions are also included for model use across a range of climates. A large dataset was compiled by digitising timeseries data from 29 publications, across 38 crop residues (both vegetable and non-vegetables), studying N dynamics in laboratory incubations with soil. To make datasets comparable, all data was recalculated as net N mineralised as a percentage of N applied as residue, and time was normalised using the method described in Mary et al. (1999). The model parameters were then fitted to the dataset using a Bayesian fitting approach.

Results and discussion

Overall, an adequate fit to the data was achieved with minimal bias in residuals with respect to time, and C:N. The model, across the range of C:N of vegetable crop residues, was able to reproduce the three N dynamic behaviours (Chen et al. 2014). Over an 80-day timespan under ideal conditions (30˚C and 100% field capacity), the transition between the three behaviours occurs at approx. C:N of 25 and 40 respectively. These are similar to those described in Chaves et al. (2004), where residues with C:N 9 to 23 mineralised, 30 to 35 immobilised then mineralised, and at 47 immobilised over a 4 month period (21˚C and 58% field capacity). Model limitations include the assumption of adequate soil mineral N available at immobilisation, temperature and moisture functions are correct, and there has yet been no field validation.

Acknowledgements

The Sustainable Vegetable Systems (SVS) programme was funded by the New Zealand Ministry for Primary Industries, Potatoes New Zealand, Horticulture New Zealand and the Vegetable Research & Innovation Board.

References

Bruun S., et al. 2006. A nitrogen mineralization model based on relationships for gross mineralization and immobilization. Soil Biology & Biochemistry 38(9): 2712-2721.

Chaves B., et al. 2004. Nitrogen mineralization of vegetable root residues and green manures as related to their (bio) chemical composition. European Journal of Agronomy 21(2): 161-170.

Chen B., et al. 2014. Soil nitrogen dynamics and crop residues. A review. Agronomy for Sustainable Development 34(2): 429-442.

Justes E., et al. 2009. Quantifying and modelling C and N mineralization kinetics of catch crop residues in soil: parameterization of the residue decomposition module of STICS model for mature and non mature residues. Plant and soil 325(1): 171-185.

Mary B., et al. 1999. Calculation of nitrogen mineralization and leaching in fallow soil using a simple dynamic model. European Journal of Soil Science 50(4): 549-566.

Reid J., Morton J. 2019. Nutrient management for vegetable crops in New Zealand. Wellington, New Zealand: Horticulture New Zealand. ISBN 978-0-473-46746-3.

Thiébeau P., et al. 2021. Dataset of biomass and chemical quality of crop residues from European areas. Data in Brief 37: 107227.

Parallel session 3

1. Utilization of Calcium Cyanamide in Cattle Slurry Storage: Greenhouse Gas Mitigation and Nutrient Conservation

Reiter, D.[a*], Winkler, S.[a], Becher, J.[a], Seilinger, S.[a] & Kappelsberger, B.V.[a]

Alzchem Trostberg GmbH, Applied Technologies & Product Management Agriculture, Germany[a]; *Corresponding author, email: dominik.reiter@alzchem.com

Introduction

In the agricultural sector, emissions are often associated not only with environmental impacts but also with losses of essential nutrients. Thus, manure management for example involves considerable carbon and nitrogen losses *via* microbial formation and liberation of the greenhouse gases (GHGs) CO_2, methane (CH_4) and nitrous oxide (N_2O) (Kupper et al., 2020). Liquid manure (*e.g.* cattle and pig slurry) has gained an image boost in the light of the global crises and is increasingly perceived less as a waste product but rather as a valuable alternative to mineral fertilizers. It is therefore also important in terms of sustainability and climate goals to fully exploit the nutrient potential and minimize losses. Recently, application of the calcium cyanamide ($CaCN_2$)-containing slurry additive Eminex has been shown as an efficient measure for reducing emissions from liquid manure storage (Holtkamp et al., 2023 & Rocha et al., 2024). However, since nutrient losses can still occur despite certain emission reductions (*e.g. via* shift to other emitters) (Mohankumar Sajeev et al., 2018), the effect of $CaCN_2$ on potential correlation with nutrient conservation was investigated in this work.

Methodology

A series of experiments were carried out under controlled laboratory conditions to reveal the impact of $CaCN_2$ on changes in fresh and organic matter (carbon (C) and nitrogen (N) in particular) of liquid manure (Reiter et al., 2024). Thus, for each experiment, fresh cattle slurry (CS; approx. 8 kg) was filled into a modified 16 L drum and stored semi-aerobically (constant air overflow: ~3 L/h) with and without $CaCN_2$ for 4 months at ambient temperature. Emissions of CH_4, CO_2, ammonia (NH_3), N_2O and hydrogen sulfide (H_2S) were determined by tracking the volumes of overflowed air and analyzing the exhaust gases using gas sampling bags and washing bottles. In combination with weighing and slurry analyses (at the beginning and end of storage), detailed mass balances with statistical validation (n = 3) were established.

Results and discussion

The experiments revealed a substantial reduction in GHG emissions of 76.3% when $CaCN_2$ is added to CS prior to storage. Despite the altered chemical-physical environmental conditions for the microbiome due to the air overflow and continuous presence of the strong electron acceptor oxygen (O_2) in contrast to strictly anaerobic storage, the reduction efficiency of $CaCN_2$ is very high. In addition, lower losses of fresh and dry matter were identified with $CaCN_2$. (34.9% and 44.4%, respectively). Absolute C (–34.1%) and N (–23.9%) losses, determined *via* nutrient analyses and mass balances, were reduced by 47.2% and 96.3% respectively. Accordingly, $CaCN_2$ not only reduces GHG emissions during CS storage, but indeed does not induce a notable increase in other emitters and thus also preserves important nutrients.

Conclusion

The experimental setup enabled the correlation between the known emission reducing effect of $CaCN_2$ and the conservation of nutrients to be determined. Utilization of $CaCN_2$ in liquid manure storage could therefore not only serve as a climate protection measure but also offer potential benefits for farmers when applying treated slurry after storage. Ongoing and future investigations are focusing on aspects such as the tendency towards enhanced fertilization effects and improved biogas yields. Moreover, additional storage experiments in the laboratory with varying parameters (*e.g.* air overflow rate, surface-area-to-volume ratio) will provide a more detailed picture of the effect of $CaCN_2$.

References

Holtkamp, F., et al. 2023. Calcium cyanamide reduces methane and other trace gases during long-term storage of dairy cattle and fattening pig slurry. Waste Manag. 161, 61–71.

Kupper, T., et al. 2020. Ammonia and greenhouse gas emissions from slurry storage – A review. Agric. Ecosyst. Environ. 300, 106963.

Mohankumar Sajeev, E.P., et al. 2018. Greenhouse Gas and Ammonia Emissions from Different Stages of Liquid Manure Management Chains: Abatement Options and Emission Interactions. J. Environ. Qual. 47, 30–41.

Reiter, D., et al. 2024. Nutrient Preservation in Cattle Slurry via Emission Reduction during Storage with Calcium Cyanamide. ACS Agric. Sci. Technol. 4, 872–881.

Rocha, A.S., et al. 2024. Effect of Eminex® on Greenhouse Gas and Ammonia Emissions from Dairy Slurry and Lagoon Wastewater. Sustainability 16, 5778.

2. Optimization of pig slurry composting with olive mill and vegetable waste using recycled tennis balls to reduce aeration needs and anaerobic gas emissions on an industrial scale

Aviñó-Calero, J.[ab*], Santateresa, E.[ab], Orden, L.[b], Marks, E.[b]. Martínez-Sabater, E.[b], Andreu-Rodriguez, J.[b], Saéz-Tovar, J.A.[b], Pérez-Murcia, M.D.[b], Bustamante, M.A.[b], Moral, R.[b]

FACSA, Calle mayor 82, 12001 Castellón (Spain)[a]; Centro de Investigación e Innovación Agroalimentaria y Agroambiental (CIAGRO-UMH), Universidad Miguel Hernández, EPS-Orihuela, Ctra. Beniel Km 3.2, 03312 Orihuela, Alicante (Spain)[b]. *Corresponding author, email: juan.avino@facsa.com

Introduction

Composting is an effective method for recycling organic waste into fertilizers, but forced aeration, while improving bio-oxidation, increases operational and investment costs. Inert bulking agents (IBAs), such as used tennis/paddle balls (TB), offer a solution to reduce these costs. Made from rubber and nylon fibres, TB are resistant to the composting conditions and help to distribute air in the pile. In Spain, around 14 million tennis balls are sold each year, contributing to waste without a clear end-of-life use. This study investigates the use of TB as an IBA in composting pig slurry solid fraction (PSSF), olive mill waste (OMW), and urban pruning residues (URP). IBAs improve air circulation, reduce anoxic conditions, and prevent compaction (Haug, 2018). Their use can also reduce the need for forced aeration and mechanical turning, which are both energy-intensive and costly (El Fels et al., 2014). This approach aims to increase composting efficiency while reducing operational costs.

Methodology

Two composting experiments (A and B) were designed to evaluate different compost mixtures. In Experiment A, olive mill waste (OMW) was incorporated at concentrations of 20%, 30%, and 40%, reducing the solid fraction of pig slurry (PSSF), while pruning residues remained constant at 20%. In Experiment B, used tennis balls (TB) were added at 1%, 2.5%, 5%, and 10%. to the mixture with the highest OMW concentration (40%). Both experiments were carried out on an industrial scale at the Todolella Slurry Treatment Plant (Castellón, Spain) between July and November 2021. The composting process included a 60-day bio-oxidation phase and a 30-day maturation phase. Weekly turning was performed with a mechanical turner, and temperatures were measured at different points and depths. Moisture was maintained at 50-60% by irrigation. Physical, chemical, and biological parameters were analysed throughout the process and in the final product. Gas measurements were taken during forced aeration to assess differences between piles. Aeration efficiency was calculated based on O_2 recovery time.

Results and discussion

Composting process parameters monitored throughout the cycle showed that tennis balls (TB) had a significant effect on thermal indicators, with increases in operating temperatures, EXI2, and organic matter mineralization. Compost properties were of equal or superior quality at the end of the process with TB. Furthermore, inert bulking agents (IBA) were found to be partially effective in replacing forced aeration, promoting better air circulation within the heaps, increasing oxygen levels by 35–50%, and reducing NH_3 emissions, CO and CH_4 emissions. IBA also had a positive effect on final compost property, including a higher germination index and lower polyphenol levels. The use of IBA demonstrated the potential to reduce the energy consumption and carbon footprint associated with forced aeration, with a reduction in energy consumption of 160 kWh during the bio-oxidation phase in Experiment A, and 546 kWh in Experiment B.

Conclusion

The use of tennis balls improved aeration and the exothermic parameters of the composting process, which could reduce the number of turnings required and the need for forced aeration. This innovation could lead to improvements in the composting process at industrial plants, reducing overall composting times, operational costs, and the environmental impact by decreasing anaerobic gas emissions and energy consumption.

Acknowledgements

AVI INNODOCTO INNTA3/2022/26 Grant and the AGROALNEXT /2022/016 Research Project.

References

El Fels, M.T., et al. 2014. Alternative bulking agents for composting: Impact on process and quality of the compost. Waste Manage. 34(8), 1426-1432.

Haug, R.T., 2018. Composting: Principles and Applications. CRC Press, Boca Raton, FL, USA.

3. Inoculum amount and material freshness drive organic degradation and methane emissions in pig slurry: insights from untargeted metabolomics

Wang, R.[a]*, Dalby, F.R.[a], Hansen, M.J.[a]
Department of Biological and Chemical Engineering, Aarhus University, 8000 Aarhus C, Denmark [a]. Corresponding author *

Introduction

The extent of organic degradation in pig slurry directly influences methane (CH_4) emissions, yet the underlying mechanisms remain unclear. Organic matter degradation progresses through hydrolysis, acidogenesis, and acetogenesis, breaking down complex organic matter into small intermediates (e.g., acetic acid, H_2/CO_2) that fuel methanogenesis. Inoculum amount and material freshness shape microbial activity and organic matter availability, affecting degradation dynamics. Current studies on organic matter degradation predominantly focus on proteins, carbohydrates, and fibers due to their high abundance and ease of measurement, leaving the degradation mechanisms of small organic compounds largely unexplored. However, these low molecular weight compounds follow distinct degradation pathways and contribute to CH_4 emissions depending on their hydrolysis susceptibility (Dalby et al., 2021). Non-targeted metabolomics bridges this gap by capturing these low molecular weight compounds and metabolic transformations (Wang et al., 2024). This study examines the effects of inoculum amount and material freshness on organic matter degradation and CH_4 emissions, aiming to (I) clarify their roles in degradation dynamics and CH_4 production, (II) identify key small organic compounds linked to CH_4 emissions that conventional methods overlook, and (III) determine their relationship with CH_4 generation.

Methodology

Pig feces, urine, and aged slurry (inoculum) were mixed and incubated in 0.5 L flasks at 20°C. In the inoculum amount experiment, inoculum was added at 0%, 25%, and 50% of the total manure mass, corresponding to control (FU0), typical (FU25), and maximum (FU50) slurry accumulation levels in pits before manure discharge. In the material freshness experiment, treatments included: (1) fresh feces, urine, and inoculum (FFF), (2) defrosted feces and urine with fresh inoculum (DDF), and (3) defrosted feces, urine, and inoculum (DDD). The inoculum ratio was fixed at 25%, as this level yielded the highest CH_4 emissions in the inoculum experiment. CH_4 emissions were monitored over 30 days using cavity ring-down spectroscopy (Picarro G4301, Santa Clara, CA, USA). Slurry composition was analyzed on days 0, 2, 14, and 30 via non-targeted metabolomics using an Orbitrap Exploris 120 mass spectrometer (Thermo Fisher Scientific). A continuous airflow was maintained in the flask headspaces during measurements.

Results and discussion

In the inoculum amount experiment, FU25 achieved the highest cumulative CH_4 yield (0.23 $g \cdot kg^{-1}$ VS_{added}), surpassing FU0 and FU50 by 22.6% – 55.8%. Non-targeted metabolomics revealed distinct degradation patterns across treatments, particularly in proteins/amino acids/peptides (e.g., L-threo-3-Phenylserine, N8-Acetylspermidine) and lipids (e.g., 2-Naphthylamine, 3-Methylcrotonylglycine), which were observed to have high relative abundance and degraded most in FU25, correlating negatively with CH_4 emissions and promoting methanogenesis. FFF initially exhibited the highest CH_4 emissions, but DDF surpassed it over time, yielding the highest cumulative CH_4 production (0.18 $g \cdot kg^{-1}$ VS_{added}). DDD had a prolonged lag phase, but its final CH_4 yield was comparable to FFF. Key protein/amino acid/peptide-derived metabolites such as L-Phenylalanine, 5-Aminovaleric acid, and L-Norleucine degraded rapidly in FFF (day 2) but degradation peaked in DDF (day 14), correlating negatively with CH_4 emissions. Consistent metabolite trends across both experiments suggest their crucial role in CH_4 production, though further analysis is ongoing, and we aim to quantify some of these compounds using standards in future studies.

Conclusion

Both inoculum amount and material freshness significantly influence CH_4 emissions from pig slurry. FU25 and DDF treatments exhibited the highest CH_4 production. Key metabolites from proteins/amino acids/peptides, lipids, and lignin/CRAM-like compounds showed distinct degradation patterns, with their abundance negatively correlated with CH_4 emissions, suggesting their breakdown promote methanogenesis. These findings underscore the role of small organic compound degradation in CH_4 regulation, offering insights for optimizing slurry management and developing targeted mitigation strategies to reduce greenhouse gas emissions in pig farming.

Reference

Dalby, F.R., et al. 2021. A mechanistic model of methane emission from animal slurry with a focus on microbial groups. PLoS One 16, e0252881.
Wang, X., et al. 2024. Inhibition of anaerobic digestion by various ammonia sources resulted in subtle differences in metabolite dynamics. Chemosphere 351, 141157.

4. Evaluating Emission Dynamics: Intensive Spatial and Temporal Analysis of NH_3 and CH_4 Emission Estimations by Indirect CO_2 Balance Method in a Dairy Barn

Harsh Sahu[1], Thomas Amon[1,2], Jürgen Zentek[3], David Janke[1]

[1]Leibniz Institute for Agricultural Engineering and Bioeconomy (ATB), Department of Sensors and Modelling, Germany

[2]Freie Universität Berlin, Institute of Animal Hygiene and Environmental Health, Department of Veterinary Medicine, Germany

[3]Freie Universität Berlin, Institute of Animal Nutrition, Department of Veterinary Medicine, Germany

* Correspondence: hsahu@atb-potsdam.de; djanke@atb-potsdam.de

Introduction

Accurate quantification of ammonia (NH_3) and methane (CH_4) emissions from naturally ventilated dairy barns (NVDBs) is crucial for environmental management and mitigation strategies. Traditional indirect CO_2-balancing method assume uniform gas distribution within NVDBs. However, spatial and temporal variations can significantly influence emission estimations. This study aims to evaluate the variability in NH_3 and CH_4 emissions by deploying a high-resolution gas sampling network with enhanced spatial and temporal resolution in an experimental NVDB located in North Germany.

Methodology

The study was conducted in an NVDB having an internal volume of 4500 m^3 (dimensions: 38.8 × 17.6 × 3.6 m; roof height of 6.2 m at gable peak). A total of 51 sampling positions (SPs) were installed: 17 horizontal SPs covering lying, walking, feeding, and manure storage areas, and 3 vertical SPs at heights of 2.6 m, 3.6 m above the barn floor, and 0.6 m below the roof. An additional SP outside the barn measured ambient background concentrations. Gas concentrations were sequentially measured at each point using two Cavity Ring-Down Spectrometers (CRDS) and two Fourier Transform Infrared (FTIR) Spectrometers, all time-synchronized and operating in parallel throughout the six-week measurement campaign from June 3 to July 31, 2024. A total of 54000 observations of NH_3, CH_4, and CO_2 concentrations (in ppm) were collected at four-minute intervals. To assess the impact of spatiotemporal resolution on emission estimates, the data is systematically analysed by reducing the sampling density and frequency.

Results and discussion

While the long term measurements are ongoing, preliminary tests indicate significant deviations in mean gas concentrations at each SP compared to the baseline: CO_2 (±5%), CH_4 (±15%), and NH_3 (±40%). The baseline for comparison is the average concentration across 51 SPs. These variations suggest potential inaccuracies in emission estimates when assuming uniform gas distribution. Currently, we are calculating NH_3 and CH_4 emissions by indirect method with existing data and continuously collecting additional data to estimate annual emissions per livestock unit (kg/Y/LU). In addition to the six weeks of data collected in summer 2024, results of emission dynamics from spring, summer, and autumn 2025 will be presented.

Conclusion

The insights gained can inform the optimization of sensor placement and sampling frequency, leading to optimized emission estimates. Our results can serve as the ground truth for modelling emissions and yield crucial information to explore a low-cost sensor approach.

Acknowledgements

This research is financially supported by the Federal Ministry of Food and Agriculture (BMEL), funding granted by the Federal Office for Agriculture and Food (BLE; No. 28N206501 to-04 and 28N206506 to -10, Joint project 'EmiMod')

References

1. Mendes, L.B., 2015. Spatial variability of mixing ratios of ammonia and tracer gases in a naturally ventilated dairy cow barn. Biosystems Engineering 2015, 129, 360–369
2. De Vogeleer, G., et al 2017. Effect of sampling density on the reliability of airflow rate measurements in a naturally ventilated animal mock-up building. Energy and Buildings 2017, 152, 313–322
3. Janke, D., 2021. Estimating ventilation rates and emissions from a naturally ventilated dairy barn: a three-column approach; Technische Universität Berlin Germany

5. Measuring emissions of greenhouse gases and ammonia from farm-scale manure stockpiles

Feilberg, A.[a*] & Kamp, J. N.[a]

Department of Biological and Chemical Engineering, Aarhus University, Denmark[a], *Corresponding author, email: af@bce.au.dk

Introduction

Storage of solid manure fractions, including deep litter from beef cattle, horses and chicken as well as the solid fraction following separation of anaerobically digested biomass is an important yet not well quantified source of methane (CH_4), ammonia (NH_3) and nitrous oxide (N_2O) emissions. Emissions from storage of solid manure has until recently predominantly been measured in relatively small scale (Hu et al., 2014) using flux chambers, which may influence the emission source and therefore potentially bias quantification of emission. Optimized manure management and identification of the best practices and efficient technologies to reduce gas emissions from manure stockpiles require reliable emission estimates for farm-scale stockpiles and documentation of emission reduction by reliable measuring techniques. Manure stockpiles are subject to variations in temperature, wind speed, and other environmental factors that significantly influence emission rates. In addition, achieving replications in representative production scale require infrastructure that is rarely available.

Over the past 5 years we have conducted a series of experiments targeting emissions from various solid manure stockpiles, some of which are published (Lemes et al., 2023, Kamp & Feilberg, 2024). Emission measurements were conducted in order to assess and quantify emissions under conditions representative of agricultural practice as well as to assess different cover strategies in order to identify mitigation options. An overview of results and recommendations for future work are provided in this presentation.

Methodology

Stockpile biomass types covered cattle deep litter, broiler litter, horse manure and solids from separation of anaerobically digested biomass. The backward Lagrangian stochastic (bLS) inverse dispersion method was applied to quantify NH_3, CH_4, and N_2O emissions over the storage periods (1½-2 months) using a line-averaging sampling system connected to online sensors (cavity ring-down spectroscopy). The method was characterized and documented based on several controlled release experiments for several iterations of sampling optimization. Additional measurements include temperature profiles, oxygen profiles, stockpile mass and manure parameters (nitrogen, dry matter and volatile solids).

Results and discussion

Measurement data include methane, ammonia and nitrous oxide. Except for broiler litter, concentration differences (downwind – upwind) for nitrous oxide were too low to provide consistent emission estimates. In general, immediate covering has been shown to have a strong mitigating effect for ammonia (>90%). For broiler litter, nitrous oxide emissions were quantified and covering was shown to reduce emissions of nitrous oxide (by 80-90%) as well as of ammonia. Methane emissions were observed to be highly variable across the different measurement campaigns. The effect of covering on methane also varied from moderate to no effect.

Conclusion

We asses that representative emission data for full-size manure stockpiles can be achieved by the bLS method. Temporal variation, including diurnal variation, and effects of covering strategies are covered by the method. Recommendations for future research and inventory documentation are provided.

Acknowledgements

This research was funded by the Danish Agency for Food and Agriculture (33010-NIFA-21-767 & 34009-20-1726).

References

Hu, E., E. L. Babcock, S. E. Bialkowski, S. B. Jones and M. Tuller (2014). "Methods and Techniques for Measuring Gas Emissions from Agricultural and Animal Feeding Operations." Critical Reviews in Analytical Chemistry **44**(3): 200-219.

Kamp, J. N. and A. Feilberg (2024). "Covering reduces emissions of ammonia, methane, and nitrous oxide from stockpiled broiler litter." Biosystems Engineering **248**: 73-81.

Lemes, Y. M., T. Nyord, A. Feilberg and J. N. Kamp (2023). "Effect of Covering Deep Litter Stockpiles on Methane and Ammonia Emissions Analyzed by an Inverse Dispersion Method." Acs Agricultural Science & Technology.

6. Impact of trace metal excess in cow diets on the agro-ecosystem: soils, leachates and plants

Royer, I.[a]; Duplessis, M.[b]; Crevecoeur, S.[c]; Zastepa, A.[c]; & Bélec, C.[d]

[a]; Agriculture and Agri-Food Canada, Quebec Research and Development Centre, Quebec, Canada [b]; Agriculture and Agri-Food Canada, Sherbrooke Research and Development Centre, Quebec, Canada [c]; Environment and Climate Change Canada, Canada Centre for Inland Waters, Burlington, Ontario, Canada; [d]; Agriculture and Agri-Food Canada, Saint-Jean-sur-Richelieu Research and Development Centre, Quebec, Canada *Corresponding author, email: isabelle.royer@agr.gc.ca

Introduction

Trace Metals (TM), required to support vital function in mammals (National Research Council (NRC), 2001), are often given in excess in dairy cow feeding ration, and accordingly be excreted in the manure. In contrast to the application of sewage sludge, which is limited by their TM contents, manure spreading rates depend only on their N and P concentrations. In fact, no restrictions are imposed on the amount of TM that can be added to the soil in manure spreading. Since manure inputs exceed plant uptake, it is therefore reasonable to expect TM build-up in the soil that could be leached into the environment following many years of cattle manure applications. It is our hypothesis that spreading manure on soils coming from increasing dietary concentrations of TM in cow diet above the recommendations will increase concentrations of TM in soils, plants and soil leachates and hence represents an environmental issue, particularly for the aquatic environment. Therefore, our aim was to evaluate the impact of different TM contents in manure spreading on levels of TM in soils, plants and leachates.

Methodology

A total of 160 leaching columns were used to assess the behavior of TM (Cu, Zn, Fe, Mn, Co) after cow manure application in a factorial experiment 2 x 2 x 2 x 4 in 5 repetitions arranged in a completely randomized design in a growth chamber. The factors studied consisted in 2 types of soil (sandy loam and silty clay), 2 cow manure treatments (control diet containing a mineral supplement of TM as recommended by the NRC and a diet containing a mineral supplement of TM above the NRC recommendations, 2 manure application rates (100 or 220 kg N ha^{-1}) and 4 sampling times (after first plant harvest, after second plant harvest , after winter and at the end of the experiment). Timothy plant was sown in each column and subjected to a water regime mimicking the precipitations normally received in Quebec between May and October and grown for 6 months. Leachates were collected once a week for the first two months and then, every other week until the end of the experiment for a total of 12 events. At the end of each of the four time periods, 40 soil columns were harvested. Each soil column was divided in 3 segments: the top 0-5 cm, middle 5-15 cm, and bottom 15-25 cm. Plants were also harvested at the same time. Soil samples of each soil layer were analyzed for their TM exchangeable form using the Mehlich (M3) method (Ziadi and Tran, 2007). The soluble TM content in leachates was determined as well as the total content of TM in soils and plants (USEPA (3050B), 1996). All samples were analyzed with an ICP-OES.

Results

Soils pH varied between 6.94 and 7.18 and between 6.40 and 6.82 for the silty clay and the sandy loam respectively. The pH values were higher in the soil surface compared to the deeper soil layer in the sandy loam. The contrary was observed in the silty clay. In general, TM-M3 contents were higher in the mineral supplement of TM above the NRC recommendations compared to the control diet especially in the 0-5 cm for Zn, Mn and Fe for both soils. Similar results were obtained for the TM plant contents, and for all 12 leaching events. In fact, Cu, Zn, Fe, Mn and Co content was higher with the TM supplement above the NRC recommendations compared to the control diet. In addition, TM concentrations in leachates were higher under the sandy loam than the silty clay. Finally, lesser differences were observed between the 2 diets for the soil total TM contents compared to the M3 extraction.

Conclusion

The project results show that the exchangeable form of soil TM extracted with M3t is more likely to react to manure spreading than the total soil content. In addition, the results show that supplementation to cows beyond the recommended doses can have a negative impact by creating a build-up in the soil, which in turn can impact water quality.

References

National Research Council. 2001. Nutrient requirements of dairy cattle. 7th revised ed. National Academy Press, Washington, DC.

United States Environmental Protection Agency (USEPA). 1996. 3050B, (Revision 2). Acid Digestion of Sediments, Sludges, and Soils.

Ziadi, N., and T. S. Tran. 2007. Mehclich-3 extractable elements. Ch. 12 in Soil sampling and methods of analysis, 2nd edition. M.R. Carter and E.G. Gregorich (eds.). CRC Press.

7. Assessment of contaminants in bokashi sampled from 76 pilots

Stokkermans, L.[a*], Rietra, R.P.J.J.[a] & Römkens, P.F.A.M.[a]

Wageningen Environmental Research, The Netherlands[a]; [*]Corresponding author, email: lotte.stokkermans@wur.nl

Introduction

Management of urban greenery and roadsides generates ca. 2 million tonnes of green waste in the Netherlands (RVO, 2014; BVOR, 2017), such as grass clippings, leaves and bark. These materials contain nutrients and organic matter, which could contribute to the maintenance of soil quality in agriculture and urban green spaces alike. However, the nutrient concentrations are quite low, and the biomass could contain contaminants, such as glass and plastic, heavy metals, PAHs or PFAS. If the biomass has to be disposed of it is legally regarded as biowaste (Directive 2008/98/EC) and is normally composted at certified facilities (Langsdorf et al., 2021). On-farm recycling of the biomass can reduce costs for transport and disposal. Recently, to improve the value of the biowaste, farmers are producing bokashi (Quiroz & Céspedes, 2019). Bokashi is made by anaerobically fermenting biomass after addition of specific microbial communities, water, clay, and lime. Bokashi has not been thoroughly studied yet, and it is not yet allowed to use bokashi from biowaste in the Netherlands, other than in pilots for research. In this study, the agronomic and environmental suitability of bokashi for agricultural use was investigated.

Methodology

Samples of bokashi and compost from roadside grass, leaves, or both, and untreated roadside grass were collected from 76 pilots throughout the Netherlands. The samples were subjected to a series of analyses, including analysis of nutrient contents, organic matter content, pH, electrical conductivity, C/N ratio, respiration rate, heavy metal contents, organic micropollutant contents, PFAS, pesticide residues, physical contaminants and weed pressure.

Results and discussion

Based on its nutrient concentration (sum of N, P_2O_5 and K_2O: <4% on average) and organic matter contents (~50% of the dry matter content), bokashi from leaves or roadside grass can be used as a soil improver, but generally have a low fertilising value. The heavy metal contents in bokashi were generally well below limits set for compost by both Dutch law and the EU Fertilising Products Regulation (FPR). Seven bokashi were investigated for organic pollutants and in all of these, mineral oil, PCB, PAH and/or dioxins were detected, but all contaminant concentrations were well below risk values as set in the Dutch Fertiliser Act for 'other organic fertilisers'. In every of these seven bokashi samples also PFAS were detected. No limits exist for PFAS in fertilisers or soil improvers in Dutch law or the FPR. For PFOA and PFOS, specific PFAS compounds, background values exist for Dutch soil, which were exceeded by two bokashi samples. Glass particles, stones and other physical contaminations such as plastic were found in 23, 102 and 33 samples, respectively, of the 166 bokashi samples investigated for physical contaminants. For physical contamination Dutch law sets a maximum of 0.5% on fresh matter basis, which was exceeded only by two bokashi samples. The weed pressure in bokashi was generally low (0-1 seed/L).

Conclusion

The studied bokashi do not exceed the limits for contaminants that are set for compost. Agronomically, the bokashi are suitable as soil improvers as they contain sufficient levels of organic matter. Environmentally, the main point of attention is physical contamination, especially from stones, glass and plastic.

Acknowledgements

We would like to thank all pilots that contributed to this research for making available their biomass products for study.

References

Branche Vereniging Organische Restromen (BVOR). (2017). Innovatief aanbesteden van groenafval en gras. Een handreiking voor aanbestedende diensten

Directive 2008/98/EC of the European Parliament and of the Council of 19 November 2008 on waste and repealing certain Directives (OJ L 312, 22.11.2008, p. 3–30).

Langsdorf, A., Volkmar, M., Holtmann, D., & Ulber, R. (2021). Material utilization of green waste: a review on potential valorization methods. Bioresources and Bioprocessing, 8(1), 1-26.

RVO (2014). Biogas uit gras, een onderbenut potentieel, Een studie naar kansen voor grasvergisting.

Quiroz, M., & Céspedes, C. (2019). Bokashi as an amendment and source of nitrogen in sustainable agricultural systems: A review. Journal of Soil Science and Plant Nutrition, 19, 237-248.

8. Impact of pharmaceutical residues in soils

Jongedijk, E.J.[a*], van de Voorde, T.F.J.[b], van Dongen, K.[a], Roelofs, G.[a], Ramadan, L.[a,c,d], Rey, F.[a,e,f], Mason-Jones, K.[d,g], Veen, G.F.[d] & van de Schans, M.G.M.[a]

[a]Wageningen Food Safety Resarch, the Netherlands; [b]Wageningen Plant Research, the Netherlands; [c]Gebze Technical University, Turkey; [d]Netherlands Institute of Ecology (NIOO-KNAW), the Netherlands; [e]Free University of Bozen-Bolzano, Italy; [f]Wageningen University, Laboratory of Nematology, the Netherlands, [g]Tuebingen University, Germany; [*]Corresponding author, email: esmer.jongedijk@wur.nl

Introduction

A key procedure for a circular bio-economy is that side products, e.g. faeces, urine, feathers, (sewage) sludge, are returned to soil for replenishing crop nutrients. However, a major concern is that these side products can contain pharmaceutical residues (e.g. antibiotics, estrogens), which may distort soil functioning as well as endangering food safety. Currently, 60-70% of Europe's soils are already considered unhealthy, which endangers the soil's services for biodiversity and the food system[1]. Other global change threats, like the build up of micro-plastics in the soil may enhance these effects.

Methodology

We present an innovative approach where we studied the impact of pharmaceutical residues on soil life and soil emissions. Soil pot experiments were executed, degradation of pharmaceuticals, representative of land application of contaminated manure/sludge[2], was quantified by means of LC- and GC-MS/MS, and activity and occurrence of soil (micro)-organisms assessed. Different realistic scenarios were created by combinations of soil amendments[3], pharmaceuticals, and microplastics[4], also evaluating multi-toxicity impacts.

Results and discussion

In our experiments we show that residues of pharmaceuticals have impact below ground, on both bacterivorous nematode abundances, as well as soil microbial activity. Additive effects were shown when contaminants were combined with microplastics. Moreover, residues were taken up in crops (radish, spinach and lettuce). Bioaccumulation and translocation factors to crops were highly dependent on chemical structure, crop type and experimental conditions. In our study, soil organisms degraded pharmaceutical residues. Under the tested circumstances, no significant differences in chemical degradation were observed between treatments with high biodiversity, compared to low biodiversity. In the future, we aim to further explore harnessing biodiversity, by exploring the potential of functional biodiversity under different stressors for degradation/transformation and mobility of chemicals.

Conclusion

In this study impact of pharmaceutical residues from side-products in soil was shown, at the same time harnessing soil properties for degradation of chemical hazards, contributing to the highlighted need for more mitigation strategies for chemical contamination in soils[5] and safe application guidelines for side-products.

References

[1]Veerman et al. 2020. EU report Caring for soil is caring for life

[2]Berendsen et al. 2018. The persistence of a broad range of antibiotics during calve, pig and broiler manure storage. Chemosphere 204, 267-276

[3]Clocchiatti et al. 2020. Utilizing woody materials for fungal-based management of soil nitrogen pools. Appl. Soil Ecol. 181

[4]Ramadan et al. 2025. Manuscript in preparation.

[5]Van Leeuwen et al. 2024. A novel approach to identify critical knowledge gaps for food safety in circular food systems. npj Science of Food. 8, 34.

Nicholson, F., et al. 2017. Nitrogen losses to the environment following food-based digestate and compost applications to agricultural land. Environ. Pollut. 228, 204–516.

9. Soil-dependent fate of naturally occurring *Klebsiella pneumoniae* and *Listeria monocytogenes* after incorporation of digestates: microcosms investigations and field experiments

Michel-Le Roux S. [a], Ziebal C. [a], Pinsard G. [a], Oliva A. [a], Piveteau P. [a*]

[a] INRAE UR OPAALE, FRANCE; *Corresponding author, email: pascal.piveteau@inrae.fr

Introduction

Managing organic resources in agriculture holds opportunities to use efficiently nutrients, fuel sustainable circular bioeconomy and reduce environmental impacts of farming. Among the processes available, anaerobic digestion can produce renewable energy and digestate as organic fertiliser. Whether or not the presence of pathogenic microorganisms in the processed biomasses is a threat to the sustainability of the current on-farm practices is still the subject of debate. From 2020 to 2024, a French nationwide project assessed impacts of digestates on soil biology and quality (Sadet-Bourgeteau et al., 2024; Vautrin et al., 2023). Effects of Digestate typology and soil types were investigated with a range of bio-indicators. This presentation focus on the sanitary indicators that were implemented in this project, especially *Klebsiella pneumoniae* and *Listeria monocytogenes*.

Methodology

To assess the occurrence of selected pathogens (*Salmonella enterica*, *Klebsiella pneumoniae*, *Listeria monocytogenes*) and indicator bacteria (*Escherichia coli*) in several types of digestates, we sampled anaerobic digestors fed with different kinds of organic matter. Selective enrichment and molecular detection (qPCR) were used to detect pathogens while *E. coli* was enumerated on selective medium.

To investigate the fate of these pathogens once digestates were included in soil, microcosm experiments were designed. Six digestates and 3 soils with contrasting edaphic characteristics were used in the microcosm experiments. Manure was used as unprocessed effluent control. Digestate was added to mimic agronomic doses and microcosms were incubated at 15°C for 42 days. All experiments were performed in quadruplicate. Occurrence of the selected indicators was assessed as described above.

In a second round of experiments, soil from fields fertilised with digestates were sampled in 3 experimental stations to track the sanitary indicators.

Results and discussion

We hypothesised that the occurrence of pathogens depends on the type of digestates. Indeed results were digestate-dependant. While *Salmonella enterica* was never detected, one out of six digestates (digestate SMS) was positive for the presence of *Klebsiella pneumoniae, Listeria monocytogenes* and *E. coli* was enumerated (50 CFU/g) in this digestate. We further hypothesised that the fate of naturally occurring pathogens is soil-dependent. After 42 days of incubation, indeed occurrence of *Klebsiella pneumoniae* was soil-dependent, while *L. monocytogenes* and *E. coli* were detected only once in silty clay loam soil microcosm prepared with digestate SMS.

Results from the field experiments showed no detection of *Salmonella enterica* nor *Listeria monocytogenes*. *Klebsiella pneumoniae sensu lato* was sporadically detected in two out of three experimental sites but the detection of this indicator did not fully correlate with the history of organic fertilisation.

Conclusion

Overall, these results show that each digestate is unique and that the fate of naturally occurring pathogens once the digestate is spread on agricultural soils very much depends on an array of environmental factors including edaphic factors such as texture, pH and soil microbial diversity. This highlights the relevance of Long-term monitoring on experimental stations dedicated to the investigation of organic fertilisation.

Acknowledgements

This work was supported by ADEME, the CASDAR Innov and GrDF.

References

Sadet-Bourgeteau, S., et al. 2024. Impact des digestats de méthanisation sur la qualité biologique des sols. Metha-BioSol (APR GRAINE). Rapport final, 75 pages.

Vautrin, F., et al. 2023. The short-term response of soil microbial communities to digestate application depends on the characteristics of the digestate and soil type. Appl Soil Ecol. 193 https://doi.org/10.1016/j.apsoil.2023.105105

10. Salinization or sodification risk from the agronomic use of pig slurry in Córdoba, Argentina

Pegoraro, V.[a*], Sosa, N.[a], Mathier, D.[a], Bragachini, M.[a], Vélez, G.[a], Lorenzon, C.[a], Conde, M.B.[a], Mazzini, P.[a], Miralles, S.[b], Crema, N.[b], Andreani, A,. [b], Casalotti, M.[b], Cuello, P.[b], Inga, M.[b], Avendaño, M.[b], Merino, B.[b], Ferrari, J.[c], Castro, P.[d] ,Lenarduzzi, V.[c] & López, E.[c]

INTA, Argentina [a]; CEPROCOR, Argentina [b]; Secretaría de Ambiente, Córdoba, Argentina [c]; Secretaría de Ganadería, Córdoba, Argentina [d];
*Corresponding author, email: pegoraro.vanesa@inta.gob.ar

Introduction

Groundwater in the south and southeast of Córdoba province (Argentina) is characterized by high salt content (Brarasin et al., 2011) and is used for washing floors in animal confinement facilities. Additionally, pig farms incorporate salt into animal diets, contributing to high electrical conductivity and sodium content in the generated slurry (Moral et al., 2008). This study aimed to assess the quality of groundwater and pig slurry stabilized in anaerobic lagoons regarding the risk of soil salinization and sodification when used for agronomic purposes in pig farms.

Methodology

Groundwater and pig slurry samples were collected from anaerobic lagoons at 14 farms in Córdoba, Argentina. Additionally, soil samples (0–20 cm depth) from areas with pig slurry applications were collected. Chemical variables, including electrical conductivity (EC), sodium (Na), calcium (Ca), magnesium (Mg), and potassium (K), were determined. The sodium adsorption ratio (SAR) in groundwater and pig slurries, as well as the exchangeable sodium percentage (ESP%) in soil, were also calculated. Correlation and relationship data analyses were performed using Infostat Professional statistical software.

Results and discussions

The results showed that 43% of the water samples were extremely saline, 7% had very high salinity, 14% had high salinity, and 36% had medium salinity. Regarding the risk of sodification, 62% of the samples had SAR values above 26, indicating a very high sodium content, while 15% had low sodium levels, 8% had medium levels, and 15% had high levels. The analysis of stabilized pig slurry revealed a high risk of salinization in all samples, with 79% showing a very high sodium content. Significant positive correlations ($p<0.05$) were identified between pig slurry SAR and groundwater parameters, as well as between pig slurry EC and Na. These findings indicate that slurry quality depends on the quality of the water used for cleaning facilities. However, in some farms, good-quality groundwater was found, although its salt concentration increased after stabilization. Applying the Riverside Index, it was determined that 86% of the farms produced slurry that could be used with caution, providing appropriate management practices when implemented (e.g., salt leaching, chemical amendments, sowing of tolerant crops). The remaining 14% of farms produced slurry unsuitable for irrigation or with extremely restricted use. Although these indices are not specifically designed to assess the agronomic use of animal slurry, they provide valuable insights into its physicochemical quality and the risks associated with its application. Finally, when analyzing the relationship between stabilized pig slurry quality and agricultural soils receiving slurry, a significant positive correlation was found between Mg in pig slurry and EC in soil ($R = 0.54$; $p < 0.05$), as well as a negative correlation between soil organic carbon and K, Na, and ESP-% ($R = -0.59, -0.53, -0.56$; $p < 0.05$).

Conclusion

Monitoring the indicators and risk indices of salinity and sodicity in the pig slurry, as well as in the agricultural soils that receive it, is very important. This will allow the implementation of both preventive and corrective practices to avoid soil quality deterioration, which could affect productivity and the environment.

Acknowledgements

Funded by Project IMPACTAR No. 119, Ministry of Innovation, Science and Technology of the Nation (MINCyT-Argentina).

References

Blarasin, M., et al. 2014. Aguas subterráneas de la provincia de Córdoba. UniRío. Universidad Nacional de Río Cuarto. Argentina.

Moral, R., et al. 2008. Salinity, organic content, micronutrients and heavy metals in pig slurries from South-eastern Spain. *Waste management*, *28*(2), 367-371.

11. Determination of gaseous emissions from naturally ventilated housings in the absence of animals

Schep, C.A. [a*], Mosquera, J. [a], Levrault, C.M.[a]

Wageningen Livestock Research, Wageningen University & Research, The Netherlands [a]; [*]Corresponding author, email: carsten.schep@wur.nl

Introduction

Gaseous emissions from livestock houses have negative effects on biodiversity (ammonia) and climate change (methane). To lower the negative effects of the food production system, these emissions should be minimised. Measurement strategies (systems and protocols) have been developed (Werkgroep richtlijnen emissies veehouderij, 2024) to enable farmers to monitor and thus manage their emissions. However, these protocols mainly focus on mechanically ventilated housings even though a major part of the emissions originates from naturally ventilated housings (NVH). The reason for this is that it is difficult to determine the ventilation rates in NVH which are needed to quantify emissions. As a solution, the produced CO_2 from animal respiration and manure storage is used as a tracer gas to determine the ventilation rate. However, this requires a continuous presence of animals which is not always the case (e.g. during grazing). Therefore, the aim of this research was to estimate the emissions from NVH without using an external tracer both in the presence and in the absence of animals.

Methodology

Between 2018 and 2024, 15 Dutch dairy NVH have been continuously monitored on ammonia (NH_3), methane (CH_4) and carbon dioxide (CO_2) concentrations as well as on the presence of animals. In 10 of the NVH, animals were partly outside for grazing. Based on the available data, scenario analyses have been performed on 5 NVH in which animals were continuously present. The absence of animals was simulated to estimate the measurement error when animals are absent. Next to that, different gap-filling methodologies have been applied to predict gas concentration levels during animal absence. The resulting emissions were compared with the emissions as calculated when the animals were continuously present.

Results and discussion

Preliminary results from this study show that gaseous emissions can be determined at satisfactory accuracy levels even though the animals were partly not present in the NVH. Next to that, gap filling based on the concentration ratios between ammonia, methane and carbon dioxide appears to have potential to improve the emission estimation. Applying these methodologies will improve emission estimations as well as enabling the farmer to continuously monitor the emissions from the NVH. The remaining challenge is the determination of the fraction of the animals not being present in the barn as this is not systematically monitored in practice.

Conclusion

Based on the preliminary results, it appears to be possible to make a proper estimation of gaseous emissions from NVH while animals are partly not present in the NVH. These methodologies are expected to enhance the current protocols for emission measurement in NVH and to facilitate the implementation of mitigation strategies. Additional analysis will bring further insights on these conclusions.

Acknowledgements

The authors acknowledge the ministry of LVVN for funding this project and the farmers who contributed to data collection.

References

Werkgroep richtlijnen emissies veehouderij, 2024. Richtlijnen voor het bepalen van emissies uit veestallen (versie 2) [Guidelines for determination of emissions from livestock barns (version 2)]. Wageningen Livestock Research, Openbaar Rapport 1525. https://doi.org/10.18174/678752.

12. Ammonia emissions from dairy barns when cows share their time between barn and pasture

Edouard, N.[a*], Delagarde, R.[a], Robin, P.[b] & Vergé, X.[c]

INRAE UMR PEGASE, France [a]; INRAE UMR SAS, France [b]; IDELE, France [c]; *Corresponding author, email: nadege.edouard@inrae.fr

Introduction

Grazing is considered as a feeding strategy to reduce ammonia emissions compared to full housing, while playing a role in the looping of CNP cycles and contributing to the provision of ecosystem services (Dumont et al., 2016). However, several times during the year (dietary transition, insufficient pasture growth rate, farmer's strategy), cows can spend some hours per day in the barn where conserved forages and concentrates may be fed in addition to grazing. In these mixed situations, the cows divide their time between the pasture, where the dejections fall directly onto the ground, and the building, where the manure has to be collected and stored, with various impacts on the environment. The aim of this study was to measure ammonia emissions from dairy barns comparing full time housing (FullHouse treatment) with day-time grazing (PartGraze treatment) managements.

Methodology

Two groups of 3 lactating cows were housed in closed rooms with dynamic ventilation for 3 3-week periods in autumn 2022. The two treatments were compared in a double reversal design (FullHouse-PartGraze-FullHouse, and conversely). In FullHouse, the cows were fed *ad libitum* a total mixed ration (TMR) based on maize silage and concentrates (75:25). In PartGraze, the cows were at pasture 8 h/day, between 8:00 and 16:00; they spent the remaining 16 hours in the room where they received a fixed amount of 8 kg DM of TMR. Daily DM intake was calculated at the group level, weighing offered and refused DM amounts at trough and using the HerbValo method for grazed pasture (Delagarde et al., 2017). Individual milk yield was measured daily. Ammonia emissions were measured in the barn (5 days, morning and evening measurements) and during manure storage (15 days) from NH_3 spot concentration measurements with Dräger tubes and the application of the "Simplified Method", based on the carbon mass balance at the room or manure pen levels (Vergé et al., 2023). Manure was manually scrapped in the rooms twice a day and samples were analysed to determine its composition.

Results and discussion

Diet CP concentration was 140 g/kg DM in FullHouse compared with 220 g/kg DM in PartGraze due to the high pasture CP content (26 %CP). Cows in FullHouse ingested 25.2 kg DM/day and produced 36.8 kg milk/day, significantly more than cows in PartGraze, which ate 21.9 kg DM/day and produced 32.2 kg of milk/day. Manure N content was significantly lower for FullHouse than for PartGraze (36.9 vs. 45.7 g N/kg DM). Ammonia emissions at barn averaged 1.26 vs. 1.72 g NH_3/h/cow for FullHouse and PartGraze, respectively. In relation to the time the cows spent in the rooms, this corresponded to 30.2 vs 27.5 g/cow/day for FullHouse (24 h/day) and PartGraze (16 h/day) respectively, i.e. fairly similar levels. However, in PartGraze, ammonia emissions were 4 times greater in the morning before the cows went out than in the evening after they returned.

Conclusion

Hourly ammonia emissions in the building were greater in PartGraze, due to the greater manure N content, but ammonia emissions were equivalent between treatments once the time the cows were at barn was considered. Barn emissions were clearly influenced by the time of day at which the measurements were taken, and can be very high in the morning before the manure is scrapped. In addition to these emissions measured at the barn and storage, emissions from manure spraeding and grazing must also be considered (see Edouard et al. companion abstract).

Acknowledgements

The authors thank ADEME (EMIGRAZE project) and the EU FP7 program (CCC farming project) for financial support.

References

Dumont B. et al. 2016. Rôles, impacts et services issus des élevages en Europe. Synthèse de l'expertise scientifique collective. INRA, France.

Delagarde R., et al. 2017. HerbValo, une méthode pour estimer dans chaque parcelle la quantité d'herbe valorisée par les ruminants au pâturage. Fourrages n°229, p. 55-61.

Vergé X., et al. 2023. Simplified method developed for estimating the on-farm GHG and NH3 emissions - Presentation and Results. 74th Annual Meeting of European Federation of Animal Science. Lyon, France.

13. Farm-scale ammonia fluxes from cattle housing and slurry storage in Switzerland

Valach, A.C.[a*], Häni, C.[a], Qin, W.[a], Bowald, S.[a] & Kupper, T.[a]

School of Agricultural, Forest and Food Sciences HAFL, Bern University of Applied Sciences, Switzerland *Corresponding author, email: alex.valach@bfh.ch

Introduction

Animal housings and slurry storages significantly contribute to ammonia emissions from livestock. External factors such as meteorology, farm design, and management activities contribute to considerable variability in emissions across the short- as well as long-term. Measurements using methods that disrupt daily operations are helpful but cannot be maintained for longer periods to capture the full range of influencing factors. The benefit of the inverse dispersion method (IDM) allows long-term monitoring of farm-scale emissions under representative conditions. However, this method may become limited if background concentrations are high. Detecting the elevated concentrations in the downwind plume may become challenging if they are only marginally higher than the background. This is particularly an issue in Switzerland, where production areas generally have high livestock densities and therefore high background concentrations. Here we present initial results from long-term measurements of total ammonia emissions from a cattle housing with a slurry storage tank using IDM in an area with high livestock densities in Switzerland. We investigate the sources of variability including impacts of deposition on the flux dynamics of ammonia.

Methodology

Ammonia concentrations were measured using miniDOAS instruments placed up- and downwind of a dairy farm to encompass the housing (55 dairy cows) with an exercise yard and storage tank (a 15 m diameter uncovered circular tank) under consistent wind conditions. The slurry tank receives additional pig slurry each spring. The long-term passive sampler measurements show that this area boasts some of the highest ammonia concentrations in Switzerland with an annual average >10 µg/m^3 (Seitler and Meier 2023). Following established IDM principles (Valach et al. 2023), the total emissions are calculated from the defined source areas. Since the instruments need to be placed at a distance from the sources, the resulting depositional loss must be accounted for (Häni et al. 2018). Measurements encompass multiple campaigns of 1-2 months for multiple seasons including typical weather and management activities.

Results and discussion

Our results so far reveal clear concentration increases in the downwind plume and therefore valid emissions could be calculated. Expected impacts of wind speed and temperature across seasons on emission variability are discussed as well as the relevance of deposition to the measurement with distance to the source.

Conclusion

Farm-scale measurements of ammonia emissions across all seasons and conditions are vital to understand sources of emission variability to be able to assess the efficacy of mitigation methods under real-world conditions. Also, the inclusion of corrections for short-range deposition for measurements and modelling requires closer investigation.

Acknowledgements

We would like to acknowledge the Swiss National Science Foundation for funding this research (Project CRSII--222799) and thank the farmer for their generous collaboration.

References

Häni, C. et al. 2018. Accounting for Field-Scale Dry Deposition in Backward Lagrangian Stochastic Dispersion Modelling of NH3 Emissions. *Atmosphere* 9 (4), p. 146. DOI: 10.3390/atmos9040146.

Seitler, E. and Meier, M. 2023. Ammoniak-Immissionsmessungen in der Schweiz: 2000 bis 2022. FUB - Forschungsstelle für Umweltbeobachtung.

Valach, A. C. et al. 2023. Ammonia emissions from a dairy housing and wastewater treatment plant quantified with an inverse dispersion method accounting for deposition loss. *J. Air. Waste. Manag. Assoc.* DOI: 10.1080/10962247.2023.2271426.

14. Effectiveness of acidification in reducing ammonia emissions from dairy slurry and digestate during storage

Dabiri, A. [a, b *], Baral, K. [b], Gilfedder, T. [b], Theodoridou, K. [a] & McIlroy, J. [b]

[a] Queen's University Belfast, Belfast, UK; [b] Agri-Food and Biosciences Institute, Hillsborough, UK;
* Corresponding author, email: adabiri01@qub.ac.uk

Introduction

Anaerobic digestion of animal manure has gained interest due to biogas and nutrient-rich digestate production, and lowering methane emissions during slurry storage. Digestate can be separated into liquid and solid fractions to enrich the nutrient content in each fraction and rationally utilized in the field. However, improper management of liquid digestate during storage and field application can lead to considerable ammonia (NH_3) losses (Balde et al., 2018, Holly et al.,2017). Slurry acidification has been evaluating against its effectiveness to lower NH_3 volatilisation and stabilise nitrogen under laboratory to pilot-scale storage facility. However, acidification of slurry in a large volume during storage is challenging; thus, most of the acidification study perform under small volume of the slurry. The results from laboratory scale trials are challenging to scale to farm level. This study evaluates the effectiveness of acidification as an NH_3 mitigation strategy during slurry storage at meso-scale under realistic storage periods and conditions.

Methodology

Eighteen underground tanks of 1 m^3 capacity used to storage 700 litres of slurry under pilot-scale facility of AFBI-Hillsborough. The storage facility has open-circuit chambers to measure gas emissions continuously across six treatments with three replicates. The treatments were: standard dairy slurry (control), digestate, liquid digestate, acidified slurry, acidified digestate, and acidified liquid digestate. Treatments were randomly assigned to the tanks. The fresh slurry was collected from an underground dairy storage tank, and digestate was obtained from an anaerobic digester plant. The liquid digestate was separated using a screw press separator. Acidification was performed manually to a pH of 5.5 using 50% sulfuric acid. NH_3 concentrations were continuous monitored over a 99-day storage period using photoacoustic gas analyser (INNOVA 1512). Three gas samples were taken at two-minute intervals from each tank before the system switched to the next tank. Once sampling was completed for the first 9 tanks out of 18, three ambient air samples were taken before proceeding to the next 9 tanks, followed by another set of three air samples. Airflow and air temperature were recorded every minute using an air velocity transmitter positioned above the sampling point to correct emission concentrations.

Results and discussion

Liquid digestate had the highest cumulative NH_3 emissions (405.8±19.2 g N/m^2), followed by digestate (280.7±6.4 g N/m^2) and slurry (191.3±11.2 g N/m^2). With acidification, the acidified liquid digestate had the lowest emissions (43.3±9.0 g N/m^2), followed by acidified digestate (65.3±14.8 g N/m^2) and acidified slurry (69.7±16.3 g N/m^2). Expressing in NH_3 reduction efficiency during slurry storage acidified liquid digestate reduce emissions by 77% followed by acidified digestate (66%) and acidified slurry (64%). Conversely, liquid digestate and digestate showed significant increases in NH_3 emissions (112% and 47%, respectively). Acidification significantly reduced NH_3 emissions across all treatments.

Conclusion

In conclusion, storage of cattle slurry or digestates without treatments can be a potential source of NH_3 emissions in the environment. With acidification, NH_3 volatilization can be effectively reduced across slurry, digestate or digestate fractions to reduce the environmental problems.

References

Balde, H., et al. 2018. Ammonia emissions from liquid manure storages are affected by anaerobic digestion and solid-liquid separation. Agricultural and Forest Meteorology. 258, 80-88.

Holly, M., et al. 2017. Greenhouse gas and ammonia emissions from digested and separated dairy manure during storage and after land application. Agriculture Ecosystems & Environment. 239, 410-419.

15. Electrochemical Ammonia Stripping to Recover Ammonia Nitrogen from Liquid Dairy Manure

Chen, L.[a*] & Das, A. K.[b]

Professor, Department of Soil and Water Systems, Twin Falls Research and Extension Center, University of Idaho, Twin Falls, ID-83301, USA[a]; Ph.D. Student, Environmental Science Program, College of Natural Resources, University of Idaho, Moscow, ID-83844, USA [b]; *Lide Chen, email: lchen@uidaho.edu

Introduction Ammonia nitrogen (NH_3-N) present in liquid dairy manure (LDM) could negatively impact the environment if it is not treated properly [1]. Existing technologies to recover NH_3-N from LDM can be expensive and energy intensive. Electrochemical stripping improved traditional ammonia stripping through elevating pH levels without adding alkaline solution and conducting internal NH_3-N stripping without the requirement of a stripping tower [2]. The process involves utilizing electric current to produce hydroxyl ions (OH^-) which increase the pH of the catholyte, and a gas permeable hydrophobic membrane is employed to extract NH_3-N from LDM. The aim of this research was to investigate the electrochemical NH_3-N recovery from LDM, focusing on the mechanisms and efficiency of NH_3-N recovery, and the energy requirements.

Methodology First, a three-chamber electrochemical ammonia stripping system (EAS) was designed and fabricated. In the three-chamber EAS, the anode and cathode compartments were divided by a cation exchange membrane (CEM), while the cathode and recovery compartments were separated by a hydrophobic gas-permeable membrane (GPM) to facilitate membrane stripping. The EAS system utilized the naturally generated acid in the anolyte and the naturally produced base in the catholyte to help transform free ammonia via GPM, which was then recovered in the recovery compartment. We tested various current densities (0, 50, 100, and 150 A/m^2) to investigate the underlying mechanisms and assess the efficiency of NH_3-N recovery, while also examining how the pH of the anolyte and catholyte changed during the process. Additionally, we measured nitrogen flux passing through the membrane over time in relation to specific energy consumption.

Results and discussion The distribution of NH_3-N across the three compartments was significantly affected by the applied current density. Higher current densities improved NH_3-N recovery efficiency. At 0 A/m^2 current density, the pH of anolyte and catholyte remained unchanged, and NH_4^+ diffusion was primarily driven by the concentration gradient in the EAS system. The NH_3-N recovery efficiency at 0 A/m^2 was 9%, which was relatively low. In contrast, at 150 A/m^2 current density, the NH_3-N recovery efficiency rose to 75%. The EAS system achieved a maximum nitrogen flux of 616.13 g N/m^2d with an energy consumption of 0.05 kWh/g N recovered. According to Faraday's law of electrolysis, higher current densities accelerate electrochemical reactions at the electrodes [3]. This promotes the generation of OH^- ions at the cathode through water electrolysis ($2H_2O + 2e^- \rightarrow H_2 + 2OH^-$), increasing the catholyte pH. This alkaline environment converts ammonium ions into free ammonia ($NH_4^+ + OH^- \rightarrow NH_3 + H_2O$), which then migrates through GPM. Subsequently, the recovered ammonia reacts with sulfuric acid in the recovery compartment to form ammonium sulfate [$(NH_4)_2SO_4$].

Conclusion The designed EAS system's authigenic acid and base enhanced NH_3-N recovery from LDM. Up to 75% of NH_3-N recovery efficiency with 0.05 kWh/g N energy consumption was achieved at a 150 A/m^2 current density. This system exhibits to be a promising technology for NH_3-N recovery from LDM. Further research is needed to explore its application on a large scale.

Acknowledgements This research was partially funded by the USDA NIFA Sustainable Agricultural Systems Program through the Idaho Sustainable Agriculture Initiative for Dairy (ISAID) grant (Award No. 2020-69012-31871).

Reference Pang, N., et al. 2020. Recycling of nutrients from dairy wastewater by extremophilic microalgae with high ammonia tolerance. Environ. Sci. Technol. 54(23), 15366-15375. Tarpeh, W.A., et al. 2018. Electrochemical stripping to recover nitrogen from source-separated urine. Environ. Sci. Technol. 52(3), 1453-1460. Lin, X., et al. 2018. Struvite precipitation from biogas digestion slurry using a two-chamber electrolysis cell with a magnesium anode. J. Clean. Prod. 174, 1598-1607.

16. Assessment of the nutrient value of slurry post-storage with a methane mitigating additive, and implementation of the additive at full scale

O'Neill, W.K.[a] and Hughes, D.[b], Nolan, S.[b], Thorn, C.E.[b*], Williams, P.[a], Chin. J.[a], McGrath, J.[a] & O'Flaherty, V.[b,c]

Queen's University Belfast, NI [a]; Glasport Bio, Ireland [b]; University of Galway, Ireland [c]; *Corresponding author, camilla@glasportbio.com

Introduction

Livestock manures, such as slurry, are valuable sources of crop nutrients, however during storage they release significant greenhouse gas (GHG) and ammonia (NH_3) emissions, representing more than 10% of agricultural GHG emissions (Shukla et al., 2019) and the majority of agricultural NH_3 emissions. In addition to impacting the environment and human health (Wyer et al. 2022), these emissions represent losses of nitrogen and carbon, thereby lowering the nutrient value of slurry and precluding the closing of nutrient loops (Marques-dos-Santos et al., 2023). Slurry additives represent a valuable means of mitigating emissions, thereby potentially retaining their maximum fertiliser value. GasAbate is a peroxide-based slurry additive, which has successfully reduced emissions in dairy and pig slurry, however its effects upon crop uptake following pig slurry application have not been assessed. To this end, a 5-month pot trial was set up to assess grass yields from fertilisation with untreated (UT) or GasAbate treated (AT) pig slurry post storage. Additionally, farm-scale implementation of this slurry additive was performed in order to assess the feasibility of retro-fitting a delivery system.

Methodology

To assess plant growth, slurry from a 750L emissions trial (Nolan et al,. 2023) was sampled after 30 days storage. Two soil types, with varying organic matter and nutrient content, were used to fill 10L pots and perennial ryegrass was sown. UT and AT slurry were surface applied and compared to a mineral control. Harvests were performed by cutting grass to the 1cm line on days 44, 83, 118 and 154, where nutrients were re-applied 3 days after each harvest day. Relative chlorophyll content was assessed and grass was dried to give dry matter yield. For full scale implementation of GasAbate slurry treatment, liquid additive was applied through a series of stainless-steel delivery tubes which fit between the slats of existing shed flooring and sit near the base of the slurry tank. Delivery tubes were serviced by pumping additive from $1m^3$ bulk containers through a manifold, to ensure equal distribution. Pump control was based on slurry depth and achieved using a programmable logic controller.

Results and discussion

In terms of additive effects on plant yields, while AT slurry had no effect on chlorophyll content versus UT slurry, dry matter yield consistently showed significant differences across treatments. AT exhibiting the highest yield across all growth periods for both soil types. This varied across the growth periods, but across the entire growing season, the cumulative yield from AT (18.3 t DM ha^{-1}) exceeded that from UT (15.8 t DM ha^{-1}; a 21.2% increase; $p < 0.001$). In the lower OM soils, cumulative yields were lower, but again yields from AT (16.6 t DM ha^{-1}), exceeded those from UT (13.8 t DM ha^{-1}; a 20.3% increase; $p < 0.001$). Prototype delivery systems were developed for both pig and dairy farm settings which enable slow, controlled delivery of the additive to prevent foaming. When scaled to multiple farms, this delivery system would be cost-effective to the farmer, particularly when considering the increased value of the treated manure

Conclusion

Yield improvements when using additive treated versus untreated stored slurries demonstrated that by reducing gaseous losses, the nutrient value of the slurry was retained. As the onward use of the slurry was not negatively impacted by the additive, the next phase of full-scale implementation began and was successfully achieved. Together this work demonstrates the progression from successful experimental scale work (Nolan et al,. 2023) to full-scale use of GasAbate, a peroxide-based slurry additive.

References

Marques-dos-Santos, C., et al. 2023. Available Technical Options for Manure Management in Environmentally Friendly & Circular Livestock Production. In *Technology for Environmentally Friendly Livestock Production* (pp. 147-176). Cham: Springer International. Nolan, S., et al. 2024. Scale-up of a peroxide-based pig slurry additive for gaseous emission reduction and downstream value retention. *Cleaner Environmental Systems*, *12*, p.100157.

Shukla, P.R., et al. 2019. IPCC: Climate Change & Land: an IPCC Special Report on Climate Change, Desertification, Land Degradation, Sustainable Land Management, Food Security & Greenhouse Gas Fluxes in Terrestrial Ecosystems. https://www.ipcc.ch/srccl/. Wyer, K.E., et al. 2022. Ammonia emissions from agriculture and their contribution to fine particulate matter: A review of implications for human health. *Journal of Environmental Management*, *323*, p.116285.

17. On-farm evaluation of near-infrared spectroscopy sensor accuracy for organic liquid manure analysis using a mobile measuring station

Olfs, H.-W.[a*]& Höpker, C.[a]

University of Applied Sciences Osnabrück, Germany [a]; *Corresponding author, email: h-w.olfs@hs-osnabrueck.de

Introduction

The nutrient composition of liquid organic fertilizers (LOM) varies due to factors such as feed, animal species and storage conditions. Although the tabulated values provided by the official advisory services are directly available, they often lead to inaccurate information on nutrient content and correspondingly incorrect LOM application rates. Laboratory analyses provide accurate data, but the collection of LOM samples is time-consuming, laboratory analysis is expensive and the delivery of laboratory results to the farmers takes a rather long time. Alternative real-time methods are needed for accurate nutrient assessment in LOMs on-farm to enable sustainable, environmentally sound fertilization with LOMs (Saeys et al. 2019). Under laboratory conditions, near-infrared spectroscopy (NIRS) is a well-established, fast and non-invasive method for analysing dry matter and nutrient content in LOMs, but its accuracy in on-farm use depends on factors such as sample composition, calibration models and measurement conditions, which is a challenge in practical application (Höpker et al. 2025; Olfs 2024).

Methodology

Repeated on-farm NIRS measurements were carried out over a period of 2 years in northern and southern Germany using two identical mobile measuring stations, each equipped with two NIRS systems (a "VanControl 2.0" from Zunhammer and a "HarvestLab 3000" from John Deere). Before each NIRS measurement, the LOMs were homogenized by pumping them around in the mobile measuring station until the NIRS devices displayed a constant value. The measurements were then started simultaneously for both sensors and recorded for one minute. In parallel to the NIRS measurements, a total of 586 slurry samples (204 pig slurry, 198 cattle slurry and 184 biogas digestate) were taken as reference samples for laboratory analysis and analysed for the parameters dry matter (DM), total nitrogen (TN), ammonium nitrogen (NH_4-N), total phosphorus (TP) and total potassium (TK).

Results and discussion

As was to be expected for samples from a survey study, the samples analysed in the laboratory show considerable variability for the investigated parameters DM, TN, AN, TP and TK for both northern and southern Germany. The repeated NIRS measurements on individual farms show similar patterns as for the laboratory data, although in some cases at very different levels. The correlations between the laboratory data and the NIRS data were between $R^2 = 0.58$ and $R^2 = 0.92$ for the detection of DM in pig and cattle manure, depending on the region, while the R^2 values for DM in biogas digestate were significantly lower. For the other parameters, the measurements in northern Germany often resulted in very low R^2 values (< 0.5), while the correlations in southern Germany often resulted in acceptable R^2 values (> 0.5).

Conclusion

Overall, the results of the survey study show that the correlations between the lab and the NIRS values (with the exception of the DM data) are nowhere near good enough for a viable on-farm application. The better correlations in southern compared to northern Germany indicate that a regionalization of the calibration of the NIR sensors might be advisable. Since the differences in nutrient concentrations are large, it seems important to correctly classify the LOM to be measured before measuring with an NIR sensor (pig manure, cattle manure, biogas digestate) and to consider special production conditions (e.g., P-reduced feed rations in pig production).

References

Höpker, C., et al. 2025. On-farm application of near-infrared spectroscopy for the determination of nutrients in liquid organic manures: Challenges and opportunities. Agriculture 2025, 15, 185. https://doi.org/10.3390/agriculture15020185.

Olfs, H.-W., 2024. Improving the use of liquid farm-based manures in arable farming. IFS Proceedings 895, 1-36

Saeys, W. et al. 2019. The role of NIR spectroscopy in precision fertilisation with manure. IFS Proceedings 840, 1-22.

18. Optimization strategies for organic fertilizer use in a seven-year field trial: Part I - Nitrogen use efficiency and soil quality

Bünemann, E.K.[a*], Agostini, L.[a], Efosa, N.[a], Kundel, D.[a], Weber, C.J.[b], Bigalke M.[b], Diener, M.[c] and Mayer, J.[c]

Research Institute of Organic Agriculture (FiBL), Switzerland [a]; Technical University of Darmstadt, Germany [b]; Agroscope, Switzerland [c];
[*]Corresponding author, email: else.buenemann@fibl.org

Introduction

Anaerobic digestion of manure and organic wastes contributes to closing nutrient cycles while generating renewable energy. The use of digestates in organic farming can alleviate nutrient deficits, especially of nitrogen (N), if potential trade-offs with respect to N losses are known and managed properly. Biochar has been advocated as a mean to decrease N losses from agroecosystems and improve soil quality. The aim of this study was to understand the benefits and trade-offs of using digestates and biochar amendments compared to undigested liquid manure or mineral N, in particular with respect to N losses, N use efficiency and soil quality.

Methodology

In a field experiment in Switzerland lasting seven years, a liquid digestate from manure with and without biochar amendments, a liquid digestate from communal organic wastes and a corresponding solid digestate composted with and without biochar amendments were compared to undigested liquid manure, mineral fertilization and a zero N control. We assessed yields, apparent N use efficiency (NUE), ammonia (NH_3) losses, N input-output budgets and soil parameters such as pH, total organic carbon, total N, microbial biomass and occurrence of microplastics in soils and fertilizers.

Results and discussion

Yields were typically lower in the zero N control and treatments with solid digestate than in treatments with liquid digestate, liquid manure and mineral N. Total N uptake into the aboveground biomass with mineral N fertilization, however, surpassed N uptake in all other treatments. Losses of NH_3 from liquid digestates contributed to their reduced N use efficiency, while limited N availability was the main reason for strongly reduced N use efficiency of solid digestates, leading to positive soil-surface N budgets. Biochar amendments did not alter N use efficiency of the respective liquid or solid digestates, but increased soil C stocks. Soil quality was generally increased by solid digestates, illustrating their role as soil improvers rather than fertilizers, except for a potential increase in N leaching potential. Liquid organic fertilizers contributed to maintenance of soil quality, while a decrease in soil pH, microbial biomass and soil organic C was observed in the absence of organic fertilization. Microplastics were found both in digestates, fertilized soils and in the control soil. The contribution of microplastic inputs with digestates over the duration of the trial were estimated to reach a maximum of 3.6% of topsoil microplastic stocks, indicating the importance and persistence of past inputs either from sewage sludge or diffuse sources such as littering or atmospheric deposition.

Conclusion

This comprehensive study on the agronomic value and management of digestates from Swiss biogas plants shows how the benefits of by-products from biogas production can be used while minimizing trade-offs with respect to nutrient losses and soil quality. Greenhouse gas emissions and nitrate leaching are presented in parts II and III.

Acknowledgements

This work was funded by the Swiss Federal Offices of Energy, for the Environment and for Agriculture.

References

Efosa, N., et al. In revision. Ammonia emissions after trailing hose application of digestates and cattle slurry. Nutrient Cycling in Agroecosystems.

Weber, C.J., et al. Submitted. Microplastic baseline concentration in agricultural soil outweighed the impact of recycling fertilizer application from biogas production. Environmental Science and Ecotechnology.

19. Optimization strategies for organic fertilizer use in a seven-year field trial: Part II – Greenhouse gas emissions

Agostini, L.[a, c*], Efosa, N.[a], Krause, H.-M.[a], Diener, M.[b], Mayer, J.[b] & Bünemann, E. K.[a]

Research Institute for Organic Agriculture, Switzerland [a]; Agroscope, Switzerland [b]; ETH Zürich, Switzerland [c]; *Corresponding author: Lucilla Agostini, lucilla.agostini@fibl.org

Introduction

Biogas production from organic side-streams enables to unleash the energetical potential of biomass while contributing to closing nutrient cycles and reducing methane emissions from farmyard manure. To mitigate the higher risk of mineral nitrogen losses from anaerobically digested liquid organic fertilizers and optimize their nitrogen use efficiency, further treatment is desirable. Promising optimization approaches are biochar amendments, in-field acidification and ammonium-stripping. In order to comprehensively evaluate those optimization approaches and avoid the risk of pollution swapping, the assessment of their climate impact is crucial. The aim of this study was to assess greenhouse gas emissions from optimized liquid organic fertilizers over multiple growing seasons under field conditions.

Methodology

Greenhouse gas emissions were measured in a Swiss field trial over seven years featuring a split-plot design with four blocks and an arable crop rotation without legumes. The trial included two control treatments (zero N fertilization, mineral fertilization), cattle slurry, digested slurry with and without biochar (2 t ha^{-1} a^{-1}) and liquid digestate. Additionally, in the last two trial years in-field acidification (sulfuric acid, pH 6-6.5) and ammonium-stripping were applied to cattle slurry and digested slurry. Nitrous oxide and methane emissions were measured weekly throughout the growing season over a total of 4.5 years using closed static chambers and gas chromatography. Data were analysed using a machine learning approach combining extreme gradient boosting and Shapley additive explanations (SHAP).

Results and discussion

Over a 4.5-year observation period, farming operations were the main drivers of nitrous oxide and methane fluxes. In particular, fertilization, tillage and harvest operations lead to elevated nitrous oxide emissions. Cumulatively over the growing season, digestates often showed lower greenhouse gas emissions compared to cattle slurry as a result of decreased nitrous oxide emissions following farming operations and lower methane emissions at application. Biochar did not significantly affect nitrous oxide emissions from agricultural digestate, but significantly increased short-lived methane emissions at application. However, results from experiments carried out under controlled conditions suggest that biochar does not increase overall methane emissions from agricultural digestate, but rather temporally shifts them from the storage period to the moment of application. Over a two-year observation period, applying in-field acidification and ammonium-stripping to cattle slurry and digested slurry did not significantly alter their cumulative nitrous oxide and methane emissions. However, in-field acidification decreased nitrous oxide emissions following tillage and harvesting operations and increased methane emissions at fertilization, in particular for digested slurry. Ammonium-stripping did not affect nitrous oxide emissions, but increased methane oxidation over the growing season.

Conclusion

Our greenhouse gas emission monitoring over multiple growing seasons showed that anaerobic digestion has the potential to reduce the climate impact of liquid organic fertilizers. Furthermore, it indicates that treating liquid organic fertilizers with biochar amendments, in-field acidification or ammonium-stripping does not increase overall greenhouse gas emissions following their application, but can significantly alter short-lived emission peaks resulting from critical farming operations.

Acknowledgements

This work was funded by the Swiss Federal Offices for Agriculture, for the Environment and for Energy.

References

Efosa, N., et al. 2023. Emissions of nitrous oxide and methane after field application of liquid organic fertilizers and biochar. Agriculture, Ecosystems & Environment, 356, 108642.

20. Optimization strategies for organic fertilizer use in a seven-year field trial: Part III – Nitrate leaching in a parallel lysimeter study

Diener, M.[a*], Agostini, L.[b], Spiess, E.[a] Liebisch F.[a], Bünemann, E.K.[b] & Mayer, J.[a]

Agroscope, Switzerland [a], Research Institute of Organic Agriculture (FiBL), Switzerland [b]; *Corresponding author: Matthias.diener@agroscope.admin.ch

Introduction

The use of nitrogen (N) in agriculture is key to guarantee high yields and ensure food security. However, N is very susceptible to being lost to groundwater via nitrate (NO_3^-) leaching (Zhou & Butterbach-Bahl, 2014). Nitrate leaching can contribute significantly to N losses with annual mean rates often exceeding 50 kg N ha^{-1}, heavily depending on crop rotation and management (Spiess et al., 2020). Manure is thought to be a major contributor to NO_3^- leaching, since organic N might be mineralised asynchronously to the crop N demand (Sørensen & Jensen, 2013). However, Frick et. al (2022) found that most of leached N did not originate from fertilizer application in the short term, but from soil N stocks. In a lysimeter trial in Switzerland, N leaching from liquid organic fertilizers was assessed over seven years (2018-2024).

Methodology

The experiment was conducted at the Agroscope lysimeter facility in Zurich (Switzerland, 445 m a.s.l., 1054 mm mean annual precipitation, 9.4 °C mean annual temperature) on undisturbed Cambisol soil monoliths with a surface of 1 m^2 and a depth of 1.5 m. The experimental design involved four treatments with three replications: untreated slurry (SLU), anaerobically digested slurry (SLA), liquid digestate from municipal green waste (LID) and a zero-N fertilization control (NON). Fertilization was carried out according to the official Swiss recommendations, based on total N in two consecutive crop rotations. Crop management followed the principles of organic farming, thus without the use of synthetic plant protection products. Seepage volumes were recorded with tipping buckets and flow-proportional water samples were analysed for NO_3-N with a continuous flow analyser every 2nd week, when enough water was leached.

Results and discussion

Seepage volume was consistently higher in NON than in organic liquid fertilizers treatments, averaging 467 ± 15 mm annually. The leached NO_3^- over the experimental period was highest under SLA with 134 ± 22 kg N ha^{-1}, followed by NON with 125 ± 22 kg N ha^{-1} and significantly higher than LID with 88 ± 6 kg N ha^{-1} (Tukey-HSD, p-value < 0.05). There were strong seasonal patterns in NO_3^- observable between summer and winter, as well as between years. However, mean annual rates of leached NO_3 were relatively low for all treatments, ranging from 13 kg N ha^{-1} yr^{-1} (LID) to 20 kg N ha^{-1} yr^{-1} (SLA) across the entire experimental period.

Conclusion

In this experiment NO_3^- leaching from liquid organic fertilizers was relatively minor. Nitrate loads across the entire experiment were comparable between SLA, SLU and NON, suggesting that fertilization had little impact on nitrate leaching within the experimental period. Fertilization with liquid digestate (LID) decreased NO_3^- leaching compared to NON, indicating that an appropriate fertilization can prevent N losses through NO_3 leaching by enhancing N uptake of well-nourished crops. Overall, the findings indicate that the leaching potential of liquid organic fertilizers was low under the applied fertilization strategy.

Acknowledgements

This project received funding from the Swiss Federal Office for Agriculture (FOAG), the Swiss Federal Office for the Environment (FOEN) and Swiss Federal Office of Energy (SFOE).

References

Frick, H., Oberson, A., Frossard, E., & Bünemann, E. K. (2022). Leached nitrate under fertilised loamy soil originates mainly from mineralisation of soil organic N. Agriculture, Ecosystems & Environment, 338, 108093. https://doi.org/10.1016/j.agee.2022.108093

Sørensen, P., & Jensen, L. S. (2013). Nutrient Leaching and Runoff from Land Application of Animal Manure and Measures for Reduction. In Animal Manure Recycling (S. 195–210). https://doi.org/10.1002/9781118676677.ch11

Spiess, E., Humphrys, C., Richner, W., Schneider, M. K., Piepho, H.-P., Chervet, A., & Prasuhn, V. (2020). Does no-tillage decrease nitrate leaching compared to ploughing under a long-term crop rotation in Switzerland? Soil and Tillage Research, 199, 104590. https://doi.org/10.1016/j.still.2020.104590

Zhou, M., & Butterbach-Bahl, K. (2014). Assessment of nitrate leaching loss on a yield-scaled basis from maize and wheat cropping systems. Plant and Soil, 374(1), 977–991. https://doi.org/10.1007/s11104-013-1876-9

Parallel session 4

1. Particulate matter concentrations and emissions at a swine farrowing building during winter

Ni, J.-Q. [a*], Fisk, A. E. [b], Kim, J. H. [a], Klassen, K. E. [b], Sachdeva, R. [a], Han, S. [c], Park, J. H. [c], Richert, B. T. [b]

Department of Agricultural and Biological Engineering, Purdue University, USA [a]; Department of Animal Sciences, Purdue University, USA [b]; School of Health Sciences, Purdue University, USA [c]; * Corresponding author. Email Address: jiqin@purdue.edu.

Introduction

Air quality in confined animal feeding operations affects the safety, health, productivity, and behaviour of animals, as well as the health of workers. The concentrations and emissions of air pollutants in livestock buildings are significantly influenced by various factors, including animal species, building structure, and seasonal variations. Particulate matter (PM) is one of the most critical pollutants in animal environments. However, limited research has been conducted on $PM_{2.5}$ (≤ 2.5 µm) and PM_{10} (≤ 10 µm) in swine farrowing buildings. This study aimed to characterize $PM_{2.5}$ and PM_{10} concentrations and emissions in a swine farrowing building during the winter season.

Methodology

The study was conducted in an environmentally controlled experimental swine farrowing room with 12 pens (one sow and one litter per pan) during the winter of 2024. Twelve sows were moved into the room on November 15. Farrowing began on November 18, and all piglets were weaned on December 10. The sows were weighed twice, and the piglets were weighed three times throughout the farrowing cycle.

Concentrations of $PM_{2.5}$ and PM_{10} were continuously measured using four optical PM sensors, with two sensors placed near the inlets of each of the two wall fans. Ventilation air speeds were continuously monitored using four anemometers, two at each fan. Additional measurements included indoor and outdoor temperature, relative humidity, pig activity, and in-room heater operation. Air quality and environmental data were recorded every minute. The collected data were analysed at 1-minute intervals and averaged over 10-minute, hourly, and daily periods to characterize the dynamics of air quality and environmental conditions in the farrowing room.

Results and discussion

During the study, hourly mean outdoor air temperatures ranged from −7.1 to 19.8 °C, with an average of 5.5 ± 6.6 °C (average ± standard deviation). The average indoor temperature and relative humidity were 20.8 ± 1.0 °C and 56.7 ± 5.7%, respectively. Because of the low outdoor temperatures in winter, only one of the wall fans, a variable-speed fan, operated continuously throughout the study. The hourly mean ventilation rates ranged from 1052 to 1971 $m^3\ h^{-1}$, with an average of 1651 ± 112 $m^3\ h^{-1}$.

Concentrations of $PM_{2.5}$ and PM_{10} in the room showed a sharp increase on the day farrowing began, followed by a gradual rise as the piglets grew. Each pen housed between 10 and 13 nursing piglets. Pig activity was observed to be the main cause of PM generation and diel variations in PM concentrations. Some room operations also caused short-term spikes in PM concentrations. A sudden drop in PM levels was recorded on the day the piglets were weaned, and all pigs were removed from the room. The average $PM_{2.5}$ concentration during the study was 37.7 ± 19.4 µg m^{-3}, and the average PM_{10} concentration was 363.7 ± 204.7 µg m^{-3}. Temporal patterns of PM emissions were similar to those of PM concentrations because of the relatively stable ventilation rates maintained during winter. The hourly mean $PM_{2.5}$ emission rates ranged from 0.75 to 44.46 mg h^{-1} AU^{-1} (animal unit = 500 kg animal mass), with an average of 11.0 ± 5.0 mg h^{-1} AU^{-1} during the entire study. The hourly mean PM_{10} emission rates ranged from 2.14 to 278.4 mg h^{-1} AU^{-1}, averaging 105.4 ± 53.3 mg h^{-1} AU^{-1}.

Conclusion

Concentrations and emissions of PM varied between day and night and increased gradually from farrowing to weaning. These variations were influenced by the birth and growth of piglets and the intensity of pig activities. The quantity and patterns of PM concentrations and emissions revealed in this study provide new insights into the farrowing building environment and could contribute to improved air quality management and enhanced animal welfare.

Acknowledgements

This study was supported by the Foundation for Food and Agriculture Research and the National Pork Board under Grant ID: 22-000290.

2. Machine learning: A New Approach for Predicting Ammonia Emissions from Digestate Storage

Firmino, M.V[a*], N. Auvinet[a], F. Guiziou[a], G. Nunes[a], M. Sarrazin[a], Girault, R[a*]

INRAE, UR OPAALE, 17 avenue de Cucilé, 35000 Rennes, France [a]; [*]Corresponding author, email: romain.girault@inrae.fr

Introduction

Anaerobic digestion has experienced significant growth in the past decade due to its ability to process diverse substrates and its role in addressing environmental concerns. However, one major drawback is the substantial loss of ammonia (NH_3) during digestate storage, which contributes to environmental issues such as acid rain, particulate matter formation, and eutrophication, while also diminishing the fertilizing value of the digestate. As a result, estimating NH_3 emissions is critical for developing mitigation strategies. Current approaches, including experimental measurements and mechanistic models, are costly and require complex physicochemical data, limiting their applicability in real-scale anaerobic digestion plants. To improve prediction accuracy and digestate management, new modeling techniques, such as machine learning (ML), offer promising solutions. XGBoost, a machine learning method that has shown strong performance in data mining competitions, may be particularly effective (Chen & Guestrin, 2016). This study aims to develop an XGBoost model using laboratory-scale data to predict NH_3 emissions from digestate and assess its performance at an industrial anaerobic digestion facility.

Methodology

To conduct this study, nine agricultural digestates were stored in 1m³ reactors for six to twelve months, with storage periods beginning in winter and summer. Ammonia emissions were measured monthly over a two-week period using dynamic chambers, acid traps, and an Innova 1412© gas analyzer. Additionally, nitrogen emission data were collected over an year from an industrial storage lagoon located at the output of the post-digester (lagoon A) and from a second lagoon used to store digestate whenever lagoon A was full (lagoon B). Similar dynamic chambers were used to ensure a consistent effect of the experimental design on emission data from lab and industrial-scaled data. The laboratory data were split into 80% for XGBoost model training and 20% for cross-validation, while model robustness was assessed with industrial data. XGBoost performance was optimized through variable selection and hyperparameter tuning via grid search. In total, 17010 models were generated through the combination of different variable sets and hyperparameters values. The five best models for predicting laboratory and industrial data were selected based on the relative absolute error (RAE).

Results and discussion

The best XGBoost models for predicting NH_3 emissions from lagoons A and B achieved RAE values of 0.55 and 0.24, respectively. The model for lagoon A incorporated storage time, crust presence, and digestate temperature as predictors, while the model for lagoon B used storage time, pH, and total ammoniacal nitrogen (TAN). Graphical analysis indicated that both models effectively captured digestate variability and the seasonal evolution of ammonia emissions, with predictions closely following the seasonal mean. However, their limited ability to capture daily flux variability reduces precision in short-term predictions. This result can be attributed to the variables selected for both models, which exhibit limited daily variation (climate influence is only take into account through storage time although measurements were available).

Conclusion

This study demonstrates that the XGBoost algorithm effectively generated a robust model for predicting nitrogen emissions from industrial digestate storage using laboratory-derived data. Notably, the model required only a small set of easily obtainable variables. This study also demonstrates that machine learning can effectively predict emissions based on laboratory experimentation. However, it is important to highlight that this approach requires the model's robustness optimization, which may involve model validation using some industrial data.

Acknowledgements

This study is part of CRUST research project founded by Ademe, GRDF et GRTGaz.

References

Chen, T., & Guestrin, C. 2016. XGBoost: A scalable tree boosting system. Proceedings of the ACM SIGKDD International Conference on Knowledge Discovery and Data Mining 13-17-Augu, 785–794.

3. A nitrification plant to reduce ammonia emissions and improve nitrogen use efficiency from segregated pig urine

Kupper, T.[a*], Ammann, C.[b], Burr, L.[c], de Chambrier, D.[d], de Chambrier, N.[d], Häni, C.[a], Joss, A.[e], Migliorelli, D.[c], Paoletti, S.[c], Udert, K.[e], Valach, A.C.[a], Birrer, M.[f]

Bern University of Applied Sciences School of Agricultural, Forest and Food Sciences, Zollikofen, Switzerland[a]; Agroscope, Climate and Agriculture Group, Zurich, Switzerland[b]; CSEM, Neuchâtel, Switzerland[c]; VunaN exus AG, Küsnacht , Switzerland[d]; EAWAG, Dübendorf, Switzerland[e]; Schauer Agrotronic AG, Schötz, Switzerland[f];*T. Kupper, email: thomas.kupper@bfh.ch

Introduction

Ammonia (NH_3) from livestock housings significantly contributes to total agricultural emissions. Rapid segregation of urine and faeces using a V-shaped scraper under a slatted floor is a promising option to reduce emissions from pig barns (Landrain et al., 2009). Further reduction of NH_3 losses from storage and field application of livestock excretions can be achieved with nitrification where about 60% of Total Ammoniacal Nitrogen (TAN) is converted to nitrate with a concomitant drop of the pH from pH 7.5 to approximately pH 6. Urine nitrification has been shown to drastically reduce ammonia losses and to remove odours from human urine (Fumasoli et al., 2016). It is expected that separately collected urine from livestock allows to improve the nitrogen use efficiency (De Vries et al. 2015). The aim of this project is: i) to adapt urine nitrification to animal urine collected in pig barns, ii) to determine emissions of NH_3 and greenhouse gases (GHGs; nitrous oxide, N_2O; methane, CH_4) during storage and field application of the treated urine, and iii) to evaluate the potential for emission reduction of NH_3 and GHGs for this system over the entire manure cascade.

Methodology

Reactors for nitrification have been implemented in two pig barns with a NatureLine system from Schauer Agrotronic AG in Switzerland. Urine is segregated from faeces and collected with a V-shaped scraper installed in the channel covered with slats. The solids are transferred to a biogas plant. 180 breeding sows and 660 weaned piglets are kept at farm A and 950 fattening pigs at farm B. The volume of the nitrification reactors is 34 m^3 for an average of 3 m^3/day of liquids treated at farm A and 45 m^3 for 4 m^3/day at farm B. The aeration and mixing are done by fine bubble aeration. pH is measured continuously, and urine is dosed based on pH and nitrite levels. Emissions of GHGs from storage and application will be measured with enclosures at the laboratory and pilot scale and in small plot experiments, respectively. Emission measurements for NH_3 will be conducted at field-scale using the inverse dispersion method (IDM).

Results and discussion

At farm A, the reactor has been operative for 2 years. Several refinements have been implemented such as a drum screen to remove solids larger than 2 mm from the urine because the solids discharged from the urine gutter clogged the peristaltic pump used to charge the reactor. At present time, fine particles still accumulate to 95% organic matter. This has an impact on the oxygen demand and the competition for the nitrifiers, as well as on nitrogen loss at oxygen levels <2 mg/L due to exceedance in organic matter load which leads to denitrification and nitrite accumulation. We observe that the properties of urine in farm A varied strongly depending on the weather conditions due to the unroofed outside yard inducing strong dilution of the collected urine and due to the variable loads in organic matter and nitrogen excreted by the pigs. The drum screen required considerable maintenance due to the variable characteristics of the segregated urine. Blockages of the removed cake occurred which needed manual cleaning of the sieve. At farm B, the urine properties strongly differ from those of farm A requiring a specifically adapted process control which is currently established.

Experiences on the optimization of the reactors and preliminary results from emission measurements will be presented.

Acknowledgements

We are grateful for the funding by Innosuisse, Swiss Innovation Agency, Berne, Switzerland (Grant No 102.391 IP-EE).

References

De Vries, J.W., et al. 2015. Integrated manure management to reduce environmental impact: II. Environmental impact assessment of strategies. Agr. Syst. 138, 88-99.

Fumasoli, A., et al. 2016. Operating a pilot-scale nitrification/distillation plant for complete nutrient recovery from urine. Water Sci. Technol. 73, 215-222.

Landrain, B., et al. 2009. Impact of the installation of a V-shaped scraper under slats in a fattening piggery on performances and on ammonia and nitrous oxide emissions. J. Rech. Porc. 41, 259-264.

4. Ammonia emissions from pig livestock converted in ammonium sulfate fertilizer for sugar beet crop

Moscatelli, G.[a*], Zanaroli, A.[a], Pignagnoli, A.[a] & Valli, L.[a]

Research Centre on Animal Production - CRPA, Reggio Emilia, Italy [a]; [*] g.moscatelli@crpa.it

Introduction

Ammonia emissions from intensive pig livestock farms, when no mitigation measures are applied, are in the range 1.8 ÷ 4.9 kg NH_3 $ap^{-1}yr^{-1}$ (IRPP Bref, 2017). Efficient and affordable solutions to reduce ammonia emissions, improve animal welfare, worker health and, at the same time, recover nitrogen, must become increasingly necessary as BAT for the sustainability of future livestock systems in the framework of the circular economy.

Methodology

The EIP-AGRI Operational Group Gas Loop has implemented (up to a TRL 8) and monitored (1 year) an air washing system that removes ammonia from pig stables, recovering it in an ammonium sulphate solution. The aim is also to increase the animal welfare and productivity due to better air quality inside the pig house (PDO Parma ham supply chain). The device draws ammonia-rich air from the pig house through suction ducts located below the slatted floor. In this way the ammonia emissions, from the pig slurry in the pits under the slatted floor, are captured and prevented from spreading into the room. The treatment is based on chemical absorption of ammonia by counter current washing by an acid reagent sprayed into a tower scrubbing. The process take place at pH 4.5 and a sulfuric acid solution is used, which reacts with ammonia to form a stable solution of ammonium sulphate then collected in a tank. The treatment does not replace the existing ventilation but complements it. Activities included monitoring and evaluation of the air treatment efficiency, measurement of avoided emissions, quantification and characterisation of the ammonium sulphate solution produced and the monitoring of the indoor air quality improvement (NH_3, N_2O, CH_4, CO_2 by INNOVA Multi Gas Monitor, Olfactometric analyses T08, temperature and humidity) compared to an identical and same managed control pig house. Moreover, the research evaluated the positive effects of the air treatment on pig welfare by evaluating the feed conversion index and the health status of the pig's lung at the slaughterhouse. The recovered ammonium sulphate was then used by EIP-AGRI Operation Group RESURGE in an agronomic trial to fertilize a sugar beet crop, intended for biogas production. The trial, on a 2-hectare plot, tested two fertilizers applied with a sdi (sub drip lines fertiirrigation) system: the first used recovered ammonium sulphate (sdi-sa), the second used synthetic ammonium nitrate (control sdi-na).

Results and discussion

The air treatment improves the indoor air quality, reducing the average ammonia concentration inside the treated room by 62% (range 57-67%) compared to the control room. The greatest benefits were found in the wintertime. In addition to reducing ammonia emissions was achieved an important result, the production of an ammonium sulphate solution (230 liters t live weight $^{-1}$ yr^{-1}) characterized by a pH 4, a Total Kjeldahl Nitrogen up to 64 kg t^{-1} (99% as NH_4^+-N) and Total Organic Carbon of 1% in weight. Ammonium sulphate solution produced complains with the UE Regulation 2019/1009 as liquid inorganic fertilizers based on macro-nutrients PFC1. This recovered fertilizer allows a GHG reduction due to replacement of N industrial fertilizers equal to 66 kg CO_{2eq} yr^{-1} t live $weight^{-1}$. The yields of sugar beet fertilized with recovered ammonium sulphate were higher than the control sdi-na thesis, both in terms of dry matter (14.3 t/ha and 12.9 t ha^{-1}, respectively) and sugar content (15.3 °Brix and 15 °Brix.

Conclusion

An important nutrient such like nitrogen, which in the form of ammonia emitted into the atmosphere causes so many problems, can be recovered and give life to fertilizers. It was possible to recover nitrogen (14.5 kg N per t of pig live weight per year) and so avoid ammonia emissions into the atmosphere for 1.94 kg NH_3 $ap^{-1}yr^{-1}$.

Acknowledgements

Initiative under the 2014-2020 Emilia-Romagna Rural Development Program - EIP-AGRI Operational Group Gas Loop (https://gasloop.crpa.it/) and RESURGE (https://goi.crpa.it/go/resurge). Operational Group Gas Loop has been involved in NUTRI-KNOW project Funded by European Union (https://www.nutri-know.eu/).

References

Germán Giner Santonja, Konstantinos Georgitzikis, Bianca Maria Scalet, Paolo Montobbio, Serge Roudier, Luis Delgado Sancho; Best Available Techniques (BAT) Reference Document for the Intensive Rearing of Poultry or Pigs; EUR 28674 EN; ISBN 978-92-79-70214-3; ISSN 1831-9424; doi:10.2760/020485. JRC, 2017.

5. Air quality in conventional and alternative Canadian barns: Perspectives under one health approach

Godbout, S.[a*], Larios, AD.[a], Létourneau, V.[b,c], St-Germain, MW. [b,c], Carranza-Díaz, AK.[ac], Bergeron, K.[b,c], Lemieux, J.[b,c], Turgeon, N.[b,c], Predicala, B.[d], Kirychuk, S.[d], Thompson, B.[d], Castillo-Toro, A.[d], Nolting, C.[d], Boulianne, M.[e], Gaucher, ML[e], Khalloufi, A.[e], Fournel, S.[c] &. Duchaine, C. [b,c]

IRDA, Canada [a]; Institut Universitaire de Cardiologie et de Pneumologie de Québec, Canada [b]; Université Laval, Canada [c]; University of Saskatchewan [d], Canada; Université de Montréal, Canada [e] *Corresponding author: stephane.godbout@irda.qc.ca

Introduction

Air quality inside concentrated and confined animal operations is a topic of continuing interest because exposure to airborne contaminants such as gases, dust and bioaerosols is linked to animal and human's infectious and non-infectious diseases and recently to antimicrobial resistance. This study discusses air quality results obtained from visits carried out in both conventional and alternative Canadian barns. A snapshot of air quality variations during the transition of Canadian barns and the perspectives of this transition under one health approach (OHA) will be presented. OHA seeks to sustainably balance and optimize the health of people, animals and the environment.

Methodology

The study involved the evaluation of air quality parameters (dust, bioaerosols, gases) from samplings carried out inside 18 poultry barns (six conventional and twelve alternative housing systems)[1]; ten dairy barns (five tie stalls, and five free stalls) [2]; and twelve gestating sows barns (six caged and six group housing systems). Furthermore, four swine barns and four chicken barns were visited three or four times to identify mainly the presence of antimicrobial resistance genes (ARGs). Environmental parameters such as temperature and relative humidity were also measured. Concentrations of greenhouse gases and ammonia (NH_3) were measured using an infrared gas analyzer. Airspeed, humidity, and temperature were measured using a thermo-hygrometer anemometer. Particulate matter (PM) concentration was measured with a DustTrak DRX Aerosol Monitor 8534. Bioaerosols were sampled on electret filters using a SASS 3100 Dry Air Sampler. DNA was extracted from the filters, and the quantification of total bacteria and ARGs were analyzed using qPCR. Airflow rates were calculated from air velocity measurements to enable the estimation of environmental emissions.

Results and Discussion

The barns with NH_3 concentrations close or higher than the occupational exposure limit (<25 ppm) were mainly aviaries and gestating sows' barns (cages and groups). Carbon dioxide (CO_2) concentrations were from 1000 ppm to 3000 ppm for most systems. Only a few of laying hens' barns with conventional cages had CO_2 concentration close to the occupational exposure limits (<5000 ppm). Methane (CH_4) concentrations were higher (from 60 ppm to 285 ppm) in dairy barns (tie and free stalls) and in some gestating sows' barns in groups (>20 ppm). Nitrous oxide concentrations were similar across all the systems (from 0.3 ppm to 0.4 ppm). Higher concentrations of airborne particulate matter (PM) of all size fractions were found mainly in aviaries. In these barns the total dust concentration was close or higher than the occupational exposure limits (>10 mg.m−3). Total dust concentration was lower than 10 mg.m−3 for all other systems. Total bacteria concentrations were high for most of the systems and mainly in dairy barns (tie and free stalls). A great diversity of bioaerosols was identified in each one of the systems. Faecal indicators, several etiological agents as well as ARGs were detected in some barns. The emissions of each one of air quality indicators are currently under analysis.

Conclusion

Factors influencing air quality include environmental conditions, ventilation, animal density, animal activity, litter and manure management. This work highlights the need for implementing strategies to monitor and decrease bioaerosols for most of the animal production systems and in some case to decrease NH_3, PM, and CH_4.

Acknowledgements

The authors thank the Quebec and Canadian farmers and funding programs (Agrivita Canada Inc, Agriculture and Agri-Food Canada, NSERC Discovery Frontiers, the Institut de recherche Robert-Sauvé en santé et en sécurité du travail (IRSST) and Quebec government).

References

[1]St-Germain, M.W., et al., 2024. Airborne dust and bioaerosols in Canadian conventional and alternative houses for laying hens. Journal of Occupational and Environmental Hygiene, 21(12), 909-919. [2]Bergeron, K., et al., 2024. Bioaerosols in Eastern Canadian Dairy Barns Using Tie- and Free-Stall Housing. Applied Engineering in Agriculture. 40(1): 111-122.

6. Slurry treatment during medium-scale storage: impacts on NH_3 and GHG emissions and pathogen load

Esteves, C.[a*]; Gramacho, J.[b]; Sequeira, A.[b]; Moreira, O.[b]; Fangueiro, D.[c]

Forest Research Centre, Instituto Superior de Agronomia, Universidade de Lisboa, Tapada da Ajuda, 1349-017 Lisboa, Portugal[a]; National Zootechnical Station, National Institute of Agricultural and Veterinary Research, IP (INIAV), Av. Professor Vaz Portugal, 2005-424 Vale de Santarém, Santarém, Portugal[b]; Linking Landscape, Environment, Agriculture and Food, LEAF Research Center, Instituto Superior de Agronomia, Universidade de Lisboa, Tapada da Ajuda, 1349-017 Lisboa, Portugal[c]. *Corresponding author, email: catarinaesteves@isa.ulisboa.pt

Introduction

Storage of animal slurry is essential for enabling its application to crop fields at the appropriate times. However, it is also a significant source of ammonia (NH_3) and greenhouse gas (GHG) emissions. Implementing slurry treatment methods, such as chemical or biological additives, offers a potential mitigation strategy to reduce these emissions and increase their fertiliser value.

Methodology

A medium-scale experiment was conducted to assess NH_3 and GHG emissions from pig slurry storage. Slurry from the fattening stage was stored in 1 m^3 tanks for three months, starting with 200 L per tank, with 100 L added every 14 days until reaching 700 L. Before each addition, tanks were mixed, and samples were collected for chemical and biological analysis (*Salmonella* spp. detection and *E. coli* colony counts). Four treatments were tested: control slurry (S), acidified slurry (AS, 1.5 mL H_2SO_4 per L), bioacidified slurry (BS, 15 g sugar per L), and Actipost360-treated slurry, which is a commercial additive containing clay, algae, and microorganisms (SA360, 2 g per L). Both AS and BS were acidified to pH 5, and each treatment had three replicates. At each addition, slurry and additives were added to the tanks and thoroughly mixed. NH_3 emissions were measured using acid traps, while CO_2, N_2O, and CH_4 were monitored with an Innova 1512 photoacoustic gas analyser. Measurement frequency was highest after slurry additions and gradually decreased until the next addition event.

Results and discussion

Slurry addition events triggered NH_3 and GHG emission peaks, likely due to fresh slurry additions introducing NH_4^+ and easily mineralisable organic matter or disturbances at the air-liquid interface from mixing and pouring the slurry (Viguria et al., 2015). First results showed that AS and BS significantly reduced cumulative NH_3 and N_2O emissions. Compared to S, NH_3 emissions decreased by 88% and 60% in AS and BS, while N_2O emissions were 86% and 94% lower, respectively. However, these treatments increased cumulative CO_2 emissions, from 6.88 g C L^{-1} to 10.81 g C L^{-1} (AS) and 20.13 g C L^{-1} (BS). BS also increased CH_4 emissions by 124%. This increase in CO_2 and CH_4 emissions in the BS treatment was likely due to labile carbon stimulating microbial activity (Regueiro et al., 2022). In contrast, the CO_2 rise in AS may be linked to carbonate release during acidification and mixing (Fangueiro et al., 2017). Addition of Actipost360 tended to increase emissions, albeit not significantly. BS resulted in the highest global warming potential (GWP), while AS and SA360 did not differ from S. Slurry analysis showed that AS had higher NH_4^+-N levels, reflecting fewer NH_3 losses. Lastly, Actipost360 was the most effective for slurry hygienisation, reducing *E. coli* counts below the permitted limit.

Conclusion

Preliminary findings suggest that sulphuric acid was the most effective additive for mitigating NH_3 and GHG emissions, although it did not achieve slurry hygienisation. Both sugar and Actipost360 addition generally increased GWP associated with slurry storage, however Actipost360 showed potential particularly as a hygienisation agent.

Acknowledgements

This work was supported by the LivingLab - Effluents and coproducts of the livestock activity project funded by PRR (PRR-C05-i03-I-000218) and by Fundação para a Ciência e a Tecnologia, I.P., (UIDB/04129/2020).

References

Viguria, M. et al., 2015. Ammonia and Greenhouse Gases Emission from On-Farm Stored Pig Slurry. Water Air Soil Pollut, 226-285

Fangueiro, D. et al., 2017. Surface application of acidified cattle slurry compared to slurry injection: Impact on NH_3, N_2O, CO_2 and CH_4 emissions and crop uptake. Geoderma. 160-166

Regueiro, I. et al., 2022. Bio-acidification of animal slurry: Efficiency, stability and the mechanisms involved. Bioresource Technology Reports. 19. 101135.

7. Value of animal manure products and RENURE as alternative to synthetic fertilisers in hydroponic greenhouse crops and arable crops

Everaert, B.E.[a*], Verleden, V.I.[a] , Tardy, E.T.[a]

Inagro, Belgium [a]; email: bert.everaert@inagro.be

Introduction

The Flemish agricultural sector is having a surplus of animal manure while additional nutrients in the form of synthetic mineral fertilisers are still being supplied, as the Nitrates Directive (91/676/EEC) limits the use of animal manure to 170 kg N ha-1 year-1. In order to find a circular use of this surplus, we are testing animal manure and processed manure in greenhouse crops as replacement of synthetic fertilisers. RENURE (Recovered Nitrogen from manure), such as ammonium salts and mineral concentrate, closely resemble these synthetic fertilisers and can contribute to a circular economy as alternatives. In addition, we are testing blends of these products to make them more interesting for farmers to use in open field application.

Methodology

Field experiments are being conducted with blends of ammonium nitrate (AN), mineral concentrate and light fraction of pig manure on farmers' fields in maize, potato and winter wheat inspired by the principle of 'on-farm experimentation' (Lacoste et al., 2022). This entails that the products are applied in wide strips to approach the farmers' practice as closely as possible. Trials have already been carried out in 2024 and more are being setup during the growing season of 2025.

The trials in hydroponic greenhouse cultivation are strawberry and tomato. These are setup in our own greenhouses in setups closely resembling those from horticulture farmers. Separate treatments of ammonium sulphate, ammonium nitrate, pig slurry and mineral concentrate are mixed in the fertigation recipes of the crops. Ammonium/nitrate ratios were changed from 1/10 (which is the advised ratio) to 1/4, to ensure more animal product can be mixed into the recipes. Production, fruit quality and crop development are being followed up and compared to a reference with purely synthetic fertilisers.

Results and discussion

The blends have positive results in arable crops. In 2024, a trial in potato was conducted. The products are showing good agronomic value, comparable to synthetic fertilisers. There are some logistical bottlenecks for practical use, such as the low nutrient content of the fertilisers. This means a high dose is needed to fill in the crop needs. We are looking at options to concentrate the products. The results of the 2025 trials will be available in October.

The results of a first trial in strawberry are promising. In the higher fruit quality classes, no differences in yield were observed in the treatments with animal manure in comparison to the mineral control. In the lower quality classes though, slight yield loss was observed in the animal manure treatments. It is unclear if this is caused by the altered ammonium/nitrate ratio or the inclusion of animal manure products in the fertigation. To determine the effect of ammonium on the fruits, a second trial with strawberry is being setup, in which the ammonium concentration is fluctuated. This second trial in strawberry the trial in tomato are being planned in spring and summer of 2025. Results will also be available in October.

Conclusion

Animal manure products are showing promising results for use in greenhouse crops. The agronomic value is good. Conducting trials with farmers is needed to eliminate practical problems and create demand of these products in hydroponic horticulture cultivation.

Results in open field trials suggest that blends of RENURE products are also promising. The blending caters to the need of crops better, ensuring multiple nutrients are being supplied.

Acknowledgements

These trials are financed by Interreg NWE ReNu2Cycle and Vlaio-LA Hermest.

References

Lacoste, M. et al. 2022. On-Farm Experimentation to transform global agriculture. Nat Food 3, 11–18.

8. Nitrogen utilization of potential RENURE products on grassland and maize

Van Dijk, W.[a*] & Specken, J.[a]

Wageningen Research, The Netherlands [a]; [*]Corresponding author, e-mail: wim.vandijk@wur.nl

Introduction

In the Netherlands till 2025 dairy farms are allowed to apply more than 170 kg N per ha from manure. From 2026 onwards this is restricted to 170 kg N per ha forcing dairy farmers to export a larger part of the produced manure N to other farms. Proposed (but not yet approved) RENURE legislation (REcovered Nitrogen from manURE) may help to utilize more N from manure sources on dairy farms as RENURE products are allowed to be applied beyond the level of 170 kg manure N per ha. Possible RENURE products that comply with RENURE criteria are stripped ammonium sulphate or urine fractions produced in adjusted housing systems. In field trials in grass and maize we compared these products with a common mineral N fertiliser.

Methodology

On grassland three experiments were conducted in which different urine fractions and stripped ammonium sulphate (AS) were compared with the mineral fertiliser calcium ammonium nitrate (CAN). We used urine fractions from dairy cattle and veal calves produced in housing systems in which urine and faeces were collected separately. In addition the urine fraction of the cow toilet was used, a system in which fresh urine of cows is collected during excretion of the urine by cows. The applications were done in one cut: the 2nd cut in 2022, the 3rd cut in 2023 and the 1st cut in 2024. The urine fractions were applied with sod injection and the AS was applied with a spoke wheel fertiliser. The CAN was broadcast spread. The total N rate was 80 kg per ha for all products. After the fertilised cut one unfertilised cut was harvested in order to take into account legacy effects.

On maize we conducted one experiment in 2023 in which the urine fraction of the cow toilet was compared with CAN at a N rate of 60 kg N per ha. Both the urine and the CAN were applied at sowing time as a band application. Band application with a starter fertiliser is common in maize growing. The urine was injected along the maize rows, the CAN was applied along the row with the common equipment on the maize planter.

For the grass as well as the maize experiments dry matter yield and the N uptake was assessed. Based on the differences in N uptake (fertilised + unfertilised cut) with the control (0 N) the apparent N recovery (ANR) of the manure products and the CAN was calculated. Subsequently, the nitrogen fertiliser replacement value (NFRV) was calculated as: $ANR_{urine/AS}/ANR_{CAN}$.

Results and discussion

The urine fractions performed less than the CAN with a NFRV ranging from 50 to 90%. Generally, NFRV was higher when applied in the 1st cut than in the later cuts. This may be due to lower ammonia emissions as application conditions less favoured emissions (e.g. lower temperatures) but also other year-effects may have played a role. AS performed also less than the CAN with NFRV values ranging from 50 to 80%. In two out of three years the pH of the AS was relatively high (6-7) which may have enhanced ammonia emission. In one experiment we compared AS with pH 3 with AS with pH 7. AS with pH 3 resulted in a higher NFRV but still significantly lower than 100%. It remains unclear whether differences in application technique between AS and CAN also played a role. In the maize trial the urine fraction (cow toilet) was comparable with the CAN with a NFRV of almost 100%.

Conclusion

The results show that especially on grassland urine fractions and AS performed less than CAN. Therefore, attention has to be paid to a proper application management in order to realize a comparable effectiveness than for mineral N fertilisers.

References

Van Dijk, W., J. Specken & W.C.A. van Geel, 2024. Landbouwkundige en milieukundige effecten van gebruik van mestproducten uit innovatieve stalsystemen in de melkvee-, varkens- en kalverhouderij. Modelmatige verkenning. Wageningen Research, Rapport WPR-1071, 50 pp, https://doi.org/10.18174/648056.

Rietra, R., K. van Dijk & O. Schoumans, 2024. Environmental Effects of Using Ammonium Sulfate from Animal Manure Scrubbing Technology as Fertilzer. Applied Science 14(12), 4998; https://doi.org/10.3390/app14124998.

9. Screening and characterization of microorganisms with enzymatic potential to enhance the compostability of the recalcitrant algae *Rugulopteryx okamurae*

Martínez-Gallardo, M.R.[a*], Estrella-González, M.J.[a], Jurado, M.M.[a], López-González, J.A.[a], Suárez-Estrella, F.[a], Contreras, J.I.[b], Segura-Pérez, M.L.[b], Hachero, I.[c], & López, M.J.[a]

Department of Biology and Geology, CITE II-B, University of Almería, Agrifood Campus of International Excellence, ceiA3, CIAIMBITAL, 04120, Almería, Spain [a]; Institute of Research and Training in Agriculture and Fishery (IFAPA), E04745, La Mojonera, Almería, Spain[b]; Institute of Research and Training in Agriculture and Fishery (IFAPA), El Toruño, E11500, Puerto de Santa María, Cádiz, Spain [c]; [*]Corresponding author, email: mmg113@ual.es

Introduction

In recent years, the invasive alga *Rugulopteryx okamurae* has proliferated in a significant part of the coasts of southern Spain and Portugal. This invasion has profoundly affected the marine flora and fauna, causing the loss of biodiversity and the degradation of their natural habitats. In addition, the accumulation of huge amounts of algal biomass on the coasts is also causing a great environmental impact (Laamraoui et al., 2024). In this regard, composting has proven to be an effective and appropriate alternative for recycling this waste, but its recalcitrant nature hinders its degradability (Correa-Bustos et al., 2024). Given this situation, it is essential to continue developing effective tools for the control and management of the invasive algae. Therefore, the aim of this work was to isolate and select microbial agents with the necessary enzymatic potential to improve the degradability of the biomass of the invasive alga *R. okamurae* during the composting process.

Methodology

For this purpose, three algae samples were collected from different locations: one sample of decomposing algae and two samples of live algae, sourced from the coasts of Almería and Cádiz (Spain). The microbiota present on the surface of the algae was analyzed by culturing on general media, and the predominant colony morphotypes were isolated. The isolated microorganisms were subcultured on selective media containing compounds such as cellulose, hemicellulose, chitin, lignin, xylan, or casein to assess their enzymatic potential for the degradation of recalcitrant algal biomass. Finally, selected microorganisms based on their enzymatic activity spectrum were molecularly identified.

Results and discussion

A total of 40 microorganisms were isolated, including 12 fungi or yeasts and 38 bacteria. Among the bacteria, 10 were from a culture medium with a salt composition that simulates a marine environment and showed characteristics of halotolerance. After enzymatic characterization, several marine bacteria stood out for their broad enzymatic activity profiles. Most of the strains exhibited the ability to degrade a lignin analog, highlighting the recalcitrant compound-degrading potential of the microbiota associated with the algal surface. Microorganisms with the broadest enzymatic spectrum and the highest activity related to the degradation of recalcitrant compounds were selected as bioactivator inocula for algae composting and other biotechnological uses.

Conclusion

The selected microorganisms, exhibiting enzymatic activities that facilitate the breakdown of *R. okamurae* biomass, represent promising biotechnological agents with the potential to improve biotransformative processess efficiency. This strategy offers a sustainable and effective solution for managing and controlling the proliferation of *R. okamurae*, contributing to both environmental and agricultural sustainability.

Acknowledgements

This work has been supported by the project "Desarrollo de herramientas dirigidas al control y la gestión del alga invasora Rugulopteryx okamurae en el litoral andaluz" (PR.FEMPA.DIP2023B.001), coordinated by Instituto de Investigación y Formación Agraria y Pesquera (IFAPA), Consejería de Agricultura, Pesca, Agua y Desarrollo Rural. The project also receives co-financing from the European Union through the European Maritime, Fisheries and Aquaculture Fund (FEMPA), IFAPA.

References

Correa-Bustos, A., et al. 2024. Characterization of mixtures of Rugulopteryx okamurae compost and plant residues to determine the most effective composition as a substrate and source of nutrients. Horticulturae, 10, 567.

Laamraoui, M.R., et al. 2024. Rapid invasion and expansion of the invasive macroalgae *Rugulopteryx okamurae* in the Mediterranean and Atlantic: A 10-year review. Mar. Pollut. Bull., 209, 117194.

10. From waste streams to P-rich organic fertilizers: Closing regional nutrient cycles for sustainable agriculture

Wollmann, I.[a*], Breitenmoser, L.[b], Gross, T.[b], Schweizer, A.[b], Mayer, J.[a]

Agroscope, Switzerland [a]; University of Applied Sciences and Arts Northwestern Switzerland, Switzerland [b]; *e-mail: iris.wollmann@agroscope.admin.ch

Introduction

Like many countries, Switzerland relies on phosphorus (P) imports for fertilizer production. At the same time, P-rich mineral deposits accumulate in the pipes of local wastewater treatment plants, leading to costly disposal. The BIOPHOSREC project aims to recover this struvite containing waste material to close regional nutrient cycles by producing P-enriched organic fertilizers from green waste and struvite-containing minerals. To produce high-quality compost suitable for agricultural use, the project investigates i) the impact of struvite application on the composting process and ii) the effect of anaerobic digestion and/or composting on P availability in the final compost. It is assumed that anaerobic digestion and composting will contribute to the hygienisation and mobilization of P-containing minerals. The agronomic value of the produced composts, particularly their P availability to plants will be tested in a greenhouse pot experiment using different soils and plant species.

Methodology

The source material for the P-rich composts is a mixture of municipal green waste and agricultural waste, which undergoes dry anaerobic digestion followed by post-composting. Struvite-containing material is added at different process stages, i.e. before digestion, before composting, or prior to soil application of the compost. The anaerobic digestion set-up was conducted in an industrial-scale dry anaerobic digestion chamber using stacked wooden pallets (0.7 m^3) placed on percolate collection containers, each lined with plastic bags for watertightness. Each set-up contained 200 kg of organic waste mixed with 20 or 40 kg of struvite containing minerals, with filtering membranes at the top and bottom to prevent material loss. The setups were arranged in triplicate. After anaerobic digestion, the digestates were post-composted in small-scale drum composters (Jora Composter JK 270; 0.27 m^3). Key parameters such as temperature, humidity, and greenhouse gas emissions (N_2O, CO_2, CH_4) were monitored during the composting process. The final composts were analysed for nutrient contents (P, N, K, Mg, Ca) and potentially toxic elements (Cd, Co, Zn).

A greenhouse pot experiment will be conducted between February and June 2025 to evaluate the P fertilizer efficacy of the produced composts in a crop rotation with ryegrass and maize. The P-rich composts will be compared to compost without struvite, the struvite-containing material itself, technologically recovered struvite, and mineral standard fertilization. There are five replicates for each fertilizer treatment. The test substrate consists of a 2:1 mixture of loamy soil with very low initial P content and sand. To evaluate P availability under different growing conditions, two substrate pH levels were adjusted through liming. Ryegrass will be harvested three times, and the concentration of nutrients and potentially toxic elements in the aboveground plant material will be analysed in both ryegrass and maize. Phosphorus use efficiency and mineral fertilizer equivalency will be calculated based on the amount of P taken up by the test plants.

Results and discussion

The results of the composting process are still under evaluation, and the pot experiment began in February 2025. The results of both the composting process and the pot experiment will be completed by, and presented in, October 2025 at RAMIRAN.

Acknowledgements

The BIOPHOSREC project has received funding from Innosuisse – Swiss Innovation Agency under Grant No. 107.941 IP-EE. Project coordination is conducted by the University of Applied Sciences and Arts Northwestern Switzerland. Implementation Partner in the Project is the Oberland Energie AG, Thun, Switzerland.

11. Composting as a source of microbial inoculants for plastic degradation

Estrella-González, M.J., Segado-Pérez, M., Salinas, J., Carpena-Istán, V., Jurado, M.M., López-González, J.A., Suárez-Estrella, F. & López, M.J.

Department of Biology and Geology, CITE II-B, University of Almería, Agrifood Campus of International Excellence, ceiA3, CIAIMBITAL, 04120 Almeria, Spain.; *Corresponding author, email: meg274@ual.es

Introduction

Composting is an effective strategy for managing agriculture waste, including vegetable waste and other organic materials. However, this process can also contain unwanted plastics, such as polypropylene (PP) raffia, widely used as a trellising guide in intensive horticulture. Due to its hydrophobicity and durability, PP raffia is highly resistant to degradation and often accumulates in agricultural waste streams. Despite this, the composting environment fosters intense microbial activity, which may facilitate the breakdown of recalcitrant materials like plastics. The objective of this study was to study the composition of bacterial and fungal communities able to colonize precolonized raffia (PP-aged) and new raffia (PP-new) during composting of vegetable waste.

Methodology

To achieve this, the microbiota capable of colonizing pre-colonized raffia (PP-aged) and new raffia (PP-new) during composting was analyzed. Samples were collected from the main thermal phases of the process: Mesophilic Phase (MES), Thermophilic Phase (THER), Maturation (MAT), and Final Product (FP). Physicochemical parameters such as moisture, C/N ratio, organic matter, pH, and electrical conductivity were monitored. At the microbiological level, metabarcoding analyses were performed for both bacteria and fungi in the Mesophilic Phase and the Final Product. Moreover, cultivar analysis was conducted, and bacteria and fungi with broader plastic-degrading enzymatic profiles were isolated and identified.

Results and discussion

The final product met the values established by R.D. 529/2023, complying with moisture (<40%), C/N ratio (<20%), and organic matter (>45%). pH and electrical conductivity increased up to MAT, with a slight decrease in FP. In PP-new, the majority families were Micrococcaceae (19%) and Pseudomonadaceae (13%) predominated initially, while Bacillaceae (15%) and Pseudomonadaceae (25%) co-dominated at the end. In PP-aged, Bacillaceae (24%) and Micrococcaceae (16%) were dominant at the start, shifting to Bacillaceae (20%) and Rhizobiaceae (15%) at the end. Fungal analysis showed co-dominance among fungal genera of *Aspergillus*, *Acremonium*, and *Cladosporium* in all samples. Additionally, bacteria with broad plastic-degrading enzymatic profiles were isolated, including *Bacillus* and *Priestia*, while fungal isolates were mostly Aspergillus, except for *Fusarium oxysporum* and *Trichurus spiralis*. These results are in agreement with numerous previous studies in which the ability of numerous species of the genus *Bacillus* and *Priestia* (previously catalogued as *Bacillus*) to degrade different types of plastic has been described (Salinas et al., 2023). In addition, Sáenz et al. (2019) observed the degradation of polyethylene (a type of plastic) by some species of *Aspergillus*.

Conclusion

These results suggest that polypropylene raffia in compost is colonized by diverse microbial communities, some of which may have the potential to contribute to polymer degradation. *Bacillus* and *Aspergillus* stood out due to their diverse plastic-degrading enzymes, highlighting their potential for bioremediation.

Acknowledgements

This project has been funded by the Bio-based Industries Joint Undertaking in the framework of the European Union's H2020 RECOVER research and innovation programme under funding agreement no. 887648. The Joint Undertaking receives support from the European Union's Horizon 2020 research and innovation programme and the Bio-based Industries Consortium.

References

BOE 529/2023 (BOE-A-2023-15736, 2023). Real Decreto 529/2023: Spanish Regulation on fertilizers.

Sáenz M., et al. 2019. Minimal Conditions to Degrade Low Density Polyethylene by Aspergillus terreus and niger. J. Ecol. Eng. 20, 40-51.

Salinas J., et al. 2023. Development of plastic-degrading microbial consortia by induced selection in microcosms. Front. Microbiol., 14, 1143769.

12. Composting marine residues

Cabell, J.F.a*, Eich-Greatorex, S.b, Løes, A-K. a, & Krogstad, T. b

aNORSØK, Tingvoll, Norway; bNMBU, Ås, Norway *corresponding author, joshua.cabell@norsok.no

Introduction

There is an increasing need to find alternative sources of fertilizer permitted for use in certified organic agriculture. Composting is a well-established method for recycling nutrients and stabilizing organic waste. However, marine-based residues remain underutilized and have a large potential. Norway's fishing and seaweed industries generate significant residual materials unsuitable for human or animal consumption but rich in N, P, K, Mg, Ca, and other essential plant nutrients (Løes et al., 2022). We tested compost production using residues from rockweed (*Ascophyllum nodosum*), cod, and blue mussels to determine if it is possible to make composts with these raw materials that meet established quality standards and identify which combinations are the most balanced nutritionally and highest content of stable compounds. The results presented here are from Cabell et al. (2024) and a manuscript in preparation.

Methodology

The following four materials were mixed in six combinations: Dried and ground seaweed (GS, *A. nodosum*); algae filter cake (AF) remaining after an acid-alkaline extraction of GS; hydrolyzed, minced cod head bones (FB); whole cod meal (FM); and crushed blue mussels (MU). GS and AF provided most of the carbon, with expanded clay aggregates (Leca®) added as a bulking agent. FB, FM, and MU contained significant N. Composting occurred in 2-liter Dewar flasks placed at 20°C, with thermocouples to monitor the temperature. The flasks were emptied, contents mixed, and samples taken on days 31 and 62, and the experiment concluded on day 92. Feedstocks, pre-compost mixtures, and finished composts were characterized by chemical and physical analyses and FT-IR spectroscopy.

Results and discussion

Initial C:N ratios ranged from 24-34, moisture contents from 63-66%, and bulk densities from 573-639 g L^{-1}. All treatments reached thermophilic temperatures (>45°C), with AF-based mixtures achieving >55°C. Treatments with AF maintained higher mean temperatures than GS treatments. All treatments underwent changes associated with aerobic decomposition, including reductions in moisture, volume, LOI, and C:N ratio. pH increased in all treatments, even those with AF, which had an initial pH >9. Electrical conductivity (EC) rose in AF treatments and declined in GS treatments. Most final composts had Mg, Ca, S, and K at concentrations comparable to commercial organic fertilizers, though P and N were lower. High Na concentrations, especially in GS treatments (~4% DM), were above acceptable limits. Another challenge is the content of cadmium (Cd) and arsenic (As) in marine residues, potentially restricting their use as amendments in agricultural soil. Indicator spectra and peak ratios from FT-IR analysis confirmed that labile organic compounds in all treatments underwent biological degradation and conversion to form more stable compounds, especially the GS treatments, indicating their potential to increase the soil organic matter content when applied.

Conclusion

This study demonstrates that marine-derived residues can be successfully composted to produce nutrient-rich composts. While composting processes and quality parameters met expected standards, high salt contents are a challenge that needs to be solved, e.g. by rinsing materials in freshwater before drying. Future research should explore strategies for reducing salt content to improve compost suitability for agricultural use.

Acknowledgements

This experiment was part of MariGreen, a project funded by the EU Horizon 2020 Era-NET BlueBio Co-fund program (Grant No. 817992) and the Research Council of Norway (Grant No. 330920).

References

Cabell, J., Eich-Greatorex, S., Ion, V. A., Krogstad, T., Matsia, S., Perikli, M., Salifoglou, A., & Løes, A.-K. 2024. Suitability of Residues from Seaweed and Fish Processing for Composting and as Fertilizer. *Sustainability*, *16*(16), 7190. Løes, A.-K., Ahuja, I., de Boer, A., & Rittl, T. 2022. Fertilisation effects of marine-derived residual materials on agricultural crops. *NORSØK Report*, *7*(13), 73 pgs. https://orgprints.org/id/eprint/45330/

13. Soil effects of organic fertilisers in cereal production

Eich-Greatorex, S.[a]*, Havranek, I.[b] & Sogn, T.A.[a]

Faculty of Environmental Sciences and Natural Resource Management, Norwegian University of Life Sciences, Norway [a]; Faculty of Chemistry, Biotechnology and Food Science, Norwegian University of Life Sciences, and Norwegian Institute of Bioeconomy Research (NIBIO), Norway [b]; *Corresponding author, email: susanne.eich@nmbu.no

Introduction

Especially in areas with little application of animal manure to arable land, residues from anaerobic digestion, biogas digestates, may represent a valuable source of nutrients and organic material with the potential to improve soil quality, e.g., with respect to biological activity and soil structure. However, depending on the feedstock used for the anaerobic digestion process, digestates may also contain contaminants with possible harmful effects on the environment. The aim of the study was to compare the effect of different organic fertilisers on soil quality aspects.

Methodology

A longer-term field experiment was carried out, comparing two different digestates, one based on food waste alone and the other on food-waste co-digested with sewage sludge, with a mixed cattle and pig slurry as fertiliser to cereals, as well as with a mineral fertiliser and a control without addition of nutrients. The effect on soil structure-related properties (bulk density, water retention characteristics, aggregate stability) as well as organic matter and nutrients was followed over a duration of seven years. Additionally, other quality aspects were determined, e.g., selected organic contaminants of emerging concern were determined in digestates, soil and plants.

Results and discussion

Fertilisation with digestates resulted in yields that were similar to mineral fertilisation and more stable than fertilisation with the combined cattle and pig slurry. Organic matter content in the soil increased for all three organic fertiliser treatments compared to mineral fertiliser and the control. Physical properties such as aggregate stability were generally more improved by addition of slurry than by either of the digestates but compared to the mineral fertiliser treatment, all three were beneficial. Organic contaminants such as the pharmaceuticals carbamazepine and metoprolol were found in both types of digestates and consequently also in soil samples from the respective treatments throughout the season, but did not, or only to a very small extent (< LOQ), lead to uptake in plants.

Conclusion

In general, digestates showed a more stable fertilisation effect than slurry while improving some chemical and physical properties in a similar way. Their content of selected organic contaminants led to detectable soil concentrations but not to significant plant uptake.

Acknowledgements

Financial support was provided by the Norwegian Research Council (Project nos. 228747 and 268214).

14. Challenges and Innovations in Assessing Biodegradable Plastic Bag Degradation in Industrial Composting

Sikander, A.[a*], Deegener, S.[a] & Körner, I.[a]

Hamburg University of Technology, Bioresource Management Group, asma.sikander@tuhh.de

Introduction

This study examines the degradation of certified biodegradable plastic (BDP) bags in industrial composting, expanding on previous research (Sikander et al., 2024). It aims to refine degradation assessment methods, addressing inaccuracies in common approaches. Key factors influencing BDP degradation include moisture and temperature gradients, which are integrated into the methodology. Additionally, the study seeks to develop a standardized, reliable method for evaluating BDP degradability across micro-, meso-, and macroplastic , tackling challenges such as particle misidentification, quantification, shape variations, and mass and area measurements.

Methodology

This study optimized substrate moisture for BDP degradation and industrial composting, adhering to standard regulations. Five certified BDP bag types (PBAT-TPS, PBAT-PLA) filled with food waste were composted in an Eggersmann reactor for nine days, followed by six weeks of post-composting in open windrows. Sampling occurred on days 9, 28, and 42. Key parameters (moisture, temperature, pH, aeration, substrate composition) were monitored using the facility's one-point method and additional sensors. BDP macro-fragments were collected, cleaned, weighed, and their area number was determined, while a 10–20 L representative compost sample was examined for micro- and mesoparticles using various modeling and measurement techniques.

Results and discussion

BDP bag degradation was monitored for six weeks under DIN 13432 conditions with optimal moisture for BDP degradation. No dry-out zones occurred, and microbial activity effectively facilitated compost maturation and hygienization. Temperature profiles met hygiene standards, ensuring pathogen reduction, though moisture adjustments led to slightly elevated compost moisture. Significant degradation occurred within the first nine days, but plastic residues persisted in all BDP types at the end of the study. Considering area and mass, TPS-blends showed greater degradation, while PLA-based bags degraded minimally, barely meeting DIN 13432 criteria. Microparticles remained in all samples, underscoring the need for comprehensive assessment methods considering macro-, meso-, and microparticles. For macroparticles, attached dirt caused the most misinterpretation, while for microparticles, removal was reliable only down to 1 mm.

Conclusion

Composting parameters, particularly temperature and moisture, are more critical for PLA-blend degradation than TPS blends. However, persistent small BDP residues highlight the need for improved detection methods. Degradation rates varied by bag type and their location within the waste pile, with kitchen waste aiding degradation but insufficient shredding hindering fragmentation. Findings suggest optimizing pre-processing and composting in industrial facilities when incorporating BDPs. To prevent plastic pollution, all plastics should be removed before composting, ideally at the source. Routine microplastic analysis is essential to ensure compost quality.

Acknowledgements

This research was conducted within the KUKOM and CLOSECYCLE projects, funded by DBU and the EU INTERREG North Sea Programme. The authors thank the composting facility EBL Lübeck and the UHH team for their cooperation.

References

Sikander, A. et al. 2024. Decomposition of biodegradable plastic bags for kitchen waste collection in industrial composting. Fron. Sustain. Food Syst. 8: 1433460. Doi: 10.3389/fsufs.2024.1433460.

15. Upcycling of biogenic waste materials to produce a sustainable bio-based peat substitute based on biogas digestate

Trenkner, Marielle[a*], Müller, Benedikt[b], Lewandowski, Iris[a] & Bauerle, Andrea. [a]

University of Hohenheim, Institute of Crop Science, Department Biobased Resources in the Bioeconomy, Germany [a], Geltz Umwelt-Technologie GmbH, Germany [b]; *Corresponding author Marielle Trenkner, email: marielle.trenkner@uni-hohenheim.de

Introduction

Peat extraction for soil production is environmentally harmful, leading to significant CO_2 emissions and ecosystem degradation (Ceglie et al., 2015). This study evaluates a bio-based peat substitute derived from the solid fraction of anaerobic digestate, aiming to provide a sustainable alternative that supports circular bioeconomy principles and aligns with Germany's peat reduction strategy.

Methodology

The peat substitute was produced using nutrient-depleted solids from anaerobic digestate of biomass residues, organic municipal wastes, green waste, and manure, processed through NutriSep technology. Growth trials have been conducted over more than two years in a greenhouse at University of Hohenheim. Trials included germination tests, small pot (0.25 L) and large pot (1.0 L) trials using pak choi, basil, different types of chilies, sunflowers and tomatoes. The peat substitute was blended with a reference medium (RM) at varying concentrations (25%-75%). Different nitrogen fertilizers (calcium ammonium nitrate, ammonium sulphate) were applied at varied concentrations and times. Laboratory analyses examined nitrogen content, cation-anion exchange capacity, and pH. Additional trials had their focus on hydroponic systems, including the Nutrient Film Technique (NFT), Deep Water Culture (DWC), and Dutch Bucket systems. More realistic outdoor conditions were simulated by repurposing 240L waste containers, filled with field soil, to grow lettuce and cabbage. A significant advancement in this study is the use of peat substitute for compressed substrate cubes, a standard in horticulture. These planting cubes are directly compared to conventional peat planting cubes regarding plant growth performance, nutrient retention, and overall sustainability. Growth parameters, crop nitrogen uptake, and microbial activity have been analyzed post-harvest.

Results and discussion

Germination rates ranged from 77-100% across all treatments. Small pot trials showed a significant difference in biomass yield, with plants grown in pure peat substitute initially yielding only 0.1 g fresh mass per plant, compared to 12 g in a 25% peat substitute mixture. Adjusting nitrogen levels through pre-fertilization significantly improved plant growth, narrowing the gap between peat substitute and reference substrates. Challenges such as mould formation and lack of material stability were addressed through optimization steps of the production process. Preliminary results of hydroponic trials (NFT, DWC, and Dutch Bucket) showed little to no differences between the peat substitute and reference substrates, indicating that the substitute performs comparably well in soilless cultivation systems. Additionally, trials in repurposed waste containers, mimicking field conditions, are ongoing to demonstrate the potential of this substitute in large-scale applications such as lettuce and cabbage production. The introduction of pressed planting cubes allows for direct comparisons with peat-based cubes. Full results will be available in late summer 2025. This evaluation will determine whether the peat substitute can serve as a commercially viable alternative while maintaining sustainable and efficient plant growth.

Conclusion

The digestate-based peat substitute presents a viable alternative to conventional peat, utilizing local biogas digestate to reduce waste and promote sustainable resource cycles. By testing the substrate in hydroponic systems, field-mimicking conditions, and pressed planting cubes, this study aims to enhance the commercial viability of peat substitutes for large-scale horticultural applications.

Acknowledgements

This research is part of the "UpCycling Plus" project, funded by the European Regional Development Fund (EFRE) in Baden-Württemberg, grant no. ELR_2378692. We thank Geltz Umwelttechnologie GmbH and UpCycling Plus GmbH & Co. KG for their support and for providing the peat substitute.

References

Ceglie, F. G., et al. 2015. The Challenge of Peat Substitution in Organic Seedling Production: Optimization of Growing Media Formulation through Mixture Design and Response Surface Analysis. PLOS ONE, 10(6), e0128600. https://doi.org/10.1371/journal.pone.0128600

16. Manure application increases soil carbon content and quality in a Mediterranean rainfed arable agricultural system.

Solé, P.[a*], González, E.[a], Masferrer, G.[a], Camps, J.[a] & Domingo-Olivé, F.[a]

Institute of Agrifood Research and Technology (IRTA), Catalonia [a]; [*]Corresponding author, email: pau.sole@irta.cat

Introduction

Manure is widely used as a fertilizer for crops as it provides all the essential nutrients for plant growth. In winter cereal rotations, traditionally involving wheat or barley, manure is applied to the soil before the sowing of the fields and may be complemented by a subsequent application of mineral fertilizer before the crop reaches the stage of stem elongation, if needed. Long-term manure application can have many benefits for soil health, though its use also has environmental implications that need to be managed carefully. While the effects of repeated manure application on the soil are widely studied around the world, more targeted research is needed in the Mediterranean region to better understand its long-term dynamics (Aguilera et al; 2013). This experiment aims to study the long-term (twenty-one years) effect of repeated dairy manure application, compared to the use of mineral fertilizers.

Methodology

The field experiment is conducted at the IRTA-Mas Badia Experimental Station in Girona, Catalonia. The area has a subhumid Mediterranean climate, which allows to grow winter arable crops under rainfed conditions. The soil in the trial is classified as a Typic Xerofluvent and has a loamy texture in the topsoil (0-30 cm).

In this experiment, started in 2001, two treatments were annually implemented, repeatedly in the same plots: application of manure (120 kg N/ha, which represents around 70 kg/ha of available nitrogen) and application of mineral fertilizer (80 kg N/ha). In each of these treatments, soil samples were taken after 21 years from the start of the experiment. The trial design is a random block with three replicates. Different top-soil parameters were determined (using standard laboratory methods): soil organic carbon (SOC), soil microbial activity (respiration), water-stable soil aggregates, soil microbial biomass, soil available phosphorus and potassium and total nitrogen. Since the start, winter cereal crops (wheat and barley) have been grown every year.

Results and discussion

After 21 years of repeated applications, manure treatment has a higher value of SOC (1.13 %) than the mineral treatment (0.89 %). The use of mineral fertilizer alone increased the level of microorganism activity (CO_2 respiration) and it is 14 % higher than when using only manure. Additionally, the long-term use of manure has improved soil structure. Water-stable aggregates (Kemper and Rosenau, 1986) are 8.30 % in the mineral treatment and 9.80 % in the treatment with manure applied, with statistically significant differences. It has also increased microbial biomass by 17 %.

The manured treatment also had higher available phosphorus and potassium content (50 % increase in phosphorus and 27 % increase in potassium compared to the mineral treatment), which may be an excessive content. Total soil nitrogen content was not different for the two treatments.

Conclusion

The benefits to soil quality of the long-term use of manure in arable crops in Mediterranean conditions were demonstrated, including its capacity to increase SOC and to improve soil structure. It was also demonstrated that the repeated use of manure has the potential to increase the available phosphorus and potassium soil content over agronomically recommended levels, highlighting the importance of proper fertilization planning to avoid negative environmental impacts.

Acknowledgements

The works presented in this paper have received financing from the Catalan government through the “Plans for the improvement of crop fertilization in the areas of Girona, Vallès and Osona”.

References

Aguilera, E., et al. 2013. Managing soil carbon for climate change mitigation and adaptation in Mediterranean cropping systems: A meta-analysis. Agriculture, Ecosystems & Environment. 168, 25–36.

Kemper, W.D. and Rosenau, R.C. 1986. Aggregate stability and size distribution. In: Klute, A. (Ed.), Methods of soil analysis. Part 1. Agronomy Monograph 9., Madison, Wisconsin, pp. 425-442.

17. Recycling of ligneous residues to improve soil fertility

Fontana, M.[a*], Sauzet, O.[b], Fontaine[b], A., Boivin, P.[b], Deluz, C.[b], Elfouki, S.[a] & Bragazza, L.[a]

[a]Agroscope, Field-Crop Systems and Plant Nutrition, Route de Duillier 60, CH-1260 Nyon, Switzerland;

[b]HEPIA Soils and Substrates, University of Applied Sciences and Arts Western Switzerland, Switzerland;

[*]Corresponding author: Fontana, M., email: mario.fontana@agroscope.admin.ch

Introduction

Ramial wood chips can be used to improve soil fertility (Fontana et al. 2023). However, the availability of ramial wood chips can be limiting In Switzerland given the quantities required to meet the needs for crops. In addition, no spreading method (mulch or incorporation) is clearly recommended. This study aims to recycle "poor quality" wood residues (conifer bark and undecomposed composted wood) with very high C/N ratios (≈65-80) into organic amendment (e.g. instead of using ramial wood chips) in mulch or incorporated.

Methodology

The effect of an input of 300 m^3 ha^{-1} of wood residues is tested on soil bio-physicochemical properties, organic matter forms via RockEval, ecophysiological traits, crop nutrition, yield of 3 successive crops (rapeseed, green manure and winter wheat) and bioturbation activity by earthworms. A field trial in western Switzerland including 5 treatments (control, bark vs. composted wood × mulch vs. incorporation) and 4 replicates (5 × 8 m) was set up (20 plots in total).

Results and discussion

In situ incubation of the residues showed that it was the year following the amendment that almost all of the mass loss occurred. At the same time, a strong increase in the C_{Org} content of the fine soil particles was observed while the values remained constant in the 2nd year. The bark induced a greater increase in C_{Org} than the composted wood. The degree of hydrogenation indicated that the C in the bark was richer in energy potentially available to microbes than the composted wood, whose decomposition stage seemed more advanced. The residues specifically influenced the activity and/or microbial communities of the soil (Biolog) at least 21 months after the application.

Despite an increase in total soil N observed in the 2 years following the amendment (part of which was linked to N fertilization and green manure crop), it is possible that the rapeseed and wheat crops were occasionally limited in N due to competition with microbes. Two months after amendment, residues (especially bark) had increased C_{mic}, 9 months later the differences with the control were no longer significant while C_{mic} was again higher 21 months after amendment compared to the control. NO_3 concentrations generally decreased 2 and 9 months after application, but not after 21 months. Compared to the control, the lower chlorophyll contents observed one month before rapeseed harvest and at the end of the wheat vegetative stage as well as the lower wheat leaf heights and areas also suggested N limitations following amendment. Regarding these ecophysiological traits, the incorporated bark had the most marked effect on rapeseed but not on wheat, which seemed to have been favoured, while it was negatively affected by the bark mulch, whose N starvation effect was possibly delayed. However, neither rapeseed nor wheat grain yields decreased following high woody residue amendment.

Conclusion

Overall, ligneous residues of poor quality allowed to increase dramatically soil C_{Org} and induced a N starvation which was nearly compensated by N fertilization. Given that a large proportion of woody residues were not decomposed after 2 years, the increase in fine soil C_{Org} could continue in subsequent years, thus optimising long-term fertility.

References

Fontana, M., et al. 2023. Improving crop nutrition, soil carbon storage and soil physical fertility using ramial wood chips. Environ. Technol. Inno. 31, 103143.

18. Soil-Applied Zeolites and High-Absorbance Clays for NH_3 Emissions Reduction

Chourak, Y.[a*], Vilaplana Ventura, R.[a] , Proia, L.[a] & Diaz Guerra , L.[a]

BETA Technological Center, University of Vic – Central University of Catalonia, Vic (Barcelona), Spain[a].

*Email: yasmina.chourak@uvic.cat

Introduction

Ammonia (NH_3) emissions from agricultural fertilization contribute to air pollution, nitrogen losses, and environmental degradation. Zeolites, particularly clinoptilolite, have been identified as an effective strategy to mitigate NH_3 volatilization due to their high cation exchange capacity, improving nutrient retention and soil properties (Mondal et al., 2021; Wang et al., 2012). Their use in composting and organic waste management enhances nitrogen availability while reducing emissions (Awasthi et al., 2016; Aziz et al., 2019). This study evaluates the potential of zeolite application to mitigate NH_3 emissions. The main hypotheses are: (i) zeolite addition can reduce NH_3 emissions; and (ii) zeolite combined with digestate can enhance NH_3 mitigation.

Methodology

A greenhouse study was conducted using a completely randomized design with four replicates per treatment. Wheat (*Triticum aestivum*) was cultivated in 3 L plastic pots under controlled conditions (temperature, humidity, and photoperiod of 12 h light/12 h dark). Four fertilization treatments were applied: control (no fertilizer), synthetic fertilizer, digestate at a low nitrogen rate (170 kg ha^{-1}), and a high nitrogen rate (340 kg ha^{-1}). Clinoptilolite zeolite was incorporated into the digestate treatments at different concentrations (0, 2, 4, and 10% w/w) and manually mixed into the soil. Growth parameters assessed included chlorophyll content (SPAD), plant height, leaf and tiller number. After harvest, soil samples were taken for further analysis. To assess greenhouse gas emissions, flux chambers with acid wet traps were used to analyse ammonia emissions from the soil. Dissolved NH_3 in the acid traps was measured by a colorimetric test over 21 days.

Results and discussion

The use of natural soil amendments and organic fertilizers improved soil fertility and moisture retention, particularly in the 10% zeolite treatments. However, no significant differences in plant growth parameters (height, leaf number, chlorophyll content) were observed. Zeolite combined with digestate showed a slight increase in NH3 retention and phosphorus availability, but nitrogen losses probably occurred due to volatilization. Although ammonium sulphate released more NH3 than digestate treatments, the slow-release properties of zeolite may provide long-term benefits. Further studies with larger samples and higher doses of zeolite are recommended to confirm these trends.

Conclusion

The application of zeolites did not affect wheat growth, but significantly reduced greenhouse gas emissions compared to conventional ammonium sulphate fertilization. The combination of zeolite and digestate improved NH3 retention, with higher doses showing some evidence of increased retention, although not statistically significant. This combination may have long-term benefits for soil sustainability and future fertilization strategies.

Acknowledgements

This research is funded by the HORIZON EUROPE NUTRIBUDGET project (GA number 101060455).

References

Awasthi, M.K., et al. 2016. Influence of zeolite and lime as additives on greenhouse gas emissions and maturity evolution during sewage sludge composting. Bioresour. Technol. 216, 172–181.

Aziz, Y., et al. 2019. ZnO nanoparticles and zeolite influence soil nutrient availability but do not affect herbage nitrogen uptake from biogas slurry. Chemosphere, 216, 564–575.

Mondal, M., et al. 2021. Zeolites Enhance Soil Health, Crop Productivity and Environmental Safety. Agronomy, 11, 448.

Wang, J.Z., et al. 2012. Effects of reed straw, zeolite, and superphosphate amendments on ammonia and greenhouse gas emissions from stored duck manure. J. Environ. Qual. 41(4), 1221–1227.

19. Organic resources as components for the CE-marked fertilising products in the EU

Van Schöll, L.[a*] & Riechelman WH[a].

Nutrient management institute NMI, The Netherlands [a]; [*]Corresponding author, email: Laura.vanscholl@nmi-agro.nl

Organic resources used as components under the EU Fertilising products regulation

The Circular economy action plan of European Commission encourages the recovery and use of nutrients and carbon from organic resources. The legal status as waste is however limiting the marketability and acceptance of these materials in agriculture. In 2022 the new Fertilising Products Regulation (FPR) started to apply fully. EU fertilisers with CE-marking obtain an end-of-waste status and an entry to the internal EU market and free movement within the EU. The FPR imposes requirements on quality and safety of the products and their components, with strict conformity controls. The FPR initially included Component Material Categories (CMC's) for organic resources: plants (CMC 2); compost (CMC 3) and digestates (CMC 4&5) from limited list of feedstocks; and a limited list of agrifood by-products (CMC 6) . Since then the list of CMC's has been expanded to cover recycled nutrients such as struvites (CMC 12), ashes (CMC13) and biochar (CMC 14) from certain organic resources. The latest amendment for the FPR included processed animal manure under CMC 10.

Possible future extension of the FPR with new materials and processes

In an EU survey (2022) 182 proposals for new materials, processes or new feedstocks for processes already covered were brought forward. The NMI has been tasked with the evaluation of the materials against the following criteria (a) materials have the potential to be the subject of significant trade on the internal EU market, and (b) for which there is scientific evidence that they ensure agronomic efficiency and do not present a risk to human, animal or plant health, to safety or to the environment. By-products, recovered waste will be prioritised. Attention will also be given to the straightforwardness of criteria setting, especially for managing safety risks.

After a first screening (van Schöll and Riechelman, 2024) the following materials derived from organic resources were included for evaluation: separately collected urine and/or faeces; Sewage sludges as feedstock for compost, digestate, and ashes; Sludges from food & feed industry and sludges from paper & pulp mills as feedstock for compost and digestate; Algae and plant biomass grown on manure or waste waters; Nutrients recycled from the processing of organic resources.

The potential EU market perspective is assessed by whether products are already covered under national fertiliser regulations, at current market, (potential) volumes, and the ratio of agricultural content to volume. Products that are mostly marketed regionally can also be regulated by the national regulations that apply parallel to the FPR.

Agronomic and safety assessment is based on the existing scientific database. No trials or tests are conducted as part of the study.

Study outcomes

The final report with the outcomes and a proposal for criteria for the new materials and processes will be finalised end of 2025. The presentation will give the interim results of the market assessment and the assessment of agronomic value and safety, and a draft of the proposed criteria. Feedback and additional scientific information will be taken up in the evaluation.

Acknowledgements

Technical Study performed for the European Commission DG GROW F2 (GROW/2022/OP/0046)

References

Van Schöll L & Riechelman W.H. (2024), Technical study to support the inclusion of new materials and processes under the Fertilising Products Regulation (FPR); Lot 2: Material and processes under the FPR Inception report; Nutrient Management Institute BV, Wageningen, Report NMI 2002.N.23(I), pp 35.

FPR (EU)2019/1009 consolidated version http://data.europa.eu/eli/reg/2019/1009/2024-11-20

20. Opportunities for reducing phosphorus inputs in EU agricultural land and implications for manure management

Van Eynde, E.[a*], Ros, G.H.[b], Yunta, F.[a], Muntwyler, A.[c], Hinsinger, P.[d], Fendrich, A.N.[e] & Panagos, P.[a]

European Commission Joint Research Centre, Italy [a]; Wageningen University and Research, the Netherlands [b], ETH Zurich, Switzerland [c]; INRAE Montpellier, France[d],*Corresponding author, email: elise.van-eynde@ec.europa.eu

Introduction

Excessive phosphorus (P) inputs in agriculture has resulted in elevated soil P concentrations in some regions in the EU. Accumulated soil P (also called legacy soil P) imposes a risk for P losses into the aquatic environment when soils become saturated. High soil P concentrations also alter biological and chemical soil functions. Currently, P inputs into EU agricultural land is about 2.62 Mt year^{-1}, out of which 50 % is applied as manure (Panagos et al., 2022). Recent proposed EU policies aim to reduce P inputs fand mitigate excessive soil P concentrations.

Methodology

We present a framework to estimate how much and where P inputs in EU agricultural (cropland and grassland) soils can be reduced. The framework, with assumptions on optimal soil P concentrations and modelled soil P balances, allowed calculating how much of the EU agricultural area experiences a build-up or maintenance of soil P concentrations despite having already high soil P concentrations. Next, we calculated how much P inputs can be reduced to reach maintenance situation (inputs = outputs) or to reach optimal soil P concentrations through mining legacy soil P (inputs < outputs).

Results and discussion

We calculated that current P inputs across the EU could be reduced by 21 % without adverse impacts on agronomic performance, in line with EU policy objectives. The most appropriate strategy strongly depended on the farming system properties and varied substantially across the European regions. Expanding the framework with spatial explicit information on the retention capacity of soils for P will allow one to further reconcile agronomic and environmental targets.

We compared the calculated maximal P application rates in livestock intensive regions with limits set by Member States and the Nitrates Directive (European Union, 2008). Using estimates of N/P ratios in different manure types, the limit on N application by the Nitrates directive is estimated to indirectly limit P application to 27 – 70 kg P ha^{-1} year^{-1} (Vlaamse Landmaatschappij, 2024). This application rate is however higher than the required P inputs in livestock dense areas to reach optimal P levels by 2050. When maximal allowed application rates exist in national legislations, they are generally higher than the P inputs required to reach optimal soil P concentrations by 2050 according to our calculations. These results show the importance of the re-allocation and processing of manure when soil P is taken into account.

Conclusion

The framework we propose, with future improvements on uncertainties in data and calculations, can guide future policy makers and land managers to set spatial explicit targets on P application rates and subsequent manure processing, thereby reconciling agronomic and environmental objectives.

References

Panagos, P. et al. 2022. Improving the phosphorus budget of European agricultural soils. Sci. Total Environ., 853.

European Union, 2008. Directive of 12 December 1991 concerning the protection of waters against pollution caused by nitrates from agricultures sources, in: Official Journal of the European Union.

Vlaamse Landmaatschappij, 2024. Normen en richtwaarden 2024 1–14.

21. Ammonia emissions in EU-27 and compliance with EU policy targets – advancements, potentials and impacts on ecosystems

Kaltenegger, K.[a*], Klimont, Z.[a], Wagner, F.[a], Kiesewetter, G.[a] & Heyes, C.[a]

International Institute for Applied Systems Analysis, Austria [a]; *Corresponding author, email: kalteneg@iiasa.ac.at

Introduction

Ammonia (NH_3) emission and subsequent deposition negatively impact human health through contributing to respiratory diseases as well as ecosystem health through eutrophication and acidification (Wyer et al. 2021, deVries, 2021). Several policies have been developed to address these issues such as the EU National Emission Ceilings Directive (NECD) aiming for a reduction of health impacts from air pollution by 50% in 2030, setting national emission reduction targets for air pollutants such as NH_3. The EU Zero Pollution Action Plan (ZPAP) adds a target to reduce ecosystems where air pollution threatens biodiversity by 25% to the EU agenda (EC, 2024a;b). We modelled the NH_3 emission pathways of all EU-27 countries in GAINS to analyse their advancements in meeting these targets and its effect on ecosystems as well as potential mitigation measures that could be implemented by countries to ensure compliance.

Methodology

We updated the GAINS database based on consultations with national experts from all EU-27 countries (EC, 2024c). The updates made sure to integrate the most up to date data on the agricultural sector such as national details on livestock, manure management and fertilizer application at a current state as well as future projections, both reflecting currently implemented policies. To analyse impacts from emissions on ecosystems, spatially explicit N deposition was calculated from the revised emissions and indicators such as critical loads[1] for eutrophication were used for the evaluation. An additional optimisation scenario was set up in GAINS to explore a cost-effective combination of measures that would ensure compliance with the NECD target and the ZPAP goal. The feasibility and extent of implementation of these measures was beforehand evaluated and discussed with country experts where possible.

Results and discussion

Our results show that most countries will neither be able to meet the 2030 targets for NH3 emissions set under the NECD nor the ZPAP target, with ecosystem areas affected by eutrophication being reduced by only 19%. Additionally, we found evidence of a potential need for even higher emission reduction when not just looking at the sum of ecosystems but reducing the affected ecosystem areas by 25% within specific ecosystem classes that are more sensitive to N deposition, such as semi-natural ecosystems. To reach at least the ZPAP goal, NH_3 emissions in the EU-27 region need to decrease another 14%. As agriculture contributes more than 90% to total NH_3 emissions, we found that measures in this sector are key, especially measures targeting NH_3 emissions from on-field application of manure and mineral fertilizer. However, the type of measure and extent of implementation varies between countries depending on the country specific feasibility of implementation leading to a range of NH_3 emission reduction of 8-24% needed to meet the ZPAP target, exploiting 50-70% of their full mitigation potential. Exploiting the full potential in each country could lead to the protection of around 41% of EU ecosystems from eutrophication.

Conclusion

The current efforts of most EU-27 countries will fall short of meeting the 2030 target for NH_3 emission reduction to reduce human and ecosystem health impacts. Cost effective mitigation strategies, taking country specific feasibility for implementation into account, could exceed compliance with the NECD and ZPAP. This might be of high relevance when aiming to not only reduce the impact of NH_3 emissions on the sum of all ecosystems but also on especially sensitive ones.

References

deVries, W. 2021. ScienceDirect Impacts of nitrogen emissions on ecosystems and human health : A mini review. *Current Opinion in Environmental Science & Health*, *21*(x), 100249. https://doi.org/10.1016/j.coesh.2021.100249

EC (European Commission), 2024a. https://environment.ec.europa.eu/topics/air/reducing-emissions-air-pollutants_en

EC (European Commission), 2024b. https://environment.ec.europa.eu/strategy/zero-pollution-action-plan_en#actions

EC (European Commission), 2024c. https://environment.ec.europa.eu/topics/air/clean-air-outlook_en

Wyer, K. E., et al. 2022. Ammonia emissions from agriculture and their contribution to fine particulate matter: A review of implications for human health. Journal of Environmental Management, 323(June 2021), 116285.

[1] Critical loads are the maximum amount of eutrophying nitrogen deposition that — in the long term — will not cause adverse effects to the structure and functions of ecosystems (UNECE 2013, ECE/EB.AIR/114)

22. SCAIL Sweden - A tool for assessing local impacts of emissions from large livestock facilities

Watne, Å.K.[a*], Hellsten, S.[a], Petersson, S.[a], Tigli, M.[b] , Vigier, A. [b] , Martin Hernandez, C.[b], Hedmark, Å.[c] & Bealey, B.[b]

IVL Swedish Environmental Research Institute, Sweden [a]; UK Centre for Ecology and Hydrology (UKCEH), United Kingdom [b]; 3Skåne County Adminstrative Board, Sweden [c]; [*]Corresponding author, email: agot.watne@ivl.se

Introduction

In Sweden, Environmental Impact Assessments (EIAs) currently often assume that the dispersion of ammonia emissions from livestock facilities is extensive, with a very limited impact on the immediate area. The assumption is often that half of the ammonia emission from the unit is spread evenly within the nearest 50 km from the source (Johansson and Albertsson, 1997). In fact, ammonia concentrations and deposition strongly decrease with distance from source (Theobald et al, 2009). Therefore, local effects of nitrogen emissions from intensive animal husbandry have been underestimated in Sweden. This reduces incentives and demands to implement efficient mitigation measures to reduce ammonia emissions from livestock units.

Methodology

To improve and simplify the assessment of local effects of ammonia emissions from Swedish livestock farming, we have developed a web-based screening tool, SCAIL Sweden. The tool is originally developed for the UK and based on Theobald et al (2009). It focuses on assessing nitrogen load, acid deposition and ammonia concentration from large agricultural facilities. SCAIL Sweden employs AERMOD to model dispersion of ammonia (NH_3) emissions from livestock installations. The tool has been developed together with stakeholders (farmers, planners, and regulators), ensuring to meet end-users needs. We assess the modelled process contributions of ammonia by comparing them to measured concentrations at three livestock farms. The measurements were taken at nine sites on each farm over the course of one year with IVL diffusion samplers. We evaluate the ammonia concentrations modelled with SCAIL by comparing them to results from the ADMS dispersion model, that is commonly used in environmental impact assessments.

Results and discussion

SCAIL Sweden effectively captured the process contributions and the decreasing concentration trend with distance from the source. However, measurements indicate that concentrations near the farms are highly sensitive to specific on-site activities not included in the models. Additionally, spreading events during April, which were not accounted for in the current model setup, significantly impact NH_3 levels. Despite the uncertainties in the descriptions of activities, SCAIL Sweden will support the county administrative boards to exercise their regulatory responsibilities and improve operational efficiencies.

Conclusion

SCAIL Sweden will support the Swedish county administrative boards to exercise their regulatory responsibilities and improve operational efficiencies.

Acknowledgements

This work was performed within the project SCAIL Sweden funded by Formas (grant 2022-01982).

References

Johansson, P & Albertsson, B. 1997. Det går att minska ammoniakförlusterna under lagring av stallgödsel, Jordbruksinformation Nr 11, Jordbruksverket (SJF), ISSN 1102-8025.

Theobald, M.R et al. 2009. A simple model for screening the local impacts of atmospheric ammonia, Science of the Total Environment 407, 6024- 6033.

23. Barriers and opportunities: regional deviation in regulating livestock manure processing and application

Luo, H.[a*], Michels, E.[a] & Meers, E.[a]

[a] Department of Green Chemistry & Technology, Faculty of Bioscience Engineering, Ghent University, Ghent, Belgium; [*]Corresponding author, email: Hongzhen.Luo@Ugent.be

Introduction

The European Commission (EC) promotes the circular use of nutrients from organic waste, including livestock manure, to enhance sustainability in agriculture. However, significant regulatory disparities among EU member states create barriers to the production, trade, and field application of manure-derived fertilisers. Addressing these regulatory inconsistencies is crucial to closing nutrient cycles, facilitating cross-border manure application, and supporting sustainable nutrient management.

Methodology

This study combines a review of EU and national legislation (e.g., Fertilising Product Regulation, Animal By-Products Regulation, Spain's Royal Decree 1053/2022) with insights from interactive discussions with policy working groups. A comparative analysis was conducted to identify regulatory gaps and opportunities for harmonization in livestock density, manure processing requirements, and fertiliser eligibility criteria across EU member states.

Results and Discussion

The study identifies key policy discrepancies that hinder the efficient use of livestock manure across Europe:

Livestock Density Limit and Manure Processing: Intensive livestock industries usually generate huge amount of livestock manure, leading to local nutrient surpluses and environmental risks. Some regions like Flanders (Belgium) and the Netherlands enforce strict livestock density limits and require excess manure to be processed (e.g. nitrification-denitrification) or exported, creating economic pressure on farmers.

National Nitrate Vulnerable Zones (NVZs) and Manure Spreading Restrictions: While the EU Nitrates Directive (Directive 91/676/EEC) sets limits on manure application (170 kg N/ha), countries like the Netherlands, Flanders (BE), Ireland and Italy have secured derogations allowing higher application rates (up to 250 kg N/ha) under specific conditions. France and Denmark impose seasonal spreading bans and buffer zones, whereas Spain and Romania have more flexible rules, resulting in disparities in water quality protection.

RENURE Acceptance and Implementation: Following an evaluation issued by the EC, the Joint Research Center proposed RENURE (REcovered Nitrogen from ManURE) criteria provides guidance on using processed manure products as alternatives to synthetic fertilisers, but its adoption remains inconsistent.

Economic and Administrative Barriers to Cross-Border Manure Trade: The EU Waste Shipment Regulation (EC 1013/2006) classifies untreated manure as waste, complicating its transport across borders. While processed manure can be reclassified as a product, administrative burdens remain high, discouraging trade crossing the border of EU member states. However, the new Regulation on waste shipments entered into force on 20 May 2024 supports an increase traceability of waste shipments within the EU and facilitate recycling and reuse. It is important to note that cross-border trade and transport can be very local in nature. Throughout Europe, along the many internal borders, we find farmers which are working on both sides of those borders. Nonetheless cross-border transport limitations forbid such farmers from spreading manure from one side of the border on other parts of their farm just across the border. In that sense, international context can still be local.

Conclusion

Barriers to manure processing and application include inconsistent RENURE acceptance, regional disparities in livestock density and NVZ regulations, and administrative hurdles in cross-border manure trade. However, opportunities exist for policy improvements by harmonizing manure processing rules, developing nutrient reallocation strategies, and simplifying trade regulations. Additionally, the common agricultural policy rural development funds should subsidize cross-regional manure transport to address nutrient imbalances. A more coordinated EU approach is needed to reduce dependency on synthetic fertilisers, mitigate environmental risks, and support sustainable agricultural practices.

Acknowledgements: This work has been done as a part of the NUTRI-KNOW funded by the European Union's Horizon Framework Programme for Coordination and Support Actions under Grant Agreement no. 101086524. We would like to acknowledge the researchers and staff of the whole NUTRI-KNOW consortia for their work and contribution.

24. A Cost and Environmental Efficiency of Technologies for Defining Future BAT Limits in Danish Growing-Finishing Pig Production

Kai, P.[a*] & Jacobsen, B.H.[b]

Aarhus University, Department of Biological and Chemical Engineering, Gustav Wieds Vej 10D, 8000 Aarhus C, Denmark [a], Copenhagen University, Department of Food and Resource Economics [b]. *Corresponding author, email: peter.kai@bce.au.dk

Introduction

In Denmark it is a basic requirement for livestock producers to obtain an environmental approval of livestock production facilities that exceed an annual ammonia emission of 750 kg NH_3-N to take the necessary measures to prevent and limit the ammonia pollution by applying the best available techniques (BAT) in accordance with the Industrial Emissions Directive (2010/75/EU). BAT is defined as the most effective and advanced stage in the development of activities and methods of operation taking into consideration environmental efficiency, practicability, and economics. Implementation of BAT is used to ensure that industrial activities, including certain agricultural activities, minimize their environmental impact. The aim of the project was to update the technical economical basis for a subsequent policy determination of threshold values for ammonia emissions (BAT limit values) used for environmental approval of livestock farms in Denmark.

Methodology

As a case the analysis of ammonia reducing technologies and their costs when applied in growing/finisher pig houses has been carried out to establish a basis for a revision of the BAT ammonia emissions levels for livestock production in Denmark (Jacobsen and Kai, 2024). The analysis included three housing types with varying share of slatted floors and ammonia reducing technologies including slurry cooling, air cleaning, slurry acidification, and solid cover of slurry tanks. Initially, the housing systems and technologies selected for analysis were evaluated based on thorough data collection including scientific literature and test reports. Investment costs were provided by the technology suppliers. The analysis included four farm sizes ranging from 450 to 12.000 animal places. For each housing type and technology ammonia reduction, additional costs, and costs per kg NH_3-N reduced was calculated. More than 1,500 possible combinations were identified since any pen type may apply one or more technologies to reduce the ammonia emission compared with the reference housing system (drained and slatted floor), more than. When the most expensive combinations were discarded, a total of 270 combinations were selected for further analysis.

Results and discussion

The analysis shows that ammonia reducing technologies at farms with growing/finishing pigs in Denmark are more expensive than previously estimated (Miljøstyrelsen, 2011). Only few technologies meet a maximum cost of €1.14 per finisher pig and €13.4 per kg NH_3-N reduction which were used to establish BAT emission levels in 2011. The cheapest technologies and combinations include pens with partly solid floor, solid cover of slurry tanks and slurry cooling. The cost of implementing technology depends highly on farm size. In many cases the total cost is more than twice as large per finisher pig for the smallest farm size compared to the largest farm size. Therefore, larger farms can achieve higher emission reductions than smaller farm at a comparable cost.

Conclusion

The analysis helps to get an updated estimation of environmental efficiency, costs, and cost efficiency, which can be used both nationally and in the international modelling of costs and measures.

Acknowledgements

The study was funded by the Ministry of Environment of Denmark and the Ministry of Food, Agriculture and Fisheries of Denmark.

References

Miljøstyrelsen, 2011. Indicative emission limits achievable using the best available technique (BAT) - Livestock farming with conventional production of fattening pigs (slurry-based housing systems) covered by sections 11 and 12 of the Livestock Approval Act (in Danish). Ministry of the Environment of Denmark, Danish Environmental Protection Agency, 16 p.

Jacobsen, B.H. and Kai, P., 2024. Growing-finishing pig housing: Summary and analysis - Memorandum prepared as a basis for the revision of the BAT (Best Available Techniques) requirements of the Livestock Approval Order. Advice memorandum from DCA - Danish Centre For Food and Agriculture, Aarhus University, 43 p.

Parallel session 5

1. How management affects methane emission from stored digestate: insights from coupling heat transfer and microbial models

Hafner, S.D. [a*] & Møller, H. [a] & Dalby, F.R. [a] & Romio, C. [a] & Adamsen, A.P.S. [a]

Department of Biological and Chemical Engineering, Aarhus University, Denmark [a] *Corresponding author, email: sasha.hafner@bce.au.dk

Introduction

Anaerobic digestion of liquid animal manure (slurry) may reduce subsequent emission of methane during storage, through destruction of degradable organic matter. However, methane emission is driven by microbial processes that respond to physical, chemical, and biological variables affected by anaerobic digestion and other management activities (Dalby et al., 2021a). The effect of anaerobic digestion on storage emission is difficult to predict. We coupled two mechanistic models to predict management effects on methane emission from stored digestate. Full-scale emission measurements were used for estimation of some parameters as well as model evaluation.

Methodology

We coupled the STM heat transfer model for digestate temperature (Hafner and Mjöfors, 2023) and the ABM microbial model for methane production (Dalby et al., 2021b). Model inputs were based on tank dimensions, digestate level measurements, digestate delivery records, analysis of digestate samples, and weather data. Emission measurements from two full-scale tanks in Denmark over > 6 months were used for estimation of STM heat transfer parameters in the presence of a tent covering as well as ABM parameters for substrate hydrolysis and methanogen groups. Measurements from two other tanks were used for evaluation. Degradable substrate concentrations were estimated from batch residual methane potential tests. The combined software tool was used to explore effects of management on methane emission.

Results and discussion

Annual digestate temperature dynamics were accurately reproduced by STM, with mean error of 3 °C for all but one tank. Predicted methane emission dynamics were similar to measurements for these three tanks. For the fourth tank, predicted emission was high early and late in the year, due in part to overprediction of temperature by as much as 10 °C. Partitioning these differences between errors in the models and in inputs is impossible; both undoubtedly contribute.

Predictions for a wide range of input and parameter scenarios show that emission likely responds to management changes in complex ways, while there is substantial uncertainty in predictions. For example, the effect of heat recovery from digestate prior to storage depends strongly on the loading schedule. When the bulk of digestate is delivered in the summer, substrate availability limits methane emission. So even a large difference in delivery temperature from 10 °C up to 45 °C changed predicted annual emission by only around 30%. In contrast, a four-fold emission difference was predicted for the tank that received more digestate during the winter, when temperature limits methanogen activity.

Conclusion

Predicting management effects on methane emission from stored digestate is not trivial. Software tools built on accurate mechanistic models can be sued to make quantitative estimates, but uncertainty remains high.

References

Dalby, F.R., Hafner, S.D., Petersen, S.O., VanderZaag, A.C., Habtewold, J., Dunfield, K., Chantigny, M.H., Sommer, S.G., 2021. Understanding methane emission from stored animal manure: A review to guide model development. J. Env. Qual. 50, 817–835. https://doi.org/10.1002/jeq2.20252

Dalby, F.R., Hafner, S.D., Petersen, S.O., Vanderzaag, A., Habtewold, J., Dunfield, K., Chantigny, M.H., Sommer, S.G., 2021b. A mechanistic model of methane emission from animal slurry with a focus on microbial groups. PLOS ONE 16, e0252881. https://doi.org/10.1371/journal.pone.0252881

Hafner, S.D., Mjöfors, K., 2023. STM: A software tool for predicting daily temperature in stored animal slurry. SoftwareX 22, 101354. https://doi.org/10.1016/j.softx.2023.101354

2. Feed, Additives, and BMP Values: A Comprehensive Study of Methane Potential Across Animal Categories

Møller, H. B.

Department of Biological and Chemical Engineering, Aarhus University, Blichers Allé 20, 8830 Tjele, Denmark; *Corresponding author, email: henrikb.moller@bce.au.dk

Introduction

The environmental benefits of using manure in biogas plants are much higher than for any other substrate due to the combined effect of production of methane as a non-fossil fuel, and the corresponding reduction in the emissions of methane to the atmosphere from unwanted anaerobic degradation during slurry storage and application on the fields (Sommer et al. 2004). At the same time concern on greenhouse gas (GHG) emission from livestock production is growing due to methane emissions associated with manure storage and enteric fermentation. Approaches to diminish ruminant enteric fermentation by changes in forage and supplementation with fat have been adopted and preliminary results indicate a positive effect. However, the effects of changing diets in terms of biogas potential and potential methane losses from manure storage has not been sufficiently studied. Knowledge on the potential variation originating from the diet in manure biogas potential and potential losses of methane during storage is scarce. Accordingly, there is a need for updated estimates of biogas potential of manure from cattle fed different diets, as national inventories on the biogas potentials from manure today are based on very rough outdated estimates that are not corrected for changes in feeding strategy. A more precise knowledge of the biogas potential of manure will also provide an improved decision tool for dimensioning, projecting and economic budgeting of new biogas installations based primarily on manure. Ultimate biogas yield of manure (B_o) during indefinite anaerobic digestion is the value that together with an emission factor is used to determine the amount of methane emitted during storage of untreated manure. Precise knowledge of B_o is a pre-requisite to predict methane emission by anaerobic digestion either during manure storage as slurry or in a biogas digester.

Methodology

Manure samples of cows were collected from cattle with different feeding and additives in Denmark and practical farms around Denmark. Samples from pig manure were collected from experimental farms and practical farms around Denmark. Broiler manure was collected from different farms in Denmark where varying bedding materials were used. Selected manure types where anaerobically digested in CSTR reactors to compare the results from batch and continuous. The experiments to determine the ultimate CH_4 yield (B_0) and CH_4 emissions under different storage temperatures were performed in batch assays using 0.5 L infusion bottles with the method described by Møller et al. (2004). The incubations were done in triplicate. The ultimate methane yield (at 90 days) from the substrate was fitted to the sigmoidal non-linear regression model:

$$BMP_t = B_0 (1- \exp^{-k \cdot t})$$

Results and discussion

The study showed a huge variation in Bo values between animal categories, feeding, bedding material and feed additives. The Bo values as affected by animal categories, additives, animal categories and chemical composition of the manure will be presented. Results from more than 60 samples from cattle, pig and broilers will be presented and models in relation to chemical composition will be developed.

References

Møller, H.B., Sommer S.G., Ahring, B.K., 2004. Methane productivity of manure, straw and solid fractions of manure. Biomass Bioenerg., 26, 485-495.

Sommer, S. G., Petersen, S. O., Søgaard, H. T., 2000. Greenhouse gas emission from stored livestock slurry. J. Environ. Qual., 29, 744-751.

3. Development of a gas collection and methane flaring system for covered slurry tanks

Adamsen, A.P.S.[a*], Kastensand, M. [b], Larsen, P.F.[b], Kristensen, J.K.[c], Kristensen, E.F. [c] & Guldberg, L.B.[a]

Department of Biological and Chemical Engineering, Aarhus University, Denmark [a]; AgroGas ApS, Denmark [b]; Department of Electrical and Computer Engineering, Aarhus University, Denmark [c]; *Corresponding author, email: apa@bce.au.dk

Introduction

Methane emission from external manure storages is a significant source of GHG from animal production. Recent focus on frequent export of manure from the barns will further increase the potentials of collecting methane from the external storages. The advantage of technologies that target emission from external storages is that it is an end-of-pipe technology, which does not require changes in the barns. External storages like slurry tanks can be covered with tents, which in fact is cost-effective as rain cannot contribute to the slurry volume in the tanks.

The aim of this project was to develop and document a system that collects slurry gas from covered slurry tanks and oxidizes methane into carbon dioxide using thermal combustion in a flaring unit. The focus was on system and flaring efficiency as well as safety (ATEX regulation).

Methodology

Collection of slurry gas from the covered slurry tanks was optimised by closing all openings in the tent. The gas ramp and flaring unit was optimised based on knowledge from a pilot plant on a sow farm and similar systems for methane collection and oxidation on old landfills. The burner head was optimised in a series of incremental steps. The optimisation included foci on methane conversion and concentrations of oxygen, carbon monoxide, organic carbon (OGC) and nitrogen oxides (NO_x) in the flue gas.

Finally, a SCADA system was developed to monitor, regulate and control the system as well as provide documentation.

Results and discussion

The developed system converts methane with an efficiency higher than 99 percent if the gas feed has a methane concentration higher than 5 volume percent. The flue gas has very low NOx concentration. A commercial slurry gas collection and flaring system is now marketed on the Danish market and already sold to several farmers by AgroGas. A documentation test based on 4 flaring units is ongoing. Recently, a study has demonstrated high methane emission from slurry tanks from both pigs and cattle in Denmark (Vechi et al., 2023), and therefore this type of flaring system could be an effective technology to collect and combust the methane, reducing GHG emission from animal production.

Reducing natural ventilation in the covered slurry tanks may potentially reduce slurry surface oxidation, which could increase methane emission (Dalby et al., 2024). Potential risk of fire or explosion in the slurry tanks or flaring system has been addressed by following ATEX regulations and ATEX approved components in the flaring system.

The potential for the system with collection and destruction of methane from covered slurry tanks estimates that a total of 1.5 million tonnes CO_2e in Denmark can be treated (Andersen et al., 2024). The total estimated methane emission from livestock manure from barns and storages in Denmark is estimated to 3.1 million tonnes in 2022 (Nielsen et al., 2023).

Conclusion

A commercial gas collection and flaring system has been developed and is currently marketed to the Danish farmers.

Acknowledgements

The project has been supported by Green Development and Demonstration Programme (GUDP), 34009-21-1939.

References

Andersen, M.N., et al. 2024. Measures for reduction of greenhouse gases in agriculture – 2024 (in Danish). Report from DCA - Danish Centre for Food and Agriculture, Aarhus University. 375 pp.

Dalby, F.R., et al. 2024. Pig manure degradation and carbon emission: Measuring and modelling combined aerobic–anaerobic transformations. Journal of Environmental Quality 53(5), 589-603. https://doi.org/10.1002/jeq2.20603

Nielsen, O.-K. et al. 2024. Denmark's National Inventory Report 2023: Emission Inventories 1990-2022. Aarhus Universitet. DCE - Danish Centre for Environment and Energy Nr. 541 https://dce2.au.dk/pub/SR541.pdf

Vechi, N.T., et al. 2023. Methane emission rates averaged over a year from ten farm-scale manure storage tanks. Science of the Total Environment 904 (2023) 166610

4. Assessment of Ammonia Emission from grazing dairy

Huijsmans, J [a*], Mosquera, J[a] ,Bannink [b], A., & Sebek, L[b]

Wageningen Plant Research, The Netherlands [a]; Wageningen Livestock Research, The Netherlands [b]; *Corresponding author, email: jan.huijsmans@wur.nl

Introduction

Assessment of ammonia (NH_3) losses from field-applied manure gets an ongoing attention within political and scientific discussions when data are used in inventories for reporting national emissions. Ammonia losses from grazing dairy are assumed to be of little importance due to relatively low emissions. The underpinning of the emission from grazing dairy in The Netherlands is based on a restricted number of measurements in the late 1980's. In that period nitrogen fertilization was high compared to nowadays restricted application rates. Therefore nitrogen content of feeding (grass) was high resulting in high nitrogen contents of the urine. Only a few data of measurements at low application rates are available. These data are currently used to assess emissions from grazing at a national scale. Feeding concentrations and grazing strategies may affect ammonia emissions from grazing. The aim of the underlying study is to underpin ammonia losses from grazing dairy considering different feeding and grazing strategies. The focus is on the ammonia emission from urine patches as the main source of ammonia volatilisation.

Methodology

A desk study was performed to provide information on both the nitrogen (N) content of urine during grazing, and the application rate (volume) of a cow urination. Different scenarios were evaluated, based on data on milk production, feed intake and composition, and restricted or unlimited grazing. Data were gathered from national inventory assessments and from real farm data. Assessment of the urine volume per day was based on Bannink et al. (1999), and for the nitrogen content in cow urine on Bannink et al. (2011 and 2018). This information was used to set up experiments to measure ammonia losses from urine (artificial prepared and collected cow urine), varying the nitrogen content of the urine and the volume per urination. Measurements were performed using open flux chambers, allowing intercomparison of eight different objects in fourfold within an experiment. Experiments were repeated during the year (variable measurement conditions). Within each experiment shallow injection of dairy manure was used as reference. The experiments resulted in an estimated quotient of the NH_3 emission (emission reduction factor) of an object with respect to the standard reference. The emission factor (EF) can then be estimated by multiplying the EF of the standard method by this quotient.

Results and discussion

According to the desk study, the expected variation in nitrogen concentration in cow urine is between 5.7-6.9 g N/litter, with a constant urination volume of circa 3 l/urination. On average 85% of the nitrogen content could volatilise. For restricted grazing five urinations per day during grazing are expected, and about twelve for unlimited grazing.

Measurement results showed that ammonia emission from urine (% of N total) hardly differed between different urine concentrations and between different urination volumes. No differences were found between artificial prepared urines and urines gathered at a farm (under the tail). The measured emissions from urine patches were comparable or slightly lower than the emission from shallow injection of dairy manure (% of total ammoniacal nitrogen).

Conclusion

The results show that ammonia losses from grazing are at this stage underestimated in national inventories and in emission assessing tools at farm scale by the Annual Nutrient Cycling Assessment (ANCO or Kringloopwijzer) tool.

Acknowledgements

The study was made possible by financing of the Ministry of Agriculture, Fisheries, Food Security and Nature.

References

Bannink, A., et al. 1999. Intake and excretion of sodium, potassium, and nitrogen and the effects on urine production by lactating dairy cows. Journal of Dairy Science, 82, 1008–1018.

Bannink, A., et al. 2011. A model of enteric fermentation in dairy cows *to estimate methane emission for the Dutch National Inventory Report using the IPCC Tier 3 approach*. Animal Feed Science and Technology 166– 167, 603– 618.

Bannink, A., et al., 2018. *A Tier 3 Method for Enteric Methane in Dairy Cows Applied for Fecal N Digestibility in the Ammonia Inventory.* Frontiers in Sustainable Food Systems, Section Waste Management in Agroecosystems, Volume 2 – 2018.

5. Effect of digestate and untreated slurry properties on ammonia emission from field application

Pedersen, J.[a*], Hafner, S. D.[a], Romio, C.[a], Pacholski, A. S.[b] & Labouriau, R.[c]

Dept. of Biological and Chemical Engineering, Aarhus University, Denmark [a]; Thünen Institute for Climate-Smart Agriculture, Braunschweig, Germany[b]; Dept. of Mathematics, Aarhus University, Denmark[c]; [*]Corresponding author, email: jp@bce.au.dk

Introduction

In Denmark slurry is often co-digested with recalcitrant waste products from agriculture, such as straw, grass, and deep litter to increase biogas yield. This results in a digestate with a high dry matter (DM) concentration and high NH_3 emission potential when surface applied in the field (Pedersen & Hafner, 2023). The aim of the study was to make a detailed investigation of how different digestate properties affect NH_3 emissions, and how these emissions compare with the emissions of applied cattle or pig slurry.

Methodology

Five field trials were conducted where NH_3 emissions were measured with a system of dynamic flux chambers (Pedersen et al., 2024) using cavity ring-down spectroscopy (Garcia et al. 2024) for NH_3 concentration measurements, allowing for replicates and high time resolution of the NH_3 flux measurements. Digestates from nine different biogas plants and three different cattle and pig slurries were applied. The biogas plants were selected to cover a wide range of digestate DM and viscosity combinations. Chemical and physical properties, including pH, DM, viscosity, and particle size distribution, were measured for all digestates and slurries. Furthermore, the exposed surface area of the slurry after application was measured with an imaging method. Probabilistic graphical models (Abreu et al., 2010) were used to study the association between these properties and NH_3 emissions. Non-parametric Gaussian regression models estimated via splines were used to identify putative explanatory variables accounting for the detected differences between the slurry types.

Results and discussion

Investigating the digestates alone, the preliminary results from the graphical model-based analysis showed a negative correlation between NH_3 emission and the exposed surface area of the digestates after application (Spearman correlation coefficient = -0.74, *p*-value = 0.0004), indicating high emissions for low area. This differs from what has been observed in previous studies. We hypothesize it is due to an effect of DM on both emissions and the exposed surface area, with high-DM digestates having a lower exposed surface area after application due to slower or less spreading out of the applied slurry. The positive effect of increasing DM on emissions has been extensively documented (Hafner et al., 2025; Häni et al., 2016). The analysis indicates that the exposed surface area carries all the information on NH_3 emission that pH, DM, viscosity, and particle size distribution carried.

Preliminary combined analysis showed higher emission from digestate and cattle slurry compared to pig slurry (*p*-value = 0.0002). These differences were related to pH and consistency coefficient (viscosity) on NH_3 emissions; when these two variables were included as predictor there were no remaining differences among digestate/slurry types (non-parametric spline regression, *p*-value = 0.18).

Care should be exercised when interpreting the results as the sample sizes are modest.

Acknowledgements

This work was funded by the Ministry of Food, Agriculture and Fisheries of Denmark (GUDP, journal nr.: 34009-21-1829)

References

Abreau, G. C. G., et al. 2010. High-dimensional graphical model search with the gRapHD R Package. J Stat Sofw., 37(1) : 1-18

García, P. et al., 2024. Investigation of non-target gas interferences on a multi-gas cavity ring-down spectrometer. Atmos. Environ. X. 22. 100258. doi: oi.org/10.1016/j.aeaoa.2024.100258

Hafner, S. D. et al., 2025. Inproved tools for estimation of ammonia emission from field-applied animal slurry: Refinement of the ALFAM2 model and database. Atmos. Environ. 340, 120910. doi: 0.1016/j.atmosenv.2024.120910

Häni, C. et al., 2016. Ammonia emission after slurry application to grassland in Switzerland. Atmos. Environ. 125, 92-99. doi: 10.1016/j.atmosenv.2015.10.069

Pedersen, J. and Hafner, S. D. 2023. Ammonia emissions after field application of anaerobically digested animal slurry: Literature review and perspectives. Agric. Ecosyst. Environ. 357. 108697. doi: 10.1016/j.agee.2023.108697

Pedersen, J., et al., 2024. Evaluation of optimized flux chamber design for measurement of ammonia emission after field application of slurry with full-scale farm machinery. Atmos. Meas. Tech., 17, 4493-4505. doi: 10.5194/amt-17-4493-2024

6. Urinary Nitrogen Concentration Influences Seasonal Dynamics of Ammonia Emissions, Herbage Yield, and Nitrogen Uptake in a Temperate Grassland

Osei-Asante, E.a,b*, Murphy, P.N.Cb,c, Richards, K.G.a, Dineen, M.d, Connolly, S.a and Krol D.J.a
aTeagasc, Crops, Environment and Land Use, Johnstown Castle, Co. Wexford, Ireland
bSchool of Agriculture and Food Science, University College Dublin, Belfield, Dublin 4 Ireland
cUCD Earth Institute, University College Dublin, Belfield, Dublin 4, Ireland
dTeagasc, Animal and Grassland Research and Innovation Centre, Moorepak, Fermoy, Co. Cork, Ireland
*Corresponding author, email: ernest.osei-asante@teagasc.ie

Introduction

Urine deposition from grazing livestock contributes significantly to N losses, primarily through ammonia (NH_3) volatilisation, which affects air, water, and soil quality while also influencing pasture productivity1,2. Dairy cow urinary nitrogen concentrations (UNC) vary widely (2 – 20 g N l-1) depending on diet3; however, comprehensive studies correlating UNC to NH3 emissions and pasture performance are lacking. Therefore, this study examined the seasonal effects of UNC on NH_3 emissions, dry matter yield (DMY), and N uptake in a temperate pasture system to inform sustainable N management strategies and modelling.

Methodology

The study was conducted in a temperate grassland on Luvic Gleysol soil, dominated by perennial ryegrass (Lolium perenne). Urinary nitrogen concentrations were controlled by diluting or spiking urine from Holstein-Friesian dairy cows (7.1 g N l-1), formulating concentrations of 0, 2.5, 5.0, 7.5, and 10.0 g N l-1. Urine patches were simulated in April and July 2023 by evenly applying 2L to a 0.16 m2 area within each 2.25 m2 plot. The experiment employed a randomised complete block design with four replicates per treatment. Ammonia emissions were monitored daily for 15 days post-application using an INNOVA 1412i analyser. The grass was harvested over three months at four-week intervals after each seasonal application to measure DMY and N uptake.

Results and discussion

Ammonia emissions increased significantly ($p < 0.05$) with rising UNC, from 2.48 to 46.7 kg N ha^{-1} as UNC increased from 0 to 10.0 g N l-1 across both seasons. Average NH_3 emissions across all treatments in April (27.6 kg N ha^{-1}) were significantly ($p < 0.01$) higher than in July (9.2 kg N ha^{-1}), likely due to higher soil moisture in April. In contrast, severe drought conditions before application in July limited NH3 emissions4. Dry matter yield was notably higher in April for the 2.5, 5.0, and 7.5 g N l^{-1} treatments but not for the 10.0 g N l^{-1} and control treatments. The 5.0 g N l^{-1} treatment produced the highest yield (6,203 kg DM ha^{-1} in April, 4,947 kg DM ha^{-1} in July), suggesting moderate UNC level enhances productivity. Nitrogen uptake varied between 74 and 191 kg N ha^{-1}, peaking in July for the control, 10.0 g N l^{-1}, and 5.0 g N l^{-1} treatments, while the 7.5 and 2.5 g N l^{-1} treatments peaked in April.

Conclusion

These results indicate that reducing UNC through dietary adjustments could help lower NH_3 emissions while maintaining or even enhancing pasture productivity. Furthermore, meteorological and soil conditions might be more significant indicators of NH_3 emissions risk than seasonality alone, highlighting their importance in emission mitigation strategies, such as decision-support tools for farmers and process-based modelling.

Acknowledgement

This research was funded by the Department of Agriculture, Food and the Marine as part of the PastureNUE project (2021R482) and the Teagasc Walsh Scholarship Programme.

References

[1]Rodriguez, M. J., et al., 2021. Use of a urease inhibitor to mitigate ammonia emissions from urine patches. Environmental Technology, 42(1), 20-31.
[2]Gourley, C.J.P., et al., 2025. Nitrogen uptake and leaching from urine and fertilizer applications during simulated grazing rotations of a perennial grass pasture. Agricultural Systems, 224, 104226.
[3]Selbie, D.R., et al., 2015. The Challenge of the Urine Patch for Managing Nitrogen in Grazed Pasture Systems. In D. L. Sparks (Ed.), Advances in Agronomy, Vol 129 (Vol. 129, pp. 229-292).
[4]Fischer, K., et al., 2016. Ammonia emissions from cattle dung, urine and urine with dicyandiamide in a temperate grassland. Soil Use and Management, 32, 83-91.

7. Nitrogen mineralisation and greenhouse gas emissions after digestate application to rice paddy soil

Foereid, B.[a*], Dietrich, M.[a] & Paruch L.[a]

Norwegian Institute of Bioeconomy Research, Norway [a] *Corresponding author, email: bfoereid@gmail.com

Introduction

Digestates are good fertilisers with ample plant available nutrients (Möller and Müller T 2012), and anaerobic digestion can make nitrogen in residues more plant available (Foereid et al. 2021). However, nitrous oxide emissions after application can be high (Dietrich et al. 2020). Rice is usually grown flooded, with waterlogged soil, but currently efforts are made to reduce water use. Relatively little is known about how waterlogging affects nutrient utilisation and greenhouse gas emissions when digestate are used as fertilisers for rice.

Methodology

Digestates from two plants were incubated in paddy soil, waterlogged and at field capacity, and greenhouse gas emissions measured. Nitrogen mineralisation and nosZ gene abundance were also assessed. Urea and no additions were used as controls. Two digestates and the same controls were also compared in pot experiment with rice plants. Biomass accumulation and nitrogen uptake were measured, as well as mineral nitrogen and nosZ and ammonia oxidation genes in soil.

Results and discussion

Plant growth and nitrogen uptake were highest with urea fertiliser, but one digestate was not far behind. Higher nitrification rate with urea may explain why urea was better, as nitrate can be taken up more quickly than ammonium. A small addition of mineral fertiliser at a critical time or somewhat higher application of total nitrogen could give as good growth and yield with digestate fertilisers. One digestate induced high methane emissions (Foereid et al. 2025) and another induced high nitrous oxide emissions. With urea, nitrous oxide emissions did not depend on if the soil was waterlogged or not, but with digestate, this was quite different. There were no nitrous oxide emissions when digestate was incubated waterlogged, but high emissions when incubated at field capacity. High organic matter together with relatively high nitrate content may explain the high nitrous oxide emissions (Senbayram et al. 2012). Nitrous oxide emissions started when nitrite levels peaked. NosZ gene abundance peaked after the nitrous oxide peak in most treatments, it and could explain why emissions decreased.

Conclusion

Digestates can be good fertilisers, also for rice, but there are large differences between digestates from different plants and processes. Nitrous oxide emissions will be a more serious concern when digestate is used as fertiliser for rice grown aerobically or with periods of drainage.

Acknowledgements

The authors wish to thank Indian exchange students Debosmita Chakraborty and Arnab Bhattacharjee as well as Jan Erik Jacobsen and Monica Fongen for analytical work. This study was funded by The Norwegian Research Council, grant no. 283570, RICEDIG - Greenhouse gas emissions from biogas digestate applications to rice production systems.

References

Dietrich, M., et al. 2020. Greenhouse gas emissions from digestate in soil. Int. J. Recycl. Or.g Waste Agric. 9, 1-19.

Foereid, B., et al. 2025. Digestate in paddy soil – methane emission and carbon sequestration. Int. J. Recycl. Or.g Waste Agric. in review

Foereid, B., et al. 2021. Effect of anaerobic digestion of manure before application to soil – benefits for nitrogen utilisation? Int. J. Recycl. Or.g Waste Agric. 10, 89-99.

Möller K., Müller T. 2012. Effects of Anaerobic Digestion on Digestate Nutrient Availability and Crop Growth : A Review. Eng. Life. Sci. 3, 242–57.

Senbayram, M., et al. 2012. N_2O emission and the N_2O /(N_2O +N_2) product ratio of denitrification as controlled by available carbon substrates and nitrate concentrations. Agric. Ecosyst. Environ. 147, 4-12.

8. Effects of Organic Amendment Pre-Treatment on Soil Carbon and Nitrogen Dynamics

Chavez-Rico, V.S.[a,b,e], Bodelier, P.L.E.[c], Van Eekert M.H.A. [b *], Sechi, V. [a], Ciocan, V. [a], Keuning, E. [d], Malagon-Mendoza, N. [b], Ringler, D.[b] & Buisman, C. [a]

Wetsus, Netherlands [a]; Wageningen University, Netherlands [b]; *NIOO-KNAW*, Netherlands [c]; Bioclear earth b.v, Netherlands [d]; SFP, Netherlands [e] *Corresponding author, email: miriam.vaneekert@wur.nl

Introduction

Soil serves as a crucial carbon sink, yet it has the potential to emit considerable quantities of greenhouse gases (GHGs) as well. Soil organic amendments (OAs) serve to restore carbon and nutrients in the soil, thereby preventing degradation and enhancing fertility. However, OAs can also lead to GHG emissions. The fate of C and N from OAs in the soil is complex, and there is limited knowledge about the long-term effects in aggregates and GHG emissions. This study investigates the impact of OA-pre-treatment on soil C and N concerning aggregate formation and GHG emissions.

Methodology

We utilized five distinct OAs, including compost, solid fraction of digestate, fermented product (similar to Bokashi), raw substrate, and a 1:1 mixture of compost and fermented product, all derived from the same initial substrate type. The physical distribution of C and N along different particle size fractions and POM were analysed. The study also measured GHG emissions (CO_2, N_2O, and CH_4), gene copy numbers (genes related to nitrification and denitrification using DNA extraction and qPCR), and microbial activity to assess the correlation between OAs and aggregate formation. We observed the alterations in a soil column experiment at the 6-month and 12-month marks. Confounding factors were controlled using a model soil without aggregates with low C content.

Results and discussion

Initial and final C content were not significantly different among treatments, but the pre-treatment technologies affected the distribution of C and N in the soil, GHG emissions, microbial cell formation, free-POM, micro- and macroaggregate formation, and time persistence. The use of compost resulted in reduced greenhouse gas emissions; however, there was no observable benefit for aggregate formation. In contrast, the raw material and the fermentation product demonstrated the highest GHG emissions with different effects on aggregation. The raw material had a transient effect that disappeared after 6 moths while macroaggregates in the soil treated with fermented product persisted after 1 year. Digestate produced intermediate levels of greenhouse gases and reported the highest amount of macroaggregates after 1 year. The total N content changed after 6 and 12 months, possibly due to the depletion of readily available C sources and differences in total N content among OAs. After 1 year, the results showed that soils treated with compost and the mix had the highest bacteria biomass formation. The soils treated with the raw material and the fermented product released one order of magnitude more N_2O that other treatments. The gas release and gene analysis suggested that pre-treatment of OAs can also influence the N_2O emission mechanism in soil which was different among the treatments. This observation was attributed to the differences in chemical composition and microbial communities present in the studied OAs.

Conclusion

This study showed that OA pre-treatment has a lasting indirect impact on the distribution of C and N in soil, including in micro and macro aggregate formation and persistence, affecting overall GHG emissions, N_2O formation processes, and biomass formation. These findings suggest that GHG production can only be reduced to intermediate levels without compromising OAs benefits on soil structure and carbon storage.

Acknowledgements

Cooperation Wetsus-Wageningen University.NIOO-KNAW. Wetsus is co-funded by the Dutch Ministry of Economic Affairs and Climate Policy, the EU Regional Development Fund, the City of Leeuwarden, the Province of Fryslân, and the Northern Netherlands Provinces. Wetsus also coordinates WaterSEED project with funding from EU's Horizon 2020 (Marie Skłodowska-Curie grant No. 665874). Recognitions to soil research theme members (Agriton, Mulder Agro, Vereniging Afvalbedrijven, Koninklijke Oosterhof Holman, Waterketen Onderzoek Noord (WON), and Waterschap Zuiderzeeland).

References

Chavez-Rico, V.S., et al. 2024. Fate of C and N of pre-treated organic amendments in soil. Pedosphere. https://doi.org/10.1016/j.pedsph.2024.07.007

9. Does biogas production from energy cover crops really mitigate climate change and is it adapted to future climate conditions? Insights from real farming practices in French field crop regions

Boros, L.[a,b*], Carozzi, M.[b], Martin, P.[b] & Levavasseur, F.[a]

Université Paris-Saclay, INRAE, AgroParisTech, UMR ECOSYS, 91120 Palaiseau, France [a] ; Université Paris-Saclay, INRAE, AgroParisTech, UMR SADAPT, 91120 Palaiseau, France [b] ; *Corresponding author, email: lea.boros@inrae.fr

Introduction

The European Union strongly promotes biogas production as a key strategy to tackle climate change, by reducing greenhouse gas (GHG) emissions through the production of renewable energy and the recycling of nutrients through digestate application. In particular, biogas production from energy cover crops (ECC) (also known as sequential or intermediate crops) is widely encouraged, as it is assumed to provide a sustainable biomass resource without competing with food production, while enhancing carbon sequestration and reducing nitrogen leaching (Malone et al., 2023; Nilsson et al., 2024). Environmental assessments of anaerobic digestion mainly based on ECC have indeed suggested that it could be an effective climate change mitigation tool (Esnouf et al., 2021; Nilsson et al., 2024). In France, anaerobic digestion from ECC has rapidly expanded in recent years, especially in field crop regions where manure availability is limited. Recent on-farm surveys has revealed that ECC cultivation practices often diverge from the assumptions made for ECC production in environmental assessments (Boros et al., 2024). In these regions, ECC are often treated with pesticides, sometimes irrigated, fertilized with digestate and/or mineral fertilizers and can impact main crop yields as well as land cover at the farm scale. This raises questions about the actual climate benefits of anaerobic digestion mainly based on ECC and its long-term sustainability under changing climatic conditions. This study aims to assess whether anaerobic digestion based mainly on ECC genuinely contributes to climate change mitigation when real farming practices are considered. Additionally, this study evaluates the resilience of such systems under future climate scenarios.

Methodology

We simulated the agronomic and environmental impacts of different scenarios of cropping systems with or without anaerobic digestion (AD) thanks to the PROLEG tool (Levavasseur & Houot, 2023). This tool embeds the Stics soil-crop model, the AMG soil C model and some emissions factors to compute the whole GHG balance, including energy production, emissions related to fertilizer production, direct field N2O emissions, soil carbon storage, machinery use and indirect land use changes. Additionally, the resilience of these systems to climate change was assessed through the analysis of biomass production, irrigation needs and drainage under two climatic scenarios (RCP 4.5 and 8.5). We defined scenarios of cropping systems involving biogas plants mainly based on ECC, using data from farm survey to reflect real farm conditions. A baseline scenario (without AD) was compared to a scenario incorporating ECC-based biogas plants. Alternative scenarios were also created to study a range of systems, considering factors as the proportion of ECC on farms, ECC type (winter or summer), amount of external waste in the biogas plant, level of inputs on crops or irrigation practices.

Results and discussion

Preliminary results indicate an improvement of the GHG balance in the cropping systems based on ECC and digestate application, primarily due to biogas production (and associated energy substitution), SOC storage and mineral N fertiliser savings. Digestate applications and ECC cultivation can help maintain low nitrate leaching level; however, ammonia volatilisation and N_2O emissions from field application tends to increase. Additionally, food (or feed) production tends to decrease, and its impact on the overall GHG balance must be carefully considered in terms of environmental sustainability. The findings will provide valuable insights for policymakers to optimise biogas development strategies, by considering the real on-farm deployment conditions of this renewable energy source.

References

Boros, L. et al. Changes in cropping systems associated with biogas plants in French cereal-growing areas. 15th IFSA Conference 2024

Esnouf, A. et al. 2021. Analyse du Cycle de Vie du biométhane issu de ressources agricoles - Rapport d'ACV. INRAE Transfert.

Levavasseur, F. and Houot, S. 2023. Predicting the Short- and Long-term Effects of Recycling Organic Wastes in Cropping Systems with the PROLEG Tool. Soil Use and Manag. 39, n°1: 535-56.

Malone, R. et al. 2023. Harvested Winter Rye Energy Cover Crop: Multiple Benefits for North Central US. Environ. Res. Lett. 18

Nilsson, J. et al. 2024. Cover Crop Cultivation Strategies in a Scandinavian Context for Climate Change Mitigation and Biogas Production – Insights from a Life Cycle Perspective. Sci. Total Environ. 918.

10. Airflow Assessment in Naturally Ventilated Barns Using a Direct Measuring Method

Declerck, A.[a*]; Peeters, Q.[a]; Laanen, L.[a] ;Coorevits, K.[a] & Brusselman, E.[a]

Flanders Research Institute for Agriculture, Fisheries and Food (ILVO), Technology and Food Science Unit, Burgemeester Van Gansberghelaan 115, 9820 Merelbeke-Melle, Belgium [a]; *Corresponding author, email: arnout.declerck@ilvo.vlaanderen.be

Introduction

Ammonia and greenhouse gas emissions are a critical concern in several European countries, making accurate, qualitative measurements from barns essential. One of the key parameters required to calculate the emission is the airflow. Determining the airflow in naturally ventilated barns has long been a challenge. In the past, tracer gas methods were used to determine the airflow through the whole barn. However, a newly developed method, using direct measurements with ultrasonic anemometers, makes it not only possible to determine the flow through the whole barn, but also through all individual openings of the barn. This measuring method provides valuable insights into the behaviour of the airflow through the barn.

Methodology

Four naturally ventilated dairy barns were selected throughout Flanders. The main sideway openings were positioned towards the SW-NE wind direction, i.e. the most dominant wind direction. In order to measure the flow through the barn using the new developed direct method, every barn was equipped with about 19 ultrasonic anemometers (8 in each side opening and 3 in the ridge). These devices continuously measured the speed and direction of air entering or leaving the barn. These parameters, together with the geometry of the barn openings, were used to determine the air flow rate through the barn.

As all openings were equipped with ultrasonic anemometers, the flow through each individual opening could be calculated. The measurements were conducted over a period of one year, thus the obtained dataset contained enough meteorological conditions to have a thorough study of the flow through the different openings.

Results and discussion

The results show that, in all barns (only one barn is shown in the Figure), the flow through the ridge was often negligible in comparison with the flow through the sideway openings (Figure 1). In one barn, the outgoing flow through the ridge was on average about 0.24 m^3/s, while in the other three barns, the average outgoing ridge flow varied from 13.07 to 24.49 m^3/s. The total outgoing flow varied from 0.16 m^3/s (barn B1) to 542.14 m^3/s (barn B4). The ridge predominantly functioned as an outlet. Expressed per animal, the average total outgoing flow varied between 0.66 and 0.95 m^3/s/animal. Further results and conclusions will be shown during the presentation.

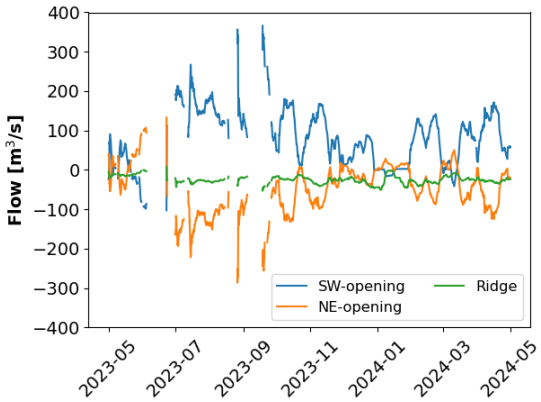


Figure 1: 7-day moving average flow through the openings of one of the naturally ventilated barns

Acknowledgements

We would like to thank the Environmental Department of the Flemish government and the Dutch Ministry of Agriculture, Fisheries, Food Security and Nature for funding this research. We would also like to thank our technical team for the installation and the day-to-day maintenance of this set-up and, of course, the dairy farmers for making their barns available for this project.

11. CowToilet for dairy cows: an evaluation of functionality and animal welfare

Schrade, S.[a*], Held, F.[a], Dohme-Meier, F.[a] & Zähner, M.[a]

[a]Ruminant Nutrition and Emissions, Agroscope,1725 Posieux and 8356 Ettenhausen, Switzerland

[*]Corresponding author, email: sabine.schrade@agroscope.admin.ch

Introduction

In dairy farming, technical measures to reduce ammonia emissions from housings are being intensively discussed. One mitigation principle is the separation of faeces and urine to reduce the formation of ammonia on the floors. The CowToilet (Hanskamp, Doetinchem, NL) follows this principle: urine is deposited by the cows directly into the CowToilet and collected separately. This urine volume is not available for ammonia formation. According to measurements carried out in the Netherlands, ammonia emissions can be reduced by between 35 and 45% (Van Dooren et al., 2024). So far, there is a lack of experience regarding the functionality and animal welfare of the CowToilet, especially in combination with an automatic milking system and with low concentrate level in the diet.

Methodology

Two CowToilets were investigated from January to April 2024 in the dairy housing in Tänikon, Switzerland. During this period, the herd size averaged 55 (51-58) cows. The CowToilets were installed in the outdoor exercise area. On the other side of the outdoor exercise area the automatic milking system was located. Both, the CowToilets and the automatic milking system, used concentrate as bait feed. The CowToilet's software recorded the number of visits, the number of stimulations and the number of urinations at individual cow level. The amount of urine per urination was measured using a scale. On six focus days, the number and duration of urinations outside the CowToilet were recorded on video. In addition, behavioural parameters indicative of stress (kicking, head-lifting, defecating, tripping, avoiding, flinching, etc.) were recorded on day 1 and 3 when the CowToilets were put in operation and on two further days after two months.

Results and discussion

During the investigation period, technical problems occurred, especially during frost. All cows visited the CowToilet. whereby almost 10 visits per cow and day were recorded. The amount of urine depended on the number of visits and differed significantly between cows. On average, a total of 11 urinations per cow and day were recorded outside the CowToilet (housing and outdoor exercise area) and around 4 urinations per cow and day inside the CowToilet. At 5.6 L per cow and day, the average amount of urine collected in the CowToilet was considerably higher than in a German study at 3.5 L per cow and day (Werner et al., 2022) and only half as much as in Dutch investigations at 10.4 L per cow and day (Van Dooren et al., 2024). Reasons for the large amount of urine in the Dutch study could be the higher amount of concentrate used as bait feed and the lower animal density per CowToilet with 16 cows. On the first and third day of the operation, the behavioural parameters flinching and tripping, as well as very occasional avoiding, kicking and defecation, were observed. After two months of operation of the CowToilet, virtually none of the parameters could be observed.

Conclusion

Once the animals have become accustomed to it, the CowToilet is not a concern from an animal welfare point of view. Since less than a third of the daily urinations took place in the CowToilet, it can be assumed that the ammonia reduction potential of the Dutch study at 35-47% (Van Dooren et al., 2024) cannot be achieved under the conditions of the present study. Further research into the potential for reducing ammonia emissions should be carried out under practical conditions with low levels of concentrate used as bait feed. Furthermore, it is necessary to clarify how the separated urine can be processed and used.

Acknowledgements

Thanks to M. Keller and B. Kuersteiner for technical assistance and BBZ Arenenberg for the cooperation in the housing.

References

Van Dooren, H. J. C. et al. 2024. Ammonia emissions of the CowToilet for use in dairy barns : case-control measurements at Dairy Campus. (Report / Wageningen Livestock Research; No. 1453). Wageningen Livestock Research. https://doi.org/10.18174/641497

Werner, D. et al., 2022. CowToilet: Kot-Harn-Trennung im Milchviehstall/CowToilet: Separation of faeces and urine in the dairy barn. In: Proceedings of the “15th Conference Construction, Engineering and Environment in Livestock Farming», Editor: Association for Technology and Structures in Agriculture (KTBL), pp. 30-34.

12. Mitigating ammonia losses from scraped dairy manure using alternative acidifiers

Aarons, S.R.[a*], Gourley, C.J.P.[b], Shelley B.[c] & Kitching, M.[d]

Agriculture Victoria Research, 1301 Hazeldean Road, Ellinbank, Victoria 3821, Australia [a]; School of Agriculture and Food Sciences, The University of Queensland, Australia [b], 44 Hamilton Drive, Ringwood North, Victoria, Australia [b]; 44 Hamilton Drive, Ringwood North, Victoria, Australia [c]; *Sharon Aarons, Sharon.Aarons@agriculture.vic.gov.au

Introduction

Increased herd sizes on Australian dairy farms have coincided with greater use of imported feed to drive increased milk production. Animals in these systems spend more time away from pasture where manure needs to be collected. Where manure is scraped and stockpiled the potential exists for large losses of nitrogen decreasing its agronomic value. Acidification with sulphuric acid can reduce ammonia (NH_3) volatilisation from manure by at least 60% (Sokolov *et al.* 2021), while less hazardous acidifying agents such as alum, lactic and acetic acids and bio-acidification have also been shown effective in reducing NH_3 loss (Regueiro *et al.* 2016; Regueiro *et al.* 2022). Acidification of stored manure is seldom practiced in grazing-system dairy farms and such strategies to reduce N loss need to be investigated. This study aimed to compare the effectiveness of acidifiers (metal salt, weak acid, sucrose) to retain N and increase the agronomic value of dairy manure scraped from a commercial dairy farm in Victoria Australia.

Methodology

Semi-solid (16% dry matter) manure deposited in late winter/early spring in concreted holding yards by grazing-based dairy cows was collected using a front-end loader and equally distributed into 160L tubs which were immediately returned to the laboratory. Triplicate treatment tubs (balanced for weight) had Alum (AL), Acetic acid (AA) and Sucrose (SUC) added (2.5% of fresh weight) then thoroughly mixed. Untreated replicated controls (CON) were also mixed. Tubs were randomly arranged in the laboratory and connected to a gas emissions measurement system consisting of a Gasmet DX4015 and multipoint sampling system which sequentially sampled gas emissions hourly from all tubs. Manure samples were periodically collected for chemical analysis over 75 days.

Results and discussion

Acidifiers immediately decreased manure pH below the target of 5.5 (recommended to reduce NH_3 losses), with an immediate decline for AA to pH 4.5 (which did not recover (Regueiro *et al.* 2016)), and for AL to pH 5.3. In contrast, SUC addition slowly reduced manure pH to pH 4.5 by Day 14. At the end of the study (Day 75), pH had increased for AL and SUC treatments but not to the original pH. Ammonia losses were immediately reduced by all acidifiers; effectively halted by AA, with slowly increasing emissions from the AL addition. For SUC treated manure rapid NH_3 losses occurred after Day 30 resulting in a smaller decline by Day 60 than reported by Prado *et al.* (2020). On Day 75, manure total N content was AL >> AA >> SUC > CON. Manure C content was similar for all treatments and greater than CON (AL = AA = SUC > CON). Manure C:N ratios (SUC > CON = AA > AL) reflected NH_3 losses and the effect of adding 3 kg of a C source to Sucrose treated manure.

Conclusion

Alum treatment appeared to result in manure with greater N value and reduced NH3 losses. Despite effectively stopping NH3 emissions Acetic acid had the same manure C:N and potential manure N value as the Control, especially after 30 days. Further Investigation of lower doses of Acetic acid could be warranted. Use of an easily fermentable carbon source such as Sucrose for 30day storage may reduce NH_3 loss although the C:N ratio was similar or greater than the control and could lead to immobilisation of N when land applied. Further research is required to quantify GHG emissions for manure collected from these pasture-based systems.

References

Prado J, Chieppe J, Raymundo A, Fangueiro D (2020) Bio-acidification and enhanced crusting as an alternative to sulphuric acid addition to slurry to mitigate ammonia and greenhouse gases emissions during short term storage. *Journal of Cleaner Production* **263**, 121443. doi:https://doi.org/10.1016/j.jclepro.2020.121443

Regueiro I, Coutinho J, Fangueiro D (2016) Alternatives to sulfuric acid for slurry acidification: impact on slurry composition and ammonia emissions during storage. *Journal of Cleaner Production* **131**, 296-307. doi:https://doi.org/10.1016/j.jclepro.2016.05.032

Regueiro I, Gómez-Muñoz B, Lübeck M, Hjorth M, Jensen LS (2022) Bio-acidification of animal slurry: Efficiency, stability and the mechanisms involved. *Bioresource Technology Reports* **19**, 101135. doi:https://doi.org/10.1016/j.biteb.2022.101135

Sokolov V, Habtewold J, VanderZaag A, Dunfield K, Gregorich E, Wagner-Riddle C, Venkiteswaran JJ, Gordon R (2021) Response Curves for Ammonia and Methane Emissions From Stored Liquid Manure Receiving Low Rates of Sulfuric Acid. *Frontiers in Sustainable Food Systems* **5**. [In English] doi:10.3389/fsufs.2021.678992

Parallel session 6

1. Measurement of ammonia and methane emissions from pig farms with an outdoor run

Sefeedpari P.[a*], Xie F.[b], Aarnink A.J.A.[a,b]

Wageningen Livestock Research, Wageningen University and Research, the Netherlands [a]; Agricultural Biosystems Engineering Group, Wageningen University and Research, the Netherlands [b]; [*]Corresponding author, email: paria.sefeedpari@wur.nl

Introduction

Pig farming is a significant source of ammonia (NH_3) and methane (CH_4) emissions, which contribute to air pollution, environmental degradation, and climate change (Blanes-Vidal et al., 2008). Measuring these emissions accurately, particularly from outdoor sources on the farm, is challenging to perform directly (Flesch et al., 2005) and poses challenges due to the open environment and variable factors such as wind, weather, and manure distribution (Laubach et al., 2024). Traditional methods often fail to capture the spatial and temporal dynamics of emissions in such systems. This study aims to address these challenges by employing a micrometeorological method to measure NH_3 and CH_4 emissions from a pig farm with an outdoor run. The objectives are to quantify emission rates under typical management conditions and evaluate the effectiveness of the micrometeorological approach for monitoring emissions in complex agricultural systems. The findings are expected to enhance understanding of emission dynamics and support the development of mitigation strategies for reducing the environmental impact of pig farming.

Methodology

This study utilized a micrometeorological approach to measure ammonia (NH_3) and methane (CH_4) emissions from a pig farm with an outdoor run. The experimental farm uses an innovative manure removal system with perforated rotating collection plates under the slatted floor of the outdoor pen to enable rapid separation of faeces and urine. Urine is collected in a gutter, while solid manure is cleaned daily from the plates and stored in a pile under a solid roof. Measurements were conducted at two downwind distances, 40 m and 75 m from the pig barn, as well as upwind (background) to capture emission variability across the sources. Gas concentrations were monitored continuously using a Picarro G2508 gas analyzer, which employs cavity ring-down spectroscopy (CRDS) for high-precision detection of NH_3 and CH_4 in ambient air. Wind parameters, including speed, direction, and turbulence, were recorded with a 3D sonic anemometer positioned to capture atmospheric conditions affecting dispersion. The emission rates were calculated using a backward Lagrangian stochastic (bLS) dispersion model. This model incorporated gas concentration data, wind measurements, and the distances to simulate the transport of gas particles and quantify emissions.

Results and discussion

Micrometeorological measurements highlighted distinct emission patterns for ammonia (NH_3) and methane (CH_4). The study found that positioning downwind measurement lines closer to the pig house enhances the accuracy of NH_3 and CH_4 emission estimates, as concentrations became too much diluted at greater distances. Average emissions were 0.028 kg NH_3/hour and 0.082 kg CH_4/hour which were significantly below the reference emission from a conventional pig farm. The bLS model successfully captured the dynamics of the emissions across the measuring rounds, providing robust estimates that align with expected emission profiles for similar systems.

Conclusion

The findings of this study highlight the effectiveness of the micrometeorological approach in quantifying emissions under real-world conditions. By integrating high-resolution gas concentrations and wind data, the study provided robust estimates of NH_3 and CH_4 emissions for a pig farm with outdoor run, offering valuable insights into the emission dynamics at the farm.

Acknowledgements

The authors would like to thank all WUR technicians and the farmers who participated in the study.

References

Blanes-Vidal V., et al. 2008. Emissions of ammonia, methane and nitrous oxide from pig houses and slurry: Effects of rooting material, animal activity and ventilation flow, Agric. Ecosyst. Environ., 124, 3–4, 237-244.

Flesch, T.K., et al. 2005. Estimating gas emissions from a farm with an inverse-dispersion technique. Atmospheric Environment 39.27, 4863-4874.

Laubach J., et al., 2024. Methane emissions from animal agriculture: Micrometeorological solutions for challenging measurement situations, Agric. For. Meteorol., 350, 109971.

2. Quantification of NH_3 and NMVOC emissions after raw and acidified pig slurry field application.

Dela Pierre, F.[a*], Fakhar, A.[b], Pedersen, J.[b], Feilberg, A.[b], Hansen, M.J.[b], Dinuccio, E.[a], Kamp, J.N.[b]

Department of Agricultural, Forest and Food Science, University of Turin, Italy [a]; Department of Biological and Chemical Engineering, Aarhus University, Denmark[b]; * Flavia Dela Pierre, email: flavia.delapierre@unito.it

Introduction

Agriculture accounts for more than 80% of the global anthropogenic ammonia (NH_3) emissions (Behera et al., 2013), with land spreading of animal slurry and manure being a significant source (Misselbrook et al., 2005). NH_3 contributes to several environmental issues, such as eutrophication, soil acidification, nitrous oxide and fine particulate matter formation. Together with hydrogen sulfide (H_2S), and non-methane volatile organic compounds (NMVOC), NH_3 also contributes to odour nuisance from animal slurry (Wang et al., 2021). Acidification with concentrated sulfuric acid (96% H_2SO_4) is an effective strategy to mitigate NH_3 emissions; however, it may increase NMVOC emissions, leading to greater volatilization of volatile fatty acids (VFAs) (Pedersen et al., 2022). This study investigated NH_3 and NMVOC emissions from pig slurry field application, with the aims to: (I) measure absolute NH_3 and NMVOC fluxes from untreated slurry using the backward Lagrangian stochastic (bLS) method, (II) assess the impact of increasing H_2SO_4 dosages on emissions using the dynamic flux chambers (DFC) method, and (III) compare the results obtained from the two measurement techniques.

Methodology

The experiment was performed at Campus Viborg, Aarhus University (Tjele, Denmark). The bLS method was used on a large plot where pig slurry was machine-applied using trailing hoses. DFC were placed in a smaller plot to test the effect of 4 H_2SO_4 dosages: 0 (untreated), 2.9 (legal Danish requirement for field acidification), 5.3, and 10.5 kg H_2SO_4 tonne^{-1} of slurry. Four additional chambers were placed inside the bLS plot, to quantify the differences between chambers and bLS. Emissions were measured using cavity ring down spectrometry (CRDS, Picarro CA, USA) for NH_3 concentrations, and proton transfer reaction-mass spectrometry (PTR-MS, IONICON Analytik, Innsbruck, Austria) for NMVOC concentrations. All fluxes were continuously monitored for 5 days.

Results and discussion

Total NH_3 losses measured with bLS were 10.8% of the total ammoniacal nitrogen (TAN), while emissions measured in the same plot using DFC averaged 16.06% of TAN. The comparison between increasing H_2SO_4 dosages did not highlight any statistical difference between treatment in terms of cumulative NH_3 emissions, and within treatments variability was high. Regarding NMVOC measurements, 19 compounds were detected, and total NMVOC emissions measured with the bLS were 2676.392 mg NMVOC m^{-2}, with carboxylic acids being the most abundant of the emitting compounds. Different dynamics were observed for different compounds where some were released immediately after application while others had a clear diurnal pattern. NMVOC data from the DFC shows some of the same trends but data treatment is still under elaboration.

Conclusion

The DFC method overestimated NH_3 emissions from applied slurry compared to the bLS method, confirming results from previous studies. The bLS method with PTR-MS has shown to be effective for characterizing NMVOC flux and dynamics from field slurry application. Acidification did not significantly reduce NH_3 emissions, likely due to the slurry's low dry matter content resulting in rapid infiltration, which limits NH_3 volatilization.

References

Behera, S.N., et al. 2013. Ammonia in the atmosphere: a review on emission sources, atmospheric chemistry and deposition on terrestrial bodies. Environ. Sci. Pollut. Res. 20, 8092–8131.

Misselbrook, T.H., et al. 2005. Predicting ammonia losses following the application of livestock manure to land. Bioresour. Technol., The 10th International Conference on Recycling of Agricultural, Municipal and Industrial Residues in Agriculture 96, 159–168.

Pedersen, J., et al. 2022. Effect of storage and field acidification on emissions of NH3, NMVOC, and odour from field applied slurry in winter conditions. J. Environ. Manage. 310, 114756.

Wang, Y.-C., et al. 2021. Emissions, measurement, and control of odor in livestock farms: A review. Sci. Total Environ. 776, 145735.

3. Mitigating ammonia and nitrous oxide emissions from cattle digestate band application using nitrification inhibitors in permanent grasslands

Dinuccio, E.[a*], Dela Pierre, F.[a], Margarini, G. [a], Rollè, L.[a]

Department of Agriculture, Forest and Food Science, University of Turin, Italy [a]; [*]Corresponding author, email: elio.dinuccio@unito.it

Introduction

Permanent grasslands are a key component of livestock production systems in northern Italy, particularly in the alpine and pre-alpine regions. Livestock effluents are applied to these grasslands, often after undergoing anaerobic digestion, to recycle nutrients and support sustainable farming. However, this practice raises environmental concerns, particularly nitrogen (N) losses in the form of nitrate (NO_3^-) leaching, which can contribute to water pollution and eutrophication, ammonia (NH_3) volatilization, leading to air pollution and nitrogen deposition, and nitrous oxide (N_2O) emissions, a potent greenhouse gas (GHG) contributing to climate change. In recent years, nitrification inhibitors (NIs) have emerged as effective tools for mitigating N losses and optimise N use efficiency (Tariq et al., 2025). By inhibiting ammonium monooxygenase, NIs slow the first steps of nitrification reactions, maintaining applied N in the soil as ammonium (NH_4^+-N) for a longer period. This process potentially reduces nitrate (NO_3^-) leaching and N_2O fluxes from the soil (Zerulla et al., 2001), improving fertilizer efficiency and minimizing environmental impact. This study evaluates the effect of adding NIs to digestate on N_2O and NH_3 emissions after its application on permanent grasslands. To this purpose, two commercial products, one based on nitrapyrin (NP) and the other on 3,4-dimethyl-1H-pyrazole phosphate (DMPP), were selected.

Methodology

Cattle digestate was applied in summer conditions on a selected permanent grass field using trailing shoes. The experimental treatments included: raw cattle digestate as the control (C), cattle digestate with NP addition and cattle digestate with DMPP. Both NIs were added to the slurry at their commercially recommended dosages. Each treatment was tested in triplicate, following a completely randomized experimental design with 20x20 m^2 plots. NH_3 fluxes from the soil were monitored for 5 consecutive days after application using the backward Lagrangian stochastic (bLS) method, with ALPHA samplers for NH_3 concentrations and a 3D sonic anemometer (GILL, Windmaster Pro) for wind statistics. N_2O emissions were monitored over 3 months, by means of the closed static chamber technique. Gas samples were collected once a week, or twice per week when N_2O peaks were expected due to rain events and analyzed with a gas cromatograph.

Results and discussion

Results showed that cumulative NH_3 emissions from the plot averaged 35% of the total applied N. NH_3 emissions were significantly ($p<0.05$) higher from the control (C) compared to NP, which resulted in a 38.7% reduction. DMPP reduced NH_3 emissions by 13.9% compared to C, but this difference was not statistically significant ($p>0.05$). No significant differences in NH_3 emissions were found between NP and DMPP. Cumulative N_2O emissions averaged 0.3% of the applied N. NP reduced N_2O emissions by 15.6%, while DMPP showed a 3.5% reduction compared to the control, although no significant differences were observed between treatments. These results could be influenced by environmental factors, such as soil moisture and temperature, application method, or the timing of emissions peaks during the monitoring period.

Conclusion

The results of the study highlight the potential of NIs to mitigate N losses in permanent grasslands. However, the addition of NIs to cattle digestate reduced NH_3 emissions, particularly with NP, but had no significant effect on N_2O emissions. Further research is needed to explore the effectiveness of NIs in reducing both NH_3 and N_2O emissions, and to evaluate their agronomic benefits in terms of nitrogen retention and forage production.

Acknowledgements

This work has been realized within the project “Towards a Mediterranean Climate Neutral Farm model (CLINMED FARM - LIFE20 CCM/ES/001751)”.

References

Tariq, A., et al. 2025. Assessing nitrous oxide mitigation efficiency of three nitrification inhibitors with synthetic and organic fertilisers in Eastern Denmark, Environ. Technol. Innov. 37.

Zerulla, W, et al. 2001. 3,4-Dimethylpyrazole phosphate (DMPP) – A new nitrification inhibitor for agriculture and horticulture. Biol. Fertil. Soils 34, 79–84.

4. Evaluating the agronomic and environmental impacts of slurry and digestate separation: A rapid evidence assessment

Langley-Randall, J.[a], Lloyd, I.L.[a*], Smith, K.E.[a] Thorman, R.E. & Sagoo, E.[a]

ADAS, ADAS Boxworth, Cambridge, United Kingdom [a]; *Corresponding author, email: isobel.lloyd@adas.co.uk

Introduction

Improving the nutrient use efficiency of organic materials is key to minimising pollution and maximising nutrient utilisation, helping to achieve climate change mitigation targets, contributing to the adoption of circular agricultural systems, and supporting food security. The separation of livestock slurry and digestate into fibre and liquid fractions can reduce slurry storage requirements and transportation costs. The low dry matter (DM) content of the liquid fraction compared to 'whole' slurry can increase slurry infiltration into the soil, which can reduce ammonia (NH3) emissions, and increase available nitrogen (N) supply. Conservation of N in the soil may increase direct nitrous oxide (N2O) emissions and nitrate (NO3) leaching losses, however. Organic materials supply significant amounts of phosphorus (P), thus applications need to be carefully managed to reduce the risk of excess soil P and associated leaching losses. A rapid evidence assessment (REA) was conducted to evaluate the agronomic and environmental impacts of livestock slurry and digestate separation and the use of the separated materials. The REA assessed current knowledge on the effects of separation techniques on the physicochemical properties of the liquid and fibre fractions, slurry storage requirements, and gaseous losses during storage, and investigated the impacts of slurry and digestate separation on crop available N and P supply, soil health, gaseous emissions to air and nutrient losses to water following land application.

Methodology

The REA process involved the development of search criteria to identify relevant peer-reviewed and grey literature via systematic searches. Evidence was screened based on relevance against specific criteria, including the research being conducted in temperate climates, published between 2009-2024, and focused on separated pig/cattle slurry or digestate. Papers were also required to include an untreated control alongside the slurry/digestate treatments applied, to identify the impact of separated slurry/digestate fractions on the environment following land application, and report analysis for the original 'whole' with the separated fractions. This screening process identified 85 relevant studies, the data from all of which were extracted into a spreadsheet database for analysis and the impacts of slurry separation evaluated.

Results and discussion

The key findings of the REA were as follows: screen press, screw press and centrifuge systems were found to be effective at separating whole slurry/digestate. Changes to slurry characteristics were driven by DM separation, with total P, total N and DM being heavily associated with the fibre fraction, which was more alkaline. Whilst separated cattle slurry fibre qualified as low readily available nitrogen (RAN) (i.e. RAN <30% of total-N) material, separated pig slurry and digestate fibre often met the definition of a high RAN material (i.e. RAN >30% of total-N). The impacts of slurry and digestate application on crop nutrient availability, greenhouse gas (GHG) emissions from soil and NO_3 leaching were highly variable depending on the slurry/digestate type, the fraction applied, application rate and method, incorporation method and environmental conditions at application. No evidence of any impact of separation technique on nutrient availability, GHG emissions from soil and NO_3 leaching could be discerned from the limited dataset. No evidence was available on slurry storage requirements, and evidence was limited on gaseous emissions during storage and the impacts of separated slurry application on soil health. Where data were presented, the combined GHG emissions from separated slurry were lower than 'whole' slurry, while the impacts on NH_3 losses were variable.

Conclusion

This REA evaluated the impact of separation on the physicochemical properties of livestock slurry and digestate, storage capacity and emissions, soil health, nutrient losses and gaseous emissions following application to land. Separation increased the levels of DM, total-N and total-P in the fibre fraction of slurry/digestate. Whilst the fibre fraction of cattle slurry was found to be a low RAN product, pig slurry fibre fraction met the definition of a high RAN product, highlighting the challenges of managing pig slurry fibre with regards to spreading restrictions in nitrate vulnerable zones. The impacts of separation on nutrient availability, GHG emissions and NO_3 leaching are highly variable because of separation. More research on storage requirements, gaseous emissions from storage, and the impacts of separation on soil health and nutrient losses are needed to fully understand the impacts of separated slurries on the environment following land application.

Acknowledgements

The funding of this work by Defra is gratefully acknowledged.

5. Reducing nitrogen waste through crop and livestock reconnection

Lassaletta, L[a*], Sanz-Cobeña, A.[a], Pinsard, C.[b], Spiegal, S.[c], Ma, L.[d], Reidsma, P.[e], & Snow, V[f].

CEIGRAM-Universidad Politécnica de Madrid, Spain[a]; ResAgrEE, TARNAC, France[b]; USDA-ARS, Jornada Experimental Range, USA[c]; Nanjing University, China[d]; Wageningen University, Netherlands (deceased) [e]; AgResearch – Lincoln Research Centre, New Zealand[f] *Corresponding author, email: luis.lassaletta@upm.es

Introduction

The specialisation of agricultural territories during the past 50 years has resulted in the disconnection of crop and livestock systems, which has boosted system inefficiencies, linearity and nitrogen (N) waste. Disconnected livestock systems hardly reuse any manure in crops at sustainable rates, exacerbating N pollution, while cropping systems rely on new inputs of synthetic fertilisers as a source of N. The reliance on external sources for feed and fertiliser also makes disconnected regions more vulnerable to commercial global instability (Lassaletta et al. 2024). We aimed 1) to identify relevant crop and livestock disconnection examples in contrasting world regions resulting in N waste; and 2) to gather diverse alternative management strategies to reduce nitrogen waste through crop and livestock reconnection.

Methodology

Using nitrogen budgeting approaches at the regional scale (province and county) and considering N flows in the entire agro-food system, we evaluated cases of crop and livestock disconnection in several countries and regions. To more fully explore these problems, we have launched a Special Issue in the Agricultural Systems journal calling for original research articles proposing strategies to reduce N waste by reconnecting crop and livestock systems.

Results and discussion

Regional analyses showed a clear specialisation of the studied regions in USA, Europe and China. Many intensive crop and livestock production systems are located in separate regions. Crop production systems are typically net exporters of feed and net importers of synthetic fertilisers, while livestock production systems generate large amounts of manure and rely on the net import of feed to sustain nitrogen flows. Fourteen contributions conducted on four continents have already been published in the Special Issue evaluating the efficiency of diverse strategies boosting reconnection and circularity. These contributions comprise dairy cattle, beef cattle, sheep, pig and mixed systems and have explored strategies aiming to reduce N waste by means of 1) improving the optimal allocation of manure (12 papers); 2) relocating feed production while reducing externalisation (10 papers); improving territorial and spatial planning (4 papers). The studies incorporated approaches across multiple spatial scales from field to national level and implementing one or a combination of the three aforementioned strategies could be beneficial across various agro-environmental dimensions.

We emphasise the following key messages: 1) The most promising strategies have to be tailored considering the singular characteristics of any target regions, which have to include a thorough analysis of livestock densities and feed rations, potential crop mix, climate and environmental vulnerabilities; 2) Circular N use can halve N waste in many regions; 3) A better internalisation and reconnection can be designed within a farm, particularly in ruminant systems. However, these strategies fully realise their potential when applied at the territorial scale; 4) Improving self-sufficiency indicators is generally possible in many regions. However, achieving full self-sufficiency in food and feed in some areas would require profound changes in the entire agro-food system and the acceptance of inevitable trade-offs; 5) Regional crop and livestock reconnection programmes require the establishment of targets and coordination to avoid a rebound or even a back-fire effect; 6) The potential of these strategies can be limited by the soil saturation of other nutrients.

Conclusion

Specialisation of farming has seriously affected circularity within agricultural systems in many areas of the world. The potential to improve system N use efficiency and reduce N waste by reconnecting crop and livestock systems has been positively tested in diverse regions worldwide.

Acknowledgements

AgrosceNa-NEXT PID2023-152562OB-I00 (Funded by MCIU /AEI /10.13039/5011000110331 FEDER, UE)

References

Lassaletta, L., Sanz-Cobeña, A., Pinsard, C., Ma, L., Spiegal, S., Reidsma, P., 2024. Special issue opening editorial: Reducing nitrogen waste through crop and livestock reconnection. Agric Syst 214, 103816.
Agricultural Systems, 2025. https://www.sciencedirect.com/special-issue/109JMKF1W5D

6. Environmental risk and potential phytotoxicity assessment of acidified slurry applied to soil

Ruas, M.J.[a], Chrysanthopoulos, S.[a], Najafia, F.[a], Alvarenga, P.[a], & Fangueiro, D.[a *]

LEAF, TERRA, Instituto Superior de Agronomia, University. de Lisboa, Portugal[a]; [*]Corresponding author, email: dfangueiro@isa.ulisboa.pt

Introduction

Acidification of animal slurry has become a popular treatment to minimize ammonia emissions in several EU countries, but the use of concentrated sulphuric acid (H_2SO_4) is still a limitation regarding farmers acceptance. On the other hand, several byproducts of food industry, usually sent to landfill, could be used as acidifying agents (Prado et al., 2020; Chrysanthopoulos et al., 2024). However, the potential ecotoxicological effects of the acidified slurry application to soil has only been marginally considered, being very important to assess potential impacts on plants, soil-dwelling invertebrates and on aquatic organisms, potentially affected by the runoff on receiving water's quality. The present work aimed to: (i) characterize agro-industrial residues and evaluate their potential as slurry acidifying agents; (ii) assess the effects of soil application of acidified slurry on plants and soil organisms; and (iii) assess the ecotoxicity of the amended-soil water extracts on aquatic organisms.

Methodology

Organic residues from the cheese and beverage industry were collected and characterized for their physicochemical properties, aiming their potential use in the bio-acidification of pig slurry, also quantifying the additive dose required to reach pH 5.5. Effects on the soil "habitat function" were assessed using terrestrial organisms and included sub-lethal and lethal bioassays: (a) plant germination of lettuce (*Lactuca sativa*) and cress (*Barbarea verna*); (b) plant growth of maize (*Zea mays*); (c) avoidance behaviour with *Eisenia fetida*; and d) acute mortality with *E. fetida*. These biotests were performed using a gradient of application rates based on the supply of nitrogen (N) per hectare of soil (600 kg/ha N, 300 Kg/ha N, 150 kg/ha N, 75 Kg/ha N) and using a sandy soil as the reference soil. Soil "retention function" was assessed using the soil water-extract (1:10 w/v, dm basis), after slurry application, and the effects towards: a) relative seed germination and roots elongation of lettuce (*Lactuca sativa*) (7d); and two aquatic organism, b) *Daphnia magna* acute immobilization test (48h); and c) *Vibrio fischeri* bioluminescence inhibition (15 and 30 min).

Results and discussion

For the direct bioassays, the results showed that, at the highest application rate, 300 kg/ha N, the application of H_2SO_4-acidified or bio-acidified slurry, affected significantly the germination of lettuce and cress seeds, completely inhibiting germination. This application rate was also the only that affected *E. fetida,* in the mortality bioassay, with registered acute toxicity towards soil invertebrates. At lower application rates, 150 Kg ha^{-1} N, the use of bio-acidified slurry led to an increase in the *Zea mays* growth bioassay, relative to H_2SO_4-acidified slurry, and to a decrease at the higher application rates (300 and 600 Kg ha^{-1}). Regarding the germination tests with the amended soil water-extract, results showed that the bio-acidified slurry application led to lower germination index values, when compared to the water-extracts of soil amended with slurry acidified with H_2SO_4, suggesting a potential higher toxicity from bio-acidified slurry when applied at higher rates.

Conclusion

The ecotoxicological evaluation showed no significant differences when applying bio-acidified or H_2SO_4-acidified slurry to the soil, but alerted for the necessity to avoid higher application doses, based on N rates, *e.g.*, 300 kg/ha N.

Acknowledgements

This study was supported by the project WASTELESS from the European Union (Grant Agreement No. 101084222). The authors also acknowledge FCT – Fundação para a Ciência e a Tecnologia, I.P., through UIDB/04129/2020 do LEAF-Linking Landscape, Environment, Agriculture and Food, Research Unit.

References

Chrysanthopoulos, S. et al. 2024. Agro-industrial by-products as alternative additives for the agronomic valorization of pig slurry through pH modification. J. Clean. Prod., 434, 140052. https://doi.org/10.1016/j.jclepro.2023.140052

Prado, J. et al. 2020. Bio-acidification and enhanced crusting as an alternative to sulphuric acid addition to slurry to mitigate ammonia and greenhouse gases emissions during short term storage. J. Clean. Prod. 263, 121443. https://doi.org/10.1016/j.jclepro.2020.121443.

7. A modelling approach on the current nutrient and carbon budgets of agricultural soils in Europe

Hendriks C.M.J.[a*] & Nikolaus K.H.[a] & Duan Y.[a] & Lesschen J.P.[a] & De Vries W.[b] & Ros, G.H.[b,c]

Wageningen Environmental Research, The Netherlands[a]; Wageningen University, The Netherlands [b]; Nutrient Management Institute, The Netherlands[c]; [*]Corresponding author, email: Chantal.hendriks@wur.nl

The European Green Deal strives to mitigate and eventually reverse environmental damage caused by agricultural nutrient pollution, and to simultaneously keep high production levels to meet the food and feed demand. When looking for the best solutions to reach these European goals, it is important to know the current state. Often, environmental assessments focus on only one or a few nutrients, potentially overlooking surpluses or deficits of another nutrient which, as a result, might be negatively influenced by a chosen measure. An integrated modelling approach on all nutrients that stimulate crop growth together with the integration of soil organic carbon (SOC) dynamics is needed for a more holistic view on the goals. This study provides this integrated look at nutrient and carbon budgets and balances of agricultural soils in Europe using the dynamic MITERRA-Europe model. This model calculates greenhouse gas (CO_2, CH_4 and N_2O) emissions, other nutrient emissions and losses to ground -and surface water (including N, P, K, S, Mg, Ca, Cd, Cu, and Zn), and soil organic carbon stock changes at regional level within EU-27, the UK, and Switzerland. The modelling approach is based on Velthof et al. (2009), Reinds et al. (2011), De Vries et al. (2023), and Hendriks et al. (in prep).

The results show most recent soil nutrient and carbon budgets and balances at regional level (NUTS 2). The direct correlation between livestock and agricultural dense regions and the soil nutrient surpluses became visible. Knowing the current soil nutrient and carbon budgets, gives us opportunities to further assess the effect of measures that help closing nutrient loops in agriculture.

Acknowledgements

This study has been developed within the framework of the European Union HORIZON-CL6-2021-ZEROPOLLUTION-01 Grant Agreement No. 101060455 (NutriBudget project).

References

Velthof, G.L., et al. 2009. Integrated assessment of nitrogen losses from agriculture in EU-27 using MITERRA-EUROPE. J Environ Qual. 38: 402-17. DOI: 10.2134/jeq2008.0108. PMID: 19202011.

Reinds, G.J., et al., 2012. Estimating nitrogen fluxes at the European scale by upscaling INTEGRATOR model outputs from selected sites. Biogeosciences, 9: 4527 – 4536. DOI: 10.5194/bg-9-4527-2012

De Vries, W., et al., 2023. Integrated assessment of agricultural practices on large scale losses of ammonia, greenhouse gases, nutrients and heavy metals to air and water. Science of The Total Environment 857: 159220. DOI: 10.1016/j.scitotenv.2022.159220.

8. Effects of 25 years of repeated application of urban composts on soil quality

Levavasseur, F.[a*], Benoit, P.[a], Bruyère, C.[b], Gaillard, S.[b], Lhoutellier, C.[b] & Houot, S.[a]

INRAE, Université Paris-Saclay, AgroParisTech, UMR ECOSYS, 91120 Palaiseau, France [a]; Veolia, France [b], *Corresponding author, email: florent.levavasseur@inrae.fr

Introduction

Repeated application of urban composts may have both positive and negative effects on soil quality. The QualiAgro long-term experiment in northern France started in 1998 with the aim of studying these effects, in comparison with farmyard manure (FYM) and to a control without any amendment (CON) (Obriot et al., 2016). Three composts are studied: a compost of green waste and sewage sludge (GWS), a compost of home sorted biowaste and green waste (BIO) and a compost of residual municipal solid waste (MSW). The composts and FYM are applied every two years at the same carbon rate. Nutrients and contaminants (trace elements (TE), PAH, PCB) in composts and FYM, soil and crop have been routinely monitored since the beginning of the experiment. The biological and physical properties of the soils have been studied punctually, as well as contamination by emerging contaminants. QualiAgro has been the source of many published studies. However, a recent and concise summary of both positive and negative effects on soil quality is missing, including results from both the routine monitoring and punctual studies.

Methodology

We reviewed and summarized the published results on soil quality in QualiAgro. We focused on soil chemical, physical and biological properties, and soil contamination. Other studies, e.g., on nutrient losses, gaseous emissions, crop production were not included. Where possible, we added updated figures from site monitoring.

Results and discussion

51 peer-reviewed articles on QualiAgro and indexed in the WOS reported results on soil quality: 14 on soil organic matter, 8 on soil nitrogen, 6 on soil phosphorus, 6 on soil biology, 6 on soil physical properties, 8 on trace elements, 5 on pharmaceuticals, 5 on pesticide dynamics, 3 on microplastics, and 2 on pathogens. The repeated application of urban composts strongly increased topsoil organic matter (SOM) content, especially GWS (+67% compared with CON and +22% compared to FYM) due to its higher OM stability. The progressive increase in SOM mineralization led to an increased N supply, while the P supply is mainly based on the inorganic P input from the composts. pH and CEC were significantly increased compared with CON (e.g., +18% and +45%, respectively, with BIO). An improvement in surface soil physical properties was observed compared with CON: increased aggregate stability, reduced bulk density (-5% on average), increased soil water holding capacity (+6% with GWS). However, these improvements were often limited and variable in space and time. Soil biological properties were improved with an increase in soil microbial biomass (+86% with GWS compared with CON) and enzymatic activities. However, other biological properties such as earthworm or nematode abundance and most diversity indicators were little affected. Concerning TE, a significant increase in the total TE content was observed compared with CON only for Cu and Zn, especially with GWS (+71% for Cu) and MSW, while their soluble form was either increased (e.g., +54% Cu_{CaCl2} with GWS) or decreased (e.g., -92% Cd_{CaCl2} with BIO), following the modification of soil pH and SOM. Pharmaceuticals were detected in soil (mainly with GWS and MSW), but the observed contents indicated a dissipation and limited ecotoxicological risks. Recently, soil contamination by microplastics has been documented, especially with MSW. All these positive and negative effects were related to the characteristics of the composts: mainly their nutrient and contaminant content and the stability of their organic matter.

Conclusion

QualiAgro provided a lot of information on the effects of repeated compost applications on soil quality. Ongoing work includes researches on the relationship between soil biology and functioning, trade-offs between C storage and N supply, effects in deep soil, or the dynamics of PFAS and microplastics. The site is open to collaboration on a wide range of topics.

Acknowledgements

The QualiAgro experiment was founded and is still supported by INRAE and Veolia. Qualiagro is integrated as a service of the infrastructure AnaEE-France (ANR-11-INBS-0001).

References

Obriot, F., et al. 2016. Multi-criteria indices to evaluate the effects of repeated organic amendment applications on soil and crop quality. Agric. Ecosyst. Environ. 232, 165–178.

9. Slurry acidification: Impact on soil health – A UK perspective from multi-site, multi-year field experiments

Langley-Randall, J.[ab*], Thorman, R.E.[a], Chadwick, D.R.[b] & Williams, J.[a]

ADAS, UK [a]; Bangor University, UK [b]; *Corresponding author, email: john.langley@adas.co.uk

Introduction

Slurry acidification, an ammonia (NH_3) abatement technique, is known to reduce NH_3 emissions by 50 – 90% across all stages of the manure management chain (Fangueiro et al., 2015). This abatement strategy is commercially available in Denmark, and surrounding countries, where sulphuric acid (H_2SO_4) is added to livestock slurry to reduce the pH to c. pH 5.5. However, there is little understanding as to the impact of slurry acidification on soil health once it has been applied to land. This Defra funded project aimed to address these knowledge gaps from a UK perspective.

Methodology

In total, 6 experimental sites (3 arable and 3 grassland) were selected across England and Wales to represent different soil, climate and cropping types. At each site, two slurry applications were made in two consecutive years. Application timings were typical for the receiving crop, and were applied via surface broadcasting and band spreading at an application rate of 30 m^3 ha^{-1}. The experimental design included replicated plots that received a single application of slurry, as well as plots receiving up to 4 repeated applications throughout the duration of the 2-year experiment.

Topsoils in each plot were sampled pre-application and post-harvest (0-15 cm depth for arable, and 0-7.5 cm for grassland) and analysed for pH and crop nutrients. In addition, detailed measurements were collected at the Bangor University experimental grassland site to determine changes in soil chemical (pH and nutrients), biological (earthworms and microbial diversity), and physical (Visual Evaluation of Soil Structure, VESS) indicators at each grass harvest period.

Results and discussion

Immediately following the application of acidified slurry (pH 5.5) to the grassland, soil pH reduced from pH 7.0 to 6.5 for surface broadcast slurry, while the reduction in soil pH was greater (a decrease of 0.7 pH unit) directly under the bands of band spread acidified slurry. However, by the end of each growing period (49-84 days depending on season) soil pH had returned to that of the control (no slurry amendment). Additionally, the maximum reduction in soil pH following the application of acidified slurry remained less than the reduction in soil pH found in plots receiving 100 kg N ha^{-1} of ammonium nitrate fertiliser. In addition, there was no long-term decrease in soil pH in plots receiving multiple applications.

A clear change in the soil microbial community (assessed via Non-metric Multidimensional Scaling, NMDS) was found immediately following the application of acidified slurry (day 1). But this change was temporary, with the soil microbial community of all the slurry treatments being similar to each other (but different to the control) by d 21, and there being no difference between all treatments and controls by d 49 (harvest). Further, microbial 16S sequencing showed a consistent reduction in the relative abundance for *Nitrosomonadaceae* throughout the 49-day period, with the greatest relative reduction found immediately following slurry application. No statistical difference was observed in earthworm biomass and abundance between slurry treatments, the fertiliser control (100 kg N ha^{-1}) and a no amendment control. Similarly, the VESS assessments showed no statistical between plots receiving up to four slurry applications.

Conclusion

Although changes in soil chemical and biological indicators were observed following the application of acidified slurry these were short-lived, i.e. returned to the control by the end of the growing season, while there were no differences in soil physical indicators between treatments. Therefore it is likely that there are no long-term negative impacts to soil health following the application of acidified slurry.

Acknowledgements

This study was funded as part of the UK Department for Environment Food and Rural Affairs (Defra) project number SCF0125.

References

Fangueiro, D., et al. 2015. Acidification of animal slurry– a review. Journal of Environmental Management 149, 46–56.

10. Duckweed Cultivation on Dairy Soiled Water: A Sustainable Alternative Protein Crop.

Redmond, C.[a*], Coughlan, N. E.[a] & Jansen, M. A. K.[a]

School of Biological, Earth and Environmental Sciences & The Environmental Research Institute, University College Cork, Ireland [a];
[*]Corresponding author, email: credmond@ucc.ie

Introduction

Typically, livestock diets are supplemented with high protein feeds derived from arable crops. Soybean, for example, is imported into Europe in large quantities, despite its cultivation being linked to significant environmental issues, such as land-use change, biodiversity loss, and dependence on synthetic fertilisers (Dreoni et al., 2022). These concerns have prompted efforts to identify sustainable alternative protein sources. Duckweeds (Lemnaceae) are a family of floating aquatic plants, known for their rapid growth on polluted waters, high protein content, and phytoremediation capacity (Sońta et al., 2019). On account of similar amino-acid profiles, duckweed biomass can be used as a substitute for soybean in animal feeds (Appenroth et al., 2017). Duckweeds also contain substantial amounts of starch, further enhancing their nutritional value (Xiao et al., 2013). In this study, it was explored whether soiled water from dairy farms can be utilised as a fertiliser for duckweed cultivation to generate high protein biomass for feed, thereby reducing reliance on imported protein while phytoremediating waste within a circular economy framework.

Methodology

Dairy soiled water (DSW) is a dilute wastewater derived from the milking process of dairy cattle and the rinsing of milking equipment and parlour. Duckweed (*Lemna minor* L.) was grown in 100 mL vessels to determine the suitability of DSW for cultivation. A scaled-up assessment of long-term duckweed growth on DSW was then conducted in 7.5 L vessels under the same conditions, where biomass, protein, and starch yield were quantified.

Results and discussion

DSW was determined to be a suitable agricultural waste stream for valorisation through duckweed cultivation (Redmond et al., 2025). Long-term growth on DSW with careful pH management led to no observed deficiencies or toxicities, whilst achieving high growth rates. When cultivated on DSW, *L. minor* biomass doubled twice in a one-week period, whilst starch content doubled, and soluble protein content reached 14.4%. Over four weeks, the nitrogen and phosphorus content in DSW decreased by 22% and 37%, respectively. Duckweed cultivation on DSW leads to valorisation through the production of a starch and protein rich biomass coupled with the phytoremediation of DSW. Growth on DSW can be sustained long-term, providing a continuous supply of biomass which can be incorporated into animal feed. Through the adoption of a duckweed-based stage in agricultural waste management, valuable nutrients that would otherwise be lost are recaptured, thus promoting a more efficient and sustainable agricultural industry.

Conclusion

Duckweeds can valorise dilute agricultural waste streams through the production of a high protein plant biomass.

Acknowledgements

This research was funded by the Department of Agriculture, Food and the Marine, Government of Ireland (2021R487: Duck-Feed).

References

Appenroth, K.-J., et al. 2017. Nutritional value of duckweeds (Lemnaceae) as human food. Food Chem. 217, 266–273.

Dreoni, I., Matthews, Z., et al. 2022. The impacts of soy production on multi-dimensional well-being and ecosystem services: A systematic review. J. Cleaner Prod. 335, 130182.

Redmond, C., et al. 2025. Optimisation of Dairy Soiled Water as a Novel Duckweed Growth Media. Plants. 14(1), 110.

Sońta, M., et al. 2019. Use of Duckweed *(Lemna* L.) in Sustainable Livestock Production and Aquaculture – A Review. Ann. Anim. Sci. 19(2), 257–271.

Xiao, Y., et al. 2013. Culturing duckweed in the field for starch accumulation. Ind. Crops. Prod. 48, 183–190.

11. Revealing the potential nutrient, ecotoxin and pathogen risks to freshwaters from livestock excreta

Castro-Castellon AT.[a*], Johnes PJ.[a], Lawrence T.[b], Enns SJA.[a], Chadwick DR.[c], Davies D.[c], Albini D.[d,e], Ball J.[f], Binley A.[f], Boote H.[d], Bull ID.[a], Evershed RP.[a], Hussey VL.[a], Jones DL.[c], Kasprzyk-Holden B.[b], Tyler CR.[d]

University of Bristol, UK [a*]; University of Bath, UK [b], Bangor University, UK [c]; University of Exeter [d], UK; Essex University, UK [e], Lancaster University, UK [f]. *Corresponding author, email: ana.castro-castellon@bristol.ac.uk

Introduction

Livestock excreta is a major pollutant in UK freshwaters, contributing significantly to eutrophication, pharmaceutical loading, pathogen transport, and ecotoxicological risks to aquatic biota.1,2 Environmental impact is likely to depend on on-farm livestock management and farming methods, including the management of direct excreta inputs (dung, urine, slurry amendments, manure spreading to land), and connectivity of land to surface waters.3-5 Allowing livestock direct access to watercourses can also influence the rate of urination and defecation, with cattle (dairy and beef) showing a 5–10% increase in frequency compared to those voiding excreta on land.6,7 This heightened deposition in streams is exacerbated during summer low flows where streams have less dilution capacity.8,9 Meanwhile slurry amendments to fields before rainfall events can generate transport of slurry and its constituent contaminants from land to watercourses which is widely reported. Here, we report the results of a major NERC-funded research programme QUANTUM in which we have characterised the contaminant profiles of livestock excreta (including solid manure, slurry, urine and dung from dairy cattle, beef cattle and sheep farming systems) to determine their nutrient, chemical contaminant and pathogen composition, to clarify the risks these materials may pose to biota in UK freshwaters

Methodology

Representative farmyard manure (FYM) and slurry samples were collected according to RB209 guidelines, while urine and dung sampling followed a multistage sampling strategy from six representative UK dairy, beef, and sheep farms between October 2023 and March 2024, and again from June to September 2024. Dry matter nutrient and metals species composition were determined using standard protocols at NRM-Cawood (a UK Accredited Laboratory). Dissolved N and P fraction concentrations in sample extracts were determined using a continuous segmented flow analyser. Ecotoxins (antibiotics, fungicides, parasiticides, endocrine disruptors and other pharmaceuticals) were identified using Ultraperformance Liquid Chromatography-Mass Spectrometry/MS (UPLC-MS/MS) and are currently undergoing quantification. Finally, PCR was used to determine DNA/RNA concentrations of target pathogens (e.g. *Escherichia coli*, Bovine Adenovirus, Adenovirus, *Mycobacterium tuberculosis*, *Chlamydia abortus* and Bovine Viral Diarrhoea).

Results and discussion

Total N and P % w/w varies by excreta type (Dung>FYM>Slurry) and livestock type (sheep>dairy>beef). Dissolved nutrient fractions findings revealed urea concentrations are highest in urine and in sheep urine specifically, while soluble reactive phosphate concentrations were highest in dung samples across all livestock types. In our ecotoxin work 198 parent compounds and their metabolites were screened for in each excreta sample, with a suite of antibiotics detected such as Erythromycin, Trimethoprim and Ciprofloxacin more commonly thought to arise from the sewage discharges to waters. A further 51 pharmaceutical and biomarker compounds were detected including non-steroidal anti-inflammatory drugs such as Ibuprofen, and compounds such as caffeine, L-Histidine, Ranitidine and Thalidomide more commonly associated domestic sewage effluents, as well as 12 fungicides and antiparasitics, and 14 hormones and endocrine disruptors e.g. Estradiol, Estrone and Progesterone. We found E. coli in all excreta and livestock types across all farms in autumn/winter, with higher concentrations in autumn/winter than summer (where it was only detected in cattle FYM and dung from two farms). This work has revealed the potential range of risks that livestock excreta present to freshwater biota, are exported to waters. Our ongoing work is quantifying the concentrations of these contaminants in excreta and in streams, determining how these different livestock excreta flush to streams, and determining their impacts on freshwater biota (www.quantumfreshwaters.org) and the conditions under which concentrations would be high enough to generate significant multiple stressors impacts on ecosystem health.

Acknowledgements

This study is part of the Natural Environment Research Council QUANTUM project (NE/K010689/1) Quantifying the combined nutrient enrichment, pathogenic and ecotoxicological impacts of livestock farming in UK rivers (NE/ X016080/1). The authors wish to acknowledge the farms for allowing access to their stock for sampling, and in particular to Dr Marie Kirby from Harper Adams Agricultural University for her assistance and advice on sampling.

References

1. Johnes, P.J., Evershed, R.P., Jones, D.L., Maberly, S.C., 2023. Biogeochemistry, 164(1), 1-12
2. Benyon, S.A. 2012. Veterinary Parasitology, 189, pp.113-124.
3. Henn, D., Humphreys, J., Duffy, C., Gibbons, J., Styles, D., 2023. Agricultural Systems, 212, 103772
4. Marsden, K., Lush, L., Holmberg, J., Whelan, M., King, A., et al., 2020. Agriculture, Ecosystems & Environment, 302, 107073.
5. Bond, T., Sear, D., Sykes, T., 2014. Agricultural Water Management, 131, 156-162.
6. Bond, T.A., Sear, D., Edwards, M., 2012. Livestock Science, 146(1), 59-66.
7. O'Callaghan, P., Kelly-Quinn, M., Jennings, E., Antunes, P., O'Sullivan, M., Fenton, O. Huallachain, D.O., 2019. JEQ 48(2), 340-51.
8. O'Neill, M., Briciu-Burghina, C., Jennings, E., Antunes, P., Huallachain, D. et al., 2023. Irish J. Agric. Food Research, 62(1), 7-17.
9. McDowell, R.W., Wilcock, R.J., 2008. New Zealand Veterinary Journal, 56(6), pp.289-296.
: an inertinite benchmark. Int. J. Coal Geol., 104409

12. Accepting and rejecting: Preferences of citizens and farmers along the Rhine Basin to reduce nutrient runoff into the Wadden Sea

Geidel, T.[a*], Fujita, J. [b], Dworak, T.[c] & Glößl, T. [d]

Fresh Thoughts Consulting GmbH, Austria [a,c,d]; Nutriënten Management Instituut, Netherlands [b]; *Teresa Geidel, email: Teresa.geidel@fresh-thoughts.eu

Introduction Various nutrient reduction measures are implemented in farming practices along the Rhine Basin. This study focuses on the perspective of the farmers experiences and the citizens preferences of nutrient reduction measures in farming practices in the Rhine river basin, and starts by understanding the need each of the groups see to apply the measures, and which ones should be applied more and/ or additionally. The study takes a look at the potential of nutrient reduction measures by applying a source-to-sea approach to better understand what role nutrient reduction measures can play in protecting the Wadden Sea. By asking citizens and farmers about current and potential nutrient reduction measures in farming practices along the river Rhine, we capture attitudes to different nutrient reduction measures along the Rhine River towards the Wadden Sea. The primary data (interviews and surveys) are analysed and interpreted to show a) which measures are most socially acceptable, and b) the expectations on responsibility and which groups should become more active in nutrient reduction and c) what could help in forming a common understanding of agricultural ecological efforts between citizens as consumers and farmers, according to both groups replies.

Methodology A combined data collection approach quantitative assessment in surveys with citizens together with in-depth interviews with farmers allowed for a deep understanding of which groups prefer which measures and why. We captured the assessment of citizens through an online and telephone survey (N=1400) and in-depth telephone interviews with farmers (N=29).The potential respondents were selected based on a representative mapping and random selection amongst different postal zip codes in areas of the Rhine river basins, ensuring also a well-balanced representation of other socio-economic parameters and for the interviews with farmers, variation in the type and size of farms. The data collection took place along the Rhine River in Germany and the Netherlands. Data was collected on the state of knowledge, expectations, perception of responsibilities and behavioural change aspects related to nutrient reduction measures.

Planned results and discussion This study brings together information from the citizens and the farmers' side on: a) **Knowledge**: The state of knowledge and assessment of citizens concerning nutrient pollution, the extent of the pollution, its sources and how much respondents believe nutrients from rivers pollute the Wadden Sea. b) **Meaning:** An assessment of the effects of nutrient pollution and who it impacts. c) **Expectations:** An assessment of 3 measures (Usage of fertilizers, livestock density and width of buffer strips) based on the citizens' responses related to the sufficiency of each measure and the expected impacts. Farmers and citizens were also asked, who else should actively reduce nutrient inputs and capture what farmers and citizens would wish for, also from the other group, respectively. d) **Behaviour:** An assessment of proposed changes between the political framework of the farmers' operations and the citizens' perspective. Also, responses on the willingness to reduce dairy and meat consumption are a survey item for checking expectations.

Trends such as whether there are differences depending on socio-economic or geographical factors (such as how close to the river and the Wadden Sea) are also acknowledged. The full results will only be analysed from February-May 2025. Previously, in a project deliverable, a thorough analysis of all existing policy instruments regarding the issue of nutrient reduction was undertaken and helped inform the discussion.

Acknowledgements

The study was conducted within the NAPSEA project, which researches the effectiveness of Nitrogen and Phosphorus load reduction measures from Source to sEA, considering the effects of climate change (NAPSEA), funded by the European Union Horizon 2020 programme, project 101060418.

References

IKSR, 2020. Rhine 2040 - sustainably managed and climate-resilient. Available at: https://www.iksr.org/fileadmin/user_upload/DKDM/Dokumente/Broschueren/EN/bro_En_2040_long.pdf (Accessed: 18 December 2024).; LAWA-VV, 2022. Aktualisierung der wirtschaftlichen Analyse (WA) der Wassernutzungen gemäß Artikel 5 Abs. 1 und 2 WRRL bzw. §§ 3 und 4 Oberflächengewässerverordnung sowie §§ 2 und 3 Grundwasserverordnung für den Bewirtschaftungszeitraum 2021-2027; Podruzsik, S. and Fertő, I., 2024. Motivations for farmers- participation in agri-environmental scheme in the EU, literature review', Open Agriculture, 9(1). doi:10.1515/opag-2022-0379.

Poster presentations

1. Validation of bio-based fertilisers from fruit and vegetable waste in European and Colombian field trials

Amery, F. [a*], Willekens, K.[a], Ramos, R.[b], Martínez-Gaitán, C.[b], Gázquez, I.[b], Sinicco, T.[c], Ronchin, E.[c], Kuiper, D.[d], Pulleman, M.[e], Peña-Chipatecua, G.[e], Mondini, C.[c]

Institute for Agricultural and Fisheries Research (ILVO), Plant Sciences Unit, Belgium [a]; Foundation of Auxiliary Industry of Agriculture Tecnova, Spain [b]; CREA Research Centre for Viticulture and Enology, Italy [c]; CropEye Foundation, The Netherlands [d]; International Center for Tropical Agriculture (CIAT), Colombia [e]; *Corresponding author, email: Fien.Amery@ilvo.vlaanderen.be

Introduction

Recycling of nutrients from fruit and vegetable waste in agriculture can reduce mineral fertiliser dependence and nutrient losses. In addition, the application of such bio-based organic fertiliser can increase the soil organic carbon content, beneficial for climate mitigation and soil health. Technologies as anaerobic digestion followed by microbial biomass production, insect breeding, pyrolysis and composting, can turn waste into respectively microbial biomass, insect biomass and frass, biochar and compost. These building blocks can be blended in various combinations, resulting in tailor-made bio-based fertilisers adapted to crop, soil and specific needs. After a first-stage verification of 15 fertilisers (blends) in laboratory incubation trials, a selection of fertilisers most suited to regional crop and conditions was produced at pilot scale and validated in field and greenhouse trials in Europe and Colombia.

Methodology

Field and greenhouse trials were performed in 5 regions: Flanders (Belgium), Almeria (Spain), Pays de la Loire (France), Friuli Venezia Giulia (Italy) and Valle del Cauca (Colombia). The bio-based blends, designed and adapted specifically for each region, were produced at pilot scale and applied on soil. Region-specific test crops were grown. The fertilisers were always compared with a reference fertiliser for that region, and sometimes a blank (no fertiliser addition). Several soil, plant and yield parameters (depending on the specific crop and region) were assessed in order to validate the fertilisers.

Results and discussion

In Flanders the Fl/1 and Fl/2 fertilisers increased the soil mineral nitrogen (N), especially in the soil layers accessible for the plant roots. The N gift associated with the fertiliser application rate of this trial was sufficient for the first crop (leek), but not for the relatively high N demanding second crop (cauliflower), with resulting lower yields and quality compared to the reference mineral fertiliser. However, Fl/2 application resulted in higher visual scores for leek and increased soil organic carbon and nitrogen. In Almeria, the Alm/2 and Alm/1b fertilisers were validated in greenhouse trials with tomatoes and cucumber. Both blends increased soil enzymatic activities, and Alm/1b increased soil N, organic matter and water retention compared to the reference organic fertilisers. The blends showed positive impacts on the oxidative stress, plant defence and tomato quality. The greenhouse and field trials in Pays de la Loire showed mixed results for the tested blends on soil, lettuce and grapes. In Friuli Venezia Giulia three blends were compared with a reference organo-mineral fertiliser and a reference manure in a grapevine trial. The bio-based blends increased the soil carbon content, N availability, microbial biomass and its activity and vine vigour. There were no differences in yield but, the quality of the must, derived from the grapes, was better for the blends compared to the references. In Valle del Cauca, the VdC/2 blend did not improve plant and fruit parameters for corn, bean and pumpkin compared to blank and mineral fertiliser, but there was a non-significant trend of improved physical, chemical and biological soil conditions after application of VdC/2.

In general, blends with larger shares of biochar showed better results compared to fertilisers with no of limited shares of biochar.

Conclusion

In conclusion, especially the soil quality was increased by the bio-based fertilisers. Effects on soil nutrient contents were diverse but can be altered by changing the fertiliser dose or composition (e.g. larger share of fast N delivering building blocks). In contrast to the lab incubation trials, biochar blends performed best in the field trials. Yield effects were less pronounced, and crop quality was sometimes improved. Longer field trials could assess the effect of multiple additions of the fertilisers and the long term impact on soil health and crop. The market, lifecycle and legal aspects of the implementation of the blends was tackled in parallel multi-actor analyses.

Acknowledgements

This project has received funding from the European Union's Horizon 2020 Research and Innovation Programme under Grant Agreement No 101000527.

2. Hollow Fibre Membrane Contactors mass transfer shell side in ammonia recovery from agricultural manure

Azizi, Niloufar.[a*], Krol, Dominika.[b] ,Connolly, Shaun.[b] & Syron, Eoin.[a]

University College Dublin (UCD), School of Chemical and Bioprocess Engineering, Ireland [a]; Teagasc, Environment, Soils, and Land Use Department, Johnstown Castle, Ireland [b]; *Corresponding author, email: niloufar.azizi@ucdconnect.ie

Introduction

Hollow fibre membrane contactors (HFMC) are a compact technology for process intensification of degassing liquids. They facilitate mass transfer of gas between fluids without direct contact of the fluids. They can be used in applications such as the removal and recovery of ammonia from agricultural manure. The ammonia can diffuse through the gas-filled membrane pores and be recovered by reacting with a stripping solution e.g sulfuric acid. The mass transfer in HFMC can be described using a resistance-in-series model with the tube side mass transfer being described with the L´eveque equation, the membrane resistance being calculated from known membrane parameters such as membrane thickness, tortuosity and porosity(Shen et al., 2010). However, mass transfer correlation for shell side fluid flow has not been well established (Zheng et al., 2005). This study investigates the impact of using real animal manure on shell side predicted mass transfer coefficients.

Methodology

In this study, a Liqui-Cel^{TM} Micro-1x5.5 membrane module was used in the experiments. The module consisted of Polypropylene membrane with 220 µm ID/300 µm OD. An initial mass transfer model was generated using ammonium chloride solution at pH 11 on the shell side and sulfuric acid on the lumen side. The mass transfer was measured for a range of shell side fluid velocities and used to generate the mass transfer coefficient model. Following that, the impact of real animal manure slurry is now being tested to explore its effect on the mass transfer coefficient model.

Results and discussion

Initial results using synthetic solutions revealed a strong agreement between the predicted correlations and the experimental data from the NH_4Cl solution. Comparison with Equation 1 (Dahuron and Cussler, 2004) published mass transfer coefficient correlations determined that the model proposed best matched experimental results with an R^2 = 0.68. Using modified coefficients Equation 2. the correlation was improved to R^2 = 0.99. This correlation effectively predicts the shell-side mass-transfer coefficient for cylindrical membrane modules operating in parallel flow without baffles.

Equation 1) $sh_s = 8.8\left(\frac{de}{l}\right) Re\, Sc^{0.33}$

Equation 2) $sh_s = 11.58\left(\frac{de}{l}\right) Re\, Sc^{0.33}$

The first results with filtered manure show a significant decrease in the rate of mass transfer across the membrane.

Conclusion

While the modified correlation Eqn 2, is suitable for determining the mass transfer coefficient on the shell side it is not suitable for real animal manure. Further investigation is needed to determine which other parameters of the animal manure are required to be included in the model to improve its accuracy.

References

DAHURON, L. & CUSSLER, E. L. 2004. Protein extractions with hollow fibers. AIChE Journal, 34, 130-136.

SHEN, S., KENTISH, S. E. & STEVENS, G. W. 2010. Shell-Side Mass-Transfer Performance in Hollow-Fiber Membrane Contactors. Solvent Extraction and Ion Exchange, 28, 817-844.

ZHENG, J., DAI, Z., WONG, F. & XU, Z. 2005. Shell side mass transfer in a transverse flow hollow fiber membrane contactor. Journal of Membrane Science, 261, 114-120.

3. Benefits of bio-based fertilisers despite yield penalties under future climate scenario

L. Bergenhuizen[1,*], V. Leemans[2,3], C. De Clerck[2,4], J. Pierreux[4], P. Delaplace[1,2], F. Vanden Brande[3], J. Bin[1], M. Waibel[5], S. Symanczik[5], J. Zhang[6], Ç. Akyol[6], M. Arganguren Rivas[7], M. Pinto[7], A. Solvåg Nesse[8], B. Foereid[8], C. Thonar[1,9], H. Vanderschuren[1,2,10], J. Michel[1,2]

[1] Plant Genetics and Rhizosphere Processes Laboratory, Gembloux Agro-Bio Tech, University of Liège, Gembloux, Belgium; [2]Transdisciplinary Agroecosystem Platform for Integrated Research (TAPIR), TERRA teaching and research centre, Gembloux Agro-Bio Tech, University of Liège, Gembloux, Belgium; [3] Biosystems Dynamics and Exchanges (BIODYNE), TERRA teaching and research centre, Gembloux Agro-Bio Tech, University of Liège, Gembloux, Belgium; [4] Plant Sciences, Agriculture is Life, Gembloux Agro-Bio Tech, University of Liège, Gembloux, Belgium; [5] Department of Soil Sciences, Research Institute of Organic Agriculture (FiBL), Frick, Switzerland; [6] Laboratory for Bioresource Recovery (Re-Source), Department of Green Chemistry and Technology, Faculty of Bioscience Engineering, Ghent University, Ghent, Belgium; [7] Tecnalia Basque Institute for Agricultural Research and Development (NEIKER), Gasteiz- Vitoria, Spain; [8] Division of Environment and Natural Resources, Norwegian Institute of Bioeconomy Research (NIBIO), Ås, Norway; [9] Agroecology Lab, Faculty of Sciences, Université Libre de Bruxelles (ULB), Brussels, Belgium; [10] Tropical Crop Improvement Lab, Department of Biosystems, KU Leuven, Heverlee, Belgium; * Correspondence: bergenhuizen.lucas@gmail.com

Introduction

Bio-based fertilisers (BBFs) are part of the circular economy model for Europe to achieve climate neutrality by 2050, decoupling economic growth from resource exhaustion and maintaining agronomic production within planetary boundaries. Here, an experiment performed at the TERRA-Ecotron evaluated the agronomic and environmental performance of four BBFs compared to a synthetic control fertiliser (SYN) under a historic reference and a future climate scenario based on RCP8.5.

Methodology

Four BBFs produced from fishery by-products originating from the main European aquatic regions were tested against a synthetic control fertiliser (SYN) under two contrasted meteorological conditions using controlled environment rooms. The cultivated crop was broccoli, grown in intact soil monoliths extracted from an agricultural field. The agronomic performance was measured as broccoli head diameter, head fresh weight, total plant biomass, and nitrogen and phosphorus use efficiencies (NUE, PUE) were determined. To estimate the environmental impact, soil nitrous oxide (N_2O) and carbon dioxide (CO_2) fluxes were measured weekly. In addition, leachable soil nitrate (NO_3^- aq.) was measured by analysing extracted soil pore water and soil microbial activity was assessed on composite samples at four times points after fertilisation.

Results and discussion

While SYN mostly outperformed BBFs in the reference climate, many advantages of SYN disappear in the future scenario where plants fertilised with some BBFs performed better. The systems under BBFs consistently emitted more GHGs than those under SYN, in line with the enhanced soil microbial activity observed under soil fertilised with BBFs. In this experiment, decreased N_2O fluxes were also observed in the future climate. In addition, drier future climate seemed to have lowered overall nitrogen mobility within the system, as soluble nitrate in extractable soil pore water also declined. The performance increase of BBFs demonstrates their potential as sustainable alternatives to SYN, particularly under future climatic conditions. However, further research is needed to address climate-induced yield penalties observed for all fertilisers (BBFs + SYN) to ensure agronomic productivity. The results revealed a complex interplay between climate and fertilisers, highlighting the importance of empirical data to anticipate the impact of climate change on agriculture.

Conclusion

Addressing climate-induced yield penalties and improving the environmental footprint of fertilisers will be critical in achieving the goals of the Paris Agreement and ensuring food security for a growing world population. The experimental outcome emphasises the value of testing fertilisers under future meteorological conditions to accurately assess their long-term viability and market potential. Their efficiency under diverse pedo-climatic contexts also warrants further study to ensure upscaling efforts align with regional crop production requirements.

4. "Fulvic and Humic-like compounds" from biomass as biostimulant: understanding the biostimulant mechanisms to reach a new way to close the organic matter cycle.

Bona, D.[a], Longa, M.C.[a], Pilati, S.[a], Giovannini, O.[a], Mingai, L.[a], Varotto, C., Bertoldi, D.[b], Franceschi, P.[a] & Silvestri, S.[a]

[a] Research and Innovation Centre, Fondazione Edmund Mach, Italy; [b] Technology Transfer Centre, Fondazione Edmund Mach

Introduction

Currently, we are facing several challenges due to growing of human population and consequently agricultural intensification in response to increasing demand of food and resources. In this way the biostimulant products (based on humic compounds) seem promising to increase the plant productivity by acting on the nutrient and water-use efficiency, as well as stress resistance (Cannellas et al., 2015). The commercial biostimulants are now produced by leonardite extraction, but the production of them from biomass is very interesting in a circular bioeconomy point of view. The organic composition of alkaline hydrolysates of biowaste, recently produced, suggests their use as plant biostimulant, but the knowledge of their hormone-like activity is now poorly understood (Montoneri et al., 2022). The work is a part of the PON PERCIVAL project (ARS01_009869) funded by Italian Ministry of Research, MUR, 2023-2025.

Methodology

Three composts (compost from agro-industrial waste, compost from digestate and compost from biowaste) have been used to produced alkaline extracts (AE) as biostimulant (50 kg of compost; 250 L of H_2O and 4 kg of KOH; pH13). The AE have been chemically characterized (pH, organic matter and nutrients). Preliminary test with lettuce growth has been performed to identify the doses and the application methods. Then, agronomic test has been carried out by using a phenotyper platform (a fully automated RGB image-based method monitoring plant growth daily in non-destructive manner under controlled environment in a long-day photoperiod) and in greenhouse, with tomato plants, to study the biostimulant mechanisms, considering the effect on rhizosphere, plant growth and the soil. The remained "solid fraction" (SF) has been characterized as ingredient to formulate soilless-growing substrate and reduce peat consumption.

Results and discussion

AE (from composted digestate) has been chosen, considering the chemical composition (dry matter -DM-: 2%; pH: 9.93; TOC: 28.1%DM; N: 4.5%DM; P2O5: 2.47%DM; K2O: 9.8%DM). The germination index (GI) demonstrated the phytostimulant effect due to organic compounds of more diluted AE, with lower salinity (GI100% of 79.17%; GI75% of 101% and GI50% of 121%). In the agronomic tests, the diluted AE were applied several times, directly on soil, simulating the fertirrigation system. The lettuce tests considered a wide range of doses (from 79 kgDM/ha to 4.5 tDM/ha), highlighting comparable results with lower doses (250 kgDM/ha and 700 kgDM/ha). The tomato plant growth rate (studied in the phenotyper's test with 81 tomato plants), after 17 days of incubation, demonstrated the prevalence of the fertilizing effect rather than the biostimulant one, at higher doses. Then, two independent agronomic experiments have been performed with tomato plants at two doses, regularly fertilizing (NPK) the plants. Data about *i)* plant growth, *ii)* nutrient uptake, *iii)* soil rhizosphere (to investigate the effect on the microbial communities) and *iv)* plant physiology (at the transcriptomic level by RNAseq, in leaf samples) are collected after 3 and 6 weeks. The experiments are currently underway. The SF has low organic matter content, but still a good content of nutrient (DM: 40%; pH: 8.48; TOC: 18.2%DM; N: 1.9%DM; P_2O_5: 2.09%DM; K_2O: 0.8%DM). To identify whether the process-waste could still have valuable chemical-physical properties for the "soilless-substrate" formulation, it has been mixed with compost and peat (from 25% to 50% of peat substitution). The MIX has higher pH value compared to peat (in the range of 6.16 to 7.04) and volatile solids content decreased from 98% of peat to 70 – 85 % of the MIX. The analyses of nutrient content and water retention capacity of the MIX are now underway. The adopted approach aims to provide some useful data regarding the possibility to obtain value-added products (as biostimulant and substrates) from a better exploitation of biomass, by reducing as much as possible the residues.

Acknowledgements

Thanks to Ing. Ilaria Galvagno (ACEA Pinerolese SpA) for providing extracts and collaborating to the work.

References

Canellas, L. P., Olivares, F. L., Aguiar, N. O., Jones, D. L., Nebbioso, P., & Piccolo, A. (2015). Humic and fulvic acids as biostimulants in horticulture. *Scientia horticulturae*, *196*, 15-27.

Montoneri, E., Baglieri, A., & Fascella, G. (2022). Biostimulant effects of waste derived biobased products in the cultivation of ornamental and food plants. Agriculture, 12(7), 994.

5. Biomethane yield from industrial pig slurry and vinasse anaerobic co-digestion: Mathematical study

Cañadas Marín, B.*, Fernández Rodríguez, J., Solera Del Río, R. & Pérez García, M.

Department of Environmental Technologies, IVAGRO, Faculty of Marine and Environmental Sciences (CASEM), University of Cádiz, Pol. Río San Pedro s/n, 11510 Puerto Real, Cádiz. *Corresponding author, email: belen.canadas@uca.es

Introduction

The generation of biomethane from industrial pig slurry and vinasse is a sustainable alternative for waste management and renewable energy production. This study focuses on studying the optimal operating conditions for the anaerobic co-digestion (AcoD) of pig slurry and vinasse with the goal to evaluate the methane (CH_4) production using a design of experiments (DoE). A DoE is a useful tool for studying multifactor systems and their influence on responses through mathematical models (Montgomery, 2001). The Response Surface Model (RSM) is a statistical tool used for experimental design, modeling, and process optimization, allowing for acceptable results with a reduced number of experiments and costs (Betiku et al., 2014). A specific type of RSM is the Box-Behnken design, which DoE, it analyses the effects of factors and their interactions on maximum, medium and minimum levels on a system's response, generating a curved surface that fits the experimental data. Since biological and chemical processes are influenced by multiple interacting factors, they can exhibit linear and non-linear effects. Identifying significant variables is essential to optimize system performance and understand the dynamics of complex reactions as the performance of AcoD of organic industrial waste.

Methodology

This study analysed AcoD of industrial pig slurry and vinasse for CH_4 production using a Box-Behnken. Three key-factors were analysed: substrate ratio (25:75, 50:50, 75:25), temperature (35, 52.5, and 70°C), and pH (7, 7.5, and 8), evaluating their impact on biomethane yield (mL CH_4/g Volatile Solids - VS) through 15 laboratory experiments over 17 days. Substrates were analysed for the determination of Chemical Oxygen Demand (COD), Total Solids (TS), Volatile Solids (VS), and pH at both the initial and final stages of the assays, in order to assess their physicochemical changes throughout the process. Methane volume and concentration were measured daily in the biogas to evaluate fermentation performance.

Results and discussion

Based on the main results, for methane production, the quadratic term of ratio substrate was the only significant variable among those analysed, emphasizing the importance of substrate composition. In VFA production, multiple factors, including temperature and ratio-related terms, showed a significant impact on organic matter breakdown. Additionally, the quadratic relationship, observed in temperature and ratio factors, indicates possible quadratic effects in the VFA production. According to the methane yield, the most significant factor was the temperature, following the quadratic term of ratio. In all cases, the pH plays a minor role in the AcoD of pig slurry and vinasse.

On the other hand, the optimization of methane yield was achieved under conditions of pH 8, a temperature of 35°C, and a 50:50 substrate ratio, yielding 487.49 mL CH4/g VS. These conditions favour microbial activity, indicating that substrate composition and temperature are key variables.

Acknowledgements

This work is part of the project GOPG-CA-23-0002, funded by Operational Groups of the European Innovation (Andalusian Regional Government) and by RDF/EU.

References

Betiku, E., Omilakin, O. R., Ajala, S. O., Okeleye, A. A., Taiwo, A. E., and Solomon, B. O. (2014). Mathematical modeling and process parameters optimization studies by artificial neural network and response surface methodology: a case of non-edible neem (Azadirachta indica) seed oil biodiesel synthesis. Energy 72,266–273. doi:10.1016/j.energy.2014.05.033

Montgomery, 2000. Design and analysis of experiments. John Wiley and sons, New York

6. Agronomic value of raw and processed organic fertilisers

D'Haene, K.[a*] & Hofman, G.[b]

ILVO Plant, Belgium [a]; Ugent, Belgium [b]; *Corresponding author, email: karoline.dhaene@ilvo.vlaanderen.be

Introduction

Leached nitrate nitrogen (NO_3^--N) from farmland remains the predominant source of N loads to ground- and surface waters. In order to increase the N efficiency, there is a need to know the agronomic value i.e. N amount that becomes plant available the first year after the application of raw and processed organic fertilisers (Schröder et al., 2005).

Methodology

In Flanders a 4-month incubation at ±15°C and ±50% water filled pore space measures the N amount that is rapidly released and gives an indication of the N amount that becomes plant available during the first year after application. The rapidly released N and parameters (dry matter (DM), organic matter (OM), carbon (C), mineral and total N content and pH) of raw and processed products incubated with the BAM-protocol (Vito, 2010) were collected (D'Haene & Hofman, 2023).

Results and discussion

The incubated products included plant based composts and raw (slurry and farmyard manure) and processed manures. The processed manure comprised raw digestate, the liquid and (dried) solid fraction of raw manure or digestate and composted manure or composted solid fraction of digestate (Vanden Nest, et al. 2015a & b, Vlaco, 2016, Sigurnjak, 2017, Anon, 2018 & 2020, Luo et al. 2021). The incubations of 47 raw and processed organic fertilisers showed that the agronomic value or the rapidly released N amount could better be predicted based on their properties than on their origin (plant or manure) or the processing degree. There was a positive correlation between the rapidly released N amount and the percentage ammonium (NH_4^+) and mineral N ($NH_4^+ + NO_3^-$) of the total N and pH in the studied products. The correlation between the C:N ratio of the studied products and rapidly released N amount was negative. A high C:N ratio can lead to immobilisation and, in compost, possibly indicates immaturity of the compost. Also a negative correlation was found between the rapidly released N amount and the OM and DM content of the studied products.

Conclusion

The incubations indicated that the product properties give a clear indication of agronomic value of the studied products. Measurement of the properties of new products can help to optimise the fertilisation amount and timing and to match N supply and crop demand. Products with a low rapidly released N amount have a high OM and DM content and a high C:N ratio. Hence (dried) solid fraction of digestate and composted manure provide little N for plant production the first year after application. In contrast, the highest rapidly released N amounts were measured in products with a low OM and DM content and a low C:N ratio e.g. liquid fraction of digestate.

Acknowledgements

Karoline D'Haene wishes to acknowledge VLM for funding her research.

References

Anon, 2018. Agronomische waarde van bewerkte dierlijke mest valoriseren en optimaliseren. Luik 2. VLM, Brussels.

Anon, 2020. Compost en digestaatproducten verdienen hun plaats in de boomkwekerij. Vlacovaria 28(1), 5-7.

D'Haene, K., Hofman, G., 2023. Stikstofwerkingscoëfficiënten van organische meststoffen. Onderzoeks- en Voorlichtingsplatform Duurzame Bemesting, Merelbeke.

Luo, H., et al. 2021. Assessing nitrogen availability in biobased fertilizers: effect of vegetation on mineralization patterns. Agriculture 11, 870.

Schröder, J.J., et al. 2005. Long term nitrogen fertilizer value of cattle slurry. Soil Use Manage. 21, 196-204.

Sigurnjak, I., 2017. Animal manure derivatives as alternatives for synthetic nitrogen fertilizers. UGent, Ghent.

Vanden Nest, T., et al. 2015a. De compostering van dikke fractie van digestaat. Vlaco, Mechelen.

Vanden Nest, T., et al. 2015b. The fertilizer replacement value of processed digestate products. In: Manureresources 2015: 2nd international conference on manure management and valorization: Final program & abstract book.

Vito, 2010. BAM/deel 1/12, Bodem - Bepaling van snel vrijkomende organische stikstof. Brussel.

Vlaco, 2016. Karakterisatie eindproducten van biologische verwerking. Vlaco, Mechelen.

7. Fertilisation with chicken manure from hens fed with macroalgae – Fate of arsenic and iodine

Eich-Greatorex, S.[a*], Mydland, L.T.[b] & Almås, Å.R.[a]

Faculty of Environmental Sciences and Natural Resource Management, Norwegian University of Life Sciences, Norway [a]; Faculty of Biosciences, Norwegian University of Life Sciences, Norway; [*]Corresponding author, email: susanne.eich@nmbu.no

Introduction

In the search for sustainable feed ingredients, sugar kelp *(Saccharina latissima)* or components extracted from kelp show potential. However, kelp often has high iodine (I) and arsenic (As) concentrations, which may not only influence animal growth and health but also restrict the use of manure from animals fed with kelp as fertiliser for crop growth. Depending on soil conditions, As may change its speciation from various non-toxic organoarsenic forms to inorganic toxic forms. Inorganic As can easily be taken up by plants and transferred into edible parts. Among the inorganic As species in soils, arsenite (AsIII) is very mobile and toxic to plants [Finnegan and Chen, 2012], and occurs under anoxic conditions. The objective of this study was therefore to evaluate the effect of using chicken manure from hens fed with sugar kelp as fertiliser on the uptake of As and I in cereal grain of plants grown under different soil moisture conditions.

Methodology

In a pot experiment with a loamy soil, we used chicken manure from hens fed with diets containing different amounts of sugar kelp (0, 2.5 and 5 g 100 g^{-1}) as fertiliser to barley, at a rate corresponding to approximately 120 kg plant-available N ha^{-1}. The chicken manure treatments were compared to a mineral fertiliser treatment, as well as a control without nutrients. Barley was grown until maturity. At the shooting stage and during maturation, half the pots were irrigated to a level corresponding to 80 % of water-holding capacity for several days, while the other half continued at 60 %. Diffusive gradients in thin films (DGTs) were inserted into the soil for three days to simulate plant-available As at the two growth stages. After harvest, biomass and grain yield, as well as grain and soil concentrations of nutrients, As, and I were determined.

Results and discussion

Kelp amounts in the diet were reflected by increased concentrations of As and I in the manure. Grain yields in treatments with chicken manure were similar to mineral fertiliser-fed plants for pots only irrigated up to 60% of water holding capacity, whereas grain yields were significantly lower and straw biomass significantly higher in treatments with manure from kelp-fed chicken exposed to 80 % of water-holding capacity. Treatments with manure from hens fed without kelp addition did not differ from mineral fertiliser-fed plants in the higher water content treatment. Soil As concentrations after harvest were similar in all treatments, indicating a relatively small contribution of kelp in hen diets to total soil concentrations. Concentrations of As in grain were generally low and also little impacted by fertiliser type in the pots kept at a lower water content, whereas grain As concentrations were considerably higher in the control and mineral fertiliser treatments that were exposed to periodically higher water content. This was not the case for the treatments fertilised with chicken manure, independent of whether the diet contained kelp, suggesting an influence of the organic material added on As mobility. DGT results will be used to relate the findings to plant-available concentrations. Iodine concentrations were slightly increased in the soil of pots with manure from kelp-containing diets. However, any potential I concentrations in the grain from those treatments were below the detection limit (0.005 mg kg^{-1}) and thus even lower than in the control.

Acknowledgements

Financial support was provided by the Norwegian Research Council (Project no. 320687).

References

Finnegan and Chen, 2012. Arsenic toxicity: the effects on plant metabolism. Front Physiol. 3: 182. doi:10.3389/fphys.2012.00182

8. Exploring the consistency and sensitivity of NUE indicators in arable long-term experiments

Epper, C.A.[a*], Oberson, A.[b], Zavattaro, L.[c], Guillaume, T.[d] & Mayer, J.[a]

Agroscope, Department of Agroecology and Environment, Switzerland [a]; ETH Zurich, Institute of Agricultural Sciences, Switzerland [b]; Department of Veterinary Sciences, University of Turin, Italy [c]; Agroscope, Field Crop System and Plant Nutrition [d]. *Corresponding author, email: carole.epper@agroscope.admin.ch

Introduction

Optimising nitrogen use efficiency (NUE) is crucial for sustaining agricultural productivity while minimizing environmental impacts. However, accurately assessing NUE is challenging due to the complexity of nitrogen (N) flows in the soil-air-groundwater continuum, which vary over time and depend, amongst others, on fertiliser type, pedoclimatic conditions and management practices. This is particularly true for organic fertilisers, whose N release occurs gradually and influences soil N dynamics for years. Long-term field experiments (LTEs) provide a valuable framework for monitoring N cycling and NUE over extended periods, capturing cumulative effects and long-term trends. However, differences in LTE design, duration, and management complicate cross-experiment comparisons.

Various approaches exist for estimating fertiliser and system NUE, each using different calculation frameworks while ultimately aiming to quantify the same indicator. These approaches integrate key N flows, including fertiliser inputs, atmospheric deposition, soil N stock changes, biological N fixation, and N removed through aboveground harvest. Although they should theoretically lead to comparable results, discrepancies arise due to differences in system boundaries and calculation methodologies. In this study, we apply different approaches for NUE assessment to better understand their consistency and identify factors contributing to variations in NUE estimates across different LTEs, with different fertiliser types, pedoclimatic and management conditions. Understanding these differences will refine NUE estimations and improve the N efficiency assessment in arable farming systems.

Methodology

The study was conducted on the basis of four LTEs located in Switzerland, which vary in design, duration (between 30 and 75 years), management practices (organic and conventional), crop rotation and site conditions. The selected LTEs include both mineral and organic fertiliser treatments, such as slurry, farmyard manure, and green-waste compost, as well as combinations with PK and NPK, following Swiss fertiliser norms.

To assess N cycling over time, we calculated multiple NUE indicators and N budgets based on established methods. In particular, we applied the N surface balance, the N system balance, and the difference approach. The NUE indicators were first evaluated within each experiment to compare fertiliser performance across treatments. To account for site-specific differences, results were then standardized, enabling a broader comparison across locations and experimental setups.

Results and discussion

Similarly to previous findings by Quan et al. (2021), our preliminary analysis does not show a consistent convergence of the NUE calculated with the difference and the balance approach, across all cases or treatments. On the contrary, Oberson et al. (2024) found similar estimates for the difference and the balance approach (both corrected via the accounting of N soil stock changes and symbiotic N fixation), with differences not exceeding 10% across treatments and management practices, after 35 years of cultivation .To better understand the observed variability in NUE indicators, we will incorporate additional explanatory variables such as management practices, the dynamics of other plant nutrient, and location, to answer why such discrepancies are not consistent.

References

Oberson, A., et al. 2024. Higher than expected: Nitrogen flows, budgets, and use efficiencies over 35 years of organic and conventional cropping. Agric. Ecosyst. Environ. 362, 108802.

Quan, Z., et al. 2021. Different quantification approaches for nitrogen use efficiency lead to divergent estimates with varying advantages. Nat. Food 2(4), 241-245.

9. Energy and nutrient potential of plant protein harvest residues

Ervasti, S.[a*], Tynkkynen, M.[a] & Rasi, S.[a]

Natural Resources Institute Finland (Luke), Finland[a]; *Corresponding author, email: satu.ervasti@luke.fi

Introduction

Traditionally, cattle farming has had a remarkable role in biogas production, providing most of the substrates, manure and surplus grass silage, enhancing renewable energy production and nutrient recycling on the farm. Plant protein production is expected to increase due to the climate impact of meat production and new nutrition recommendations. If livestock production is reduced, grassland will be freed up for other crops. In Finland, for example, the potential for an increase in plant protein production is high, which will lead to increased cultivation of pulses and oilseeds. The aim of this study is to investigate the potential of harvest residues of common plant protein crops, pea, faba bean and oil hemp, for biogas production, taking into account the impact on energy production and nutrient balance.

Methodology

Harvest residues of pea (*Pisum sativum*), faba bean (*Vicia faba*) and oil hemp (*Cannabis sativa*) were collected in August-September 2024 from Jokioinen, Finland. All eatable parts, beans and seeds were removed prior the mechanical pretreatments, chopping and shredding. Biochemical methane potential was measured using automated AMPTS II equipment (Bioprocess Control AB, Sweden) in 37 °C, using digestate from farm plant treating dairy cattle slurry, with substrate to inoculum ratio of 0.5. Chemical characteristics were analysed using methods previously reported by Tampio et al. (2024).

Results and discussion

Harvest residues, including stems and leaves, of pea (TS 604 g/kg, VS 560 g/kg), faba bean (TS 796 g/kg, VS 763 g/kg) and oil hemp (TS 617 g/kg, VS 586 g/kg) showed biochemical methane potentials of 177, 202 and 129 NmL/g-VS, respectively. All tested harvesting residues had rather high lignin content (pea 47; faba bean 126; oil hemp 77 g/kg), and low hemicellulose content (pea 81, faba bean 149; oil hemp 125 g/kg). Concentrations of the major nutrients N-P-K were 10.1-1.5-11.1 g/kg in pea residues, 11.4-0.9-6.6 g/kg in faba bean residues and 3.4-0.6-4.0 g/kg in oil hemp residues. All biomasses had high C/N ratios, 23, 31, and 76 for pea, faba bean and oil hemp, respectively, which promotes their use as co-feedstocks for nitrogen-rich manures to balance the C/N ratio of the feedstock mixture. The methane potentials were low compared to grass (270-380 NmL/g-VS, Zhang et al., 2021), which is the most common plant biomass used for biogas in Finland. However, according to Jansik et al. (2024), the total area under pea, faba bean and oil hemp in Finland could almost triple between 2023 and 2040, reaching over 150 000 ha in 2040, with the highest potential for increase in faba bean. In addition, the cultivation of several other pulse and oilseed species is likely to increase. This will increase the importance of plant protein harvest residues as nutrient- and carbon-rich biomass, and they may become regionally significant in terms of their biomass potential.

Conclusion

Plant protein residues may be of regional importance in the future, especially in areas where biogas production is increasing and additional feedstocks are needed, while the amount of livestock manure is decreasing.

Acknowledgements

This study was supported by the European Union LIFE Programme funded project LIFE22-IPC-FI-ACE LIFE/101104613. The authors thank the staff of the laboratories of the Natural Resources Institute for carrying out the chemical analyses and assisting with the experiment.

References

Jansik, C., et al. 2024. Kasviproteiini kasvun tiellä : Tiekartta ruoan korkeampaan kasviproteiiniomavaraisuuteen [Plant protein on the road to growth : A road map to higher plant protein self-sufficiency in food]. Natural resources and bioeconomy studies 68/2024. Natural Resources Institute Finland. Helsinki. 76 p. http://urn.fi/URN:ISBN:978-952-380-948-2

Tampio, E., et al. 2024. Effect of manure co-digestion on methane production, carbon retention, and fertilizer value of digestate. Sci. Total Environ. 927, 172083. https://doi.org/10.1016/j.scitotenv.2024.172083

Zhang, Y., et al. 2021. Estimating the methane potential of energy crops: an overview on types of data sources and their limitations. Processes 9, 1565. https://doi.org/10.3390/pr9091565

10. Insect frass use as ryegrass fertilizer in distinct soils

Rehan, I.[a,b], Esteves, C.[c*], Lopes, I. G.[d], Murta, D.[e,f], Lidon, F.[b], Fareleira, P.[g,h], Moreira, O.[a,f,i,j] & Menino, R.[g,h]

Instituto Nacional de Investigação Agrária e Veterinária, I.P. (INIAV, I.P.), Polo de Inovação da Fonte Boa, Vale de Santarém, Portugal[a]; GeoBioTec Research Center, FCT-NOVA, Caparica, Portugal[b]; Linking Landscape, Environment, Agriculture and Food Research Centre, Terra Associate Laboratory, Instituto Superior de Agronomia, Universidade de Lisboa, Lisboa, Portugal[c]; Swedish University of Agricultural Sciences, Department of Biosystems and Technology, Lomma, Sweden[d]; EntoGreen, Ingredient Odyssey SA, Santarém, Portugal[e]; Centro de Investigação Interdisciplinar Egas Moniz (CiiEM), Monte da Caparica, Portugal[f]; INIAV, I.P., Polo de Inovação de Oeiras, Portugal[g]; GREEN-IT Bioresources for Sustainability, ITQB NOVA, Oeiras, Portugal[h]; Centro de Investigação Interdisciplinar em Sanidade Animal (CIISA), FMV-UL, Lisboa, Portugal[i]; AL4AnimalS, FMV-UL, Lisboa, Portugal[j]; *Corresponding author, email: catarinaesteves@isa.ulisboa.pt

Introduction

In the context of the various constraints on the potential fertilising effect (immediate and delayed) of organic fertilisers, this work aimed to carry out a preliminary assessment (1st year of testing) of the fertilising potential of Black Soldier Fly Frass (BSFF) in soils with different textures. The choice of BSFF was based not only on the widely reported positive potential to replace Mineral Fertilisers (MF) in part (or, more rarely, in total), but also on the important role to be played in circular economy systems, both by the frass and by the larvae and pupae themselves (Menino & Murta, 2021).

Methodology

In a pot trial with five replications, *Lolium multiflorum* Lam. was used as a test plant in three soils differing in texture and structure: Gleyic Podzol (sandy), Haplic Calcisol (calcareous) and Haplic Fluvisol (clayey). The organic fertiliser used in the trial resulted from the BSF biodigestion of an effluent from an intensive livestock farm, was chosen due to the notorious environmental impact and consequent operating costs of this type of material. Five treatments were applied to all the soils, all of which had a content equivalent to 140 kg of total N ha^{-1}, assuming that, in the case of the BSFF, it was considered that, by the end of the crop cycle, the mineralisation rate would only have allowed 50% of the mineral N to be made available. This resulted in the following treatments: mineral fertilisation (100% MF), the combinations of mixed fertilisation (75% MF + 25% BSFF; 50% MF + 50% BSFF; 25% MF + 75% BSFF) and organic fertilisation (100% BSFF). Plant biomass and soil microbial activity (assessed through dehydrogenase enzyme activity) were evaluated in all treatments.

Results and discussion

On the sandy soil, mixed fertilisation provided, in proportion to the percentage of BSFF, increasing yields of fresh weight (FW), which were always higher than those observed with extreme fertilisation, whether mineral or organic, with the latter producing significantly more FW than mineral fertilization (Rehan *et al*., 2024). The opposite was true for the clay soil, while for the limestone soil there were no significant differences between the different treatments. These results are confirmed even more clearly in the results for dry matter production and are justified, in particular, by the scarcity of mineral colloids in sandy soils. In addition, the presence of frass stimulated microbial activity when used as sole input in the sandy soil, but not in the clay or limestone soils.

Conclusion

The reported results support the hypothesis that, under the conditions of this trial, in alluvial soils, judicious mineral fertilisation of crops (in the quantities and timing of its application) is the best support for maximising production, while in sandy soils, the addition of organic matter guarantees an increase in production and is therefore the preferred outlet for effluent from intensive livestock farming.

Acknowledgements

This work was supported by PRR through the project (C632327738-00466948: InsectERA) and by FCT - Fundação para a Ciência e a Tecnologia, I.P., through the R&D Unit "GREEN-IT - Bioresources for Sustainability" - UIDB/04551/2020 (DOI 10.54499/UIDB/04551/2020); and UIDP/04551/2020 (DOI 10.54499/UIDP/04551/2020).

References

Menino, R., & Murta, D. 2021. The Insects as a Workforce for Organic Fertilizers Production – Insect Frass. *In* M. Turan, E. Yildirim, & A. P. S. Argin (Eds.), *New Generation of Organic Fertilizers*. IntechOpen. https://doi.org/10.5772/intechopen.100144.

Rehan, I., et al. 2024. Agronomic potential of Hermetia illucens frass in the cultivation of ryegrass in distinct soils. Journal of Insects as Food and Feed (published online ahead of print 2024). https://doi.org/10.1163/23524588-00001242

11. Effects of manure application on the performance of 'Gala' apple trees: a two-year study

Vieira, J.[a*], Gonçalves, M.[b], Sousa, M.L. [b], Henriques, A.[c], Pombinho, M.[c], Fangueiro, D.[a], Ribeiro, H.[a], Oliveira, C.[a] & Mota, M.[a]

Laboratório Associado TERRA, Centro de investigação LEAF—Linking Landscape, Environment, Agriculture and Food, Instituto Superior de Agronomia, Universidade de Lisboa, Portugal[a]; Instituto Nacional de Investigação Agrária e Veterinária, Estação Nacional de Fruticultura Vieira Natividade (INIAV IP./ENFVN), Portugal[b]; Instituto Superior de Agronomia, Universidade de Lisboa, Portugal[c]; *Corresponding author, email: jorgemv@isa.ulisboa.pt

Introduction

To create a more resilient and sustainable agriculture in Europe, it is imperative that chemical fertilizers and animal manure are used simultaneously when fertilizing crops. The aim of this study was to understand the effects of partial replacement of mineral fertilizers with animal manure on various physiological parameters of of 'Gala' apple trees and qualitative parameters of the fruits.

Methodology

Four different fertilizations treatments were established (three replicates), aiming to supply 100 kg of plant available nitrogen per hectare: T1: 100% mineral fertilization throughout the crop cycle; T2: 75% mineral fertilization throughout the cycle + 25% organic fertilization (cattle manure) at bud break; T3: 75% mineral fertilization throughout the cycle + 25% organic fertilization (pig slurry) at bud break; T4: 50% mineral fertilization throughout the cycle + 25% organic fertilization (cattle manure) at bud break + 25% organic fertilization (pig slurry) at post-harvest. These 4 treatments were established in 5 different apple orchards located close to Alcobaça (Portugal). These 5 orchards were selected based on soil characteristics and management. Sampling and analyses of leaves and fruits were carried out using standard methods. Results presented here correspond to the first two years of the field trial (2023-2024).

Results and discussion

An increase in soil levels of NO_3^-, NH_4^+, OM, P_2O_5, and K_2O, along with a decrease in soil pH and EC, was observed in all orchards following a single application of livestock effluents. The effect of two years of application on these parameters are still being analysed. Apple production showed heterogeneous results across the two experimental years. In terms of apple tree productivity, T3 appears to be the most promising, as trees under this strategy are sometimes more productive than those in the control strategy. However, in most cases, the difference is not statistically significant. The highest registered values were 1.09 ± 0.32 kg cm^{-2} and 0.95 ± 0.25 kg cm^{-2} for T3 and T1, respectively. Fertilization had a greater effect on foliar macronutrient and micronutrient content than on the fruit. Differences between fertilization strategies for the latter were observed only in 2023. Regarding fruit quality, the different treatments did not affect fruit size and mass but affected colour in almost all orchards in 2023. Firmness and TSS were affected by fertilization, with a trend towards higher values of soluble solids content in T4 and lower values in T1 and T3, with a greater difference in 2023 than in 2024. The results obtained during the first two years showed that it is possible to partially replace mineral fertilizers with livestock effluents, and this organic fertilization strategies (T2, T3 and T4) performed as well as the mineral fertilizers (T1) on most of the parameters assessed. These observed trends have to be confirmed by the next year´s results.

Acknowledgements

This work is funded by the program IFAP/PRR/Agenda de investigação e inovação para a sustentabilidade da agricultura, alimentação e agroindústria, through the project MO PLUS (PRR-C05-i03-I-000018). And by national funds through FCT - Fundação para a Ciência e a Tecnologia, I.P., under the projects UIDB/04129/2020 of LEAF-Linking Landscape, Environment, Agriculture and Food, Research Unit and LA/P/0092/2020 of Associate Laboratory TERRA.

12. Capacity of slurry pits on dairy farms in Galicia

García Pomar, M.I.[a*], Báez Bernal, M.D.[a] & Santiago Andión, C.[a]

Mabegondo Agricultural Research Center - AGACAL, Spain [a]; [*]Corresponding author, email: maria.isabel.garcia.pomar@xunta.gal

Introduction

The main limitation encountered by farmers for the right management of slurry on dairy cattle farms in Galicia (NW Spain) is the lack of pit storage capacity, and this slurry is used when the grasslands and forage crops do not need it or when the soil and climate conditions are not suitable. In order to improve management, structural conditions, nutrient recycling and reduce the environmental impact of dairy cattle slurry, a study has been carried out on the net capacity of the pits on Galician farms to see if it is in line with the minimum capacity needed.

Methodology

A total of nineteen dairy farms in Galicia were selected to represent the four types of feeding systems (Flores et al., 2017) used in the region: grazing (n= 5); grass silage (GS n=4); maize and grass silage (n=5); and maize silage (n=5). Between March 2018 and April 2019, data were collected on type of cows that generated the slurry stored in each pit, stabling or grazing, bedding materials, destination of the cleaning water to independent pits or to slurry pits, capacity and coverage of the pits and doses and times of slurry application to grasslands and forage crops.

The storage capacity per livestock unit (LSU) of the main pits, which collect the slurry from lactating and dry cows, and of the secondary pits, which mainly collect the slurry from rearing cows, was calculated. The animals that actually provide the slurry were considered. The net storage capacity per LSU of the farm was calculated from these data, subtracting the accumulation of rainwater in the uncovered pits during the period of greatest rainfall (November to February) when the climatic conditions for application to the field are not the most suitable due to low temperatures that prevent the vegetative growth of grasslands and forage crops and to excess moisture in the soil.

Results and discussion

The main pits have an average capacity of 660 m^3 pit^{-1} and represent 83% of the total capacity of the farm. The secondary pits have an average capacity of 268 m^3 pit^{-1} and represent 27% of the total capacity of the farm. Uneven capacity of the pits within the farm was found, average capacity per LSU of main pits (10.67 m^3 LSU^{-1}) was lower than in secondary pits (16.90 m^3 LSU^{-1}). Subtracting the rainwater accumulated in the uncovered pits (52% of main pits and 31% of secondary pits) gave a net capacity per LSU of 9.19 m^3 LSU^{-1} for main pits and 13.94 m^3 LSU^{-1} for secondary pits. This capacity was further reduced in the main pits because 47% of the farms collected the water used during milking management and in the maize silage farms because they had sand in the beds that accumulated in the pit.

The minimum recommended volume per LSU according to the new legislation (12.40 m^3 LSU^{-1}) is above the average net capacity of the farm (9.66 m^3 UGM^{-1}) and only 16% of the farms studied (n=3) reach it. Net capacity is consistent with this reported by Botana (2019) in the same region. No increase in capacity was found with productive intensification.

As a result of this lack of capacity, the application of slurry on grasslands which was to be carried out in March to obtain the first cut was sometimes brought forward to February and slurry was also applied in autumn after a third cut when no more cuts were to be made in the year and where the subsequent heavy rainfall increased the risk of nitrate leaching.

Conclusion

In general, the sizing of the slurry pits in the dairy farms studied in Galicia is not enough for the right use of slurry as fertilizer, which means that farmers applied slurry on the grasslands at unsuitable times such as winter and autumn, with the risk of water pollution by nitrates. The pits must be enlarged, covered and the water from the milk tank room and milking parlor diverted to an independent pit.

Acknowledgements

This work was funded by the INIA RTA-2015-00058-C06-01 of the Ministerio de Economía, Industria y Competitividad of Spain and cofunded by the European Regional Development Fund (ERDF) and Xunta de Galicia.

References

Botana, A, 2019. https://www.educacion.gob.es/teseo/imprimirFicheroTesis.do?idFichero=tUaljrAt87c%3D

Flores, G. et al, 2017. http://ciam.gal/pdf/informeinia.pdf

13. Unraveling the microbial composition and functionality of compost extracts used as an effective and sustainable alternative to chemical inputs

Jurado, M.M*, Estrella-González, M.J., Suárez-Estrella, F., Lorente-Escánez, D., Martínez-Gallardo, M.R., Toribio, A.J., López-González, J.A., Jiménez, R., Lerma-Moliz, R. & López, M.J.

Unit of Microbiology, Department of Biology and Geology, CITE II-B, University of Almeria, Agrifood Campus of International Excellence, ceiA3, UNIgreen, CIAIMBITAL, Almería, Spain*Corresponding author, email: macarenajurado@ual.es

Introduction

Currently, metataxonomic studies have gained great importance since they allow greater depth to be obtained about the structure and functionality of the microbiome of a sample. Thus, the main goal of this work was to analyze the differences between compost samples, from industrial-scale plant-based composting, and aqueous extracts of compost obtained after the application of different extraction protocols, in order to determine the changes caused in the microbial structure and composition and their influence on the functionality of the new liquid biofertilizers.

Methodology

To obtain the extracts, compost based on plant waste was used, applying four different extraction protocols depending on temperature and incubation time. DNA extraction was performed using the DNeasy PowerSoil Isolation Kit (Qiagen). Data analysis was conducted using the QIIME2 software (v2021.4) (Bolyen et al., 2019). Functional Annotation of Prokaryotic Taxa (FAPROTAX, version 1.2.6) (Louca et al., 2016) was employed to predict the functionality of the prokaryotic taxa. Phytotoxicity tests (Zucconi et al., 1981) and other stability parameters, such as respirometry in compost (Adani et al., 2001), and biochemical oxygen demand, in compost extracts, were also performed.

Results and discussion

The results showed that extracts obtained with longer extraction times at mild temperatures presented higher functional diversity and microbial abundance, while samples extracted during shorter time at higher temperatures showed lower biological activity. In general, compost extracts showed a greater abundance in bacterial groups associated with the stimulation and protection of plants, such as the taxonomic families Flavobacteriaceae and Rhizobiaceae, with respect to solid samples of compost not transformed into liquid. In addition, compost extracts preserve the biological stability of mature compost samples and improve the phytostimulant capability of these bioproducts. Consequently, this research suggests that the development of appropriate extraction protocols could improve the biostimulant profile of compost extracts, serving as a sustainable novel alternative or complement to other agrochemical products.

Conclusion

This study highlights the potential of compost extracts to be used as phytostimulant biofertilizers in sustainable agriculture, highlighting their role in reducing the dependence on agrochemicals. The results indicate that the application of simple extraction protocols, using water as solvent, improves the homogeneity and functional properties of compost.

Acknowledgements

This work was funded by the COMPOBIOTICS project (PID2023-149455OB-I00), supported by Ministry of Science, Innovation and Universities (Spain).

References

Journal citation format:

Adani et al., 2001. Determination of biological stability by oxygen uptake on municipal solid waste and derived products. Compost Sci. Util., 9 (2), 163-178.

Bolyen et al., 2019. Reproducible, interactive, scalable and extensible microbiome data science using QIIME 2. Nat. Biotechnol., 37, 852-857.

Louca et al., 2016. Decoupling function and taxonomy in the global ocean microbiome. Science, 353, 1272-1277.

Zucconi et al., 1981. Evaluating toxicity of immature compost. Biocycle, 22 (2), 54-57.

14. Full-Scale Slurry Tank Sampling: Effects of Sampling Strategy and Sample Storage on Measured Physical and Chemical Properties

Kamp, J.N.[a]*, Sørensen, M.K.[a,b] & Pedersen, J.[a]

Department of Biological and Chemical Engineering, Aarhus University, Denmark[a;] NanoNord A/S, Aalborg, Denmark[b]; *Corresponding author, email: jk@bce.au.dk

Introduction

Accurate analysis of liquid animal manure (slurry) is crucial for optimizing nutrient management when used as a fertilizer in crop production. Sampling strategy and improper storage conditions can significantly affect measured nutrient contents and pH values. This study aims to evaluate the impact of different slurry sampling methods and storage conditions on the physical and chemical properties of slurry from full-scale storage tanks. We hypothesize that (i) profile sampling provides equivalent results to mixed tank sampling, (ii) sampling method influences dry matter (DM), total ammoniacal nitrogen (TAN), total nitrogen (TN), and total phosphorus (TP), but not pH, and (iii) storage type and duration do not alter slurry properties.

Methodology

Slurry was sampled from a full-scale tank using three different methods: top, bottom, and profile sampling. Sampling was conducted before and after mixing the tank. Subsamples were analysed directly after sampling and after storage for varying durations at 5°C (1–4 weeks) and -18°C (4-24 weeks). Analyses included NHx-N, TN, TP, Na^+, DM, VS, and pH, using a Tveskaeg NMR sensor (Jensen et al., 2021; Sørensen et al., 2015) and standard laboratory methods.

Results and discussion

Sampling method significantly influenced the measured parameters. Profile sampling produced similar results to mixed tank sampling, while top sampling underestimated and bottom sampling overestimated DM and TP due to sedimentation. Storage at 5°C preserved sample integrity for four weeks, whereas storage at -18°C led to pH increases of up to 1.0 unit over 24 weeks, likely due to mineral precipitation and dissolution. Significant differences between replicate samples were also observed, which demonstrate the importance of taking multiple replicate samples from the slurry tank of interest.

Conclusion

Slurry samples obtained as profile samples from an unmixed slurry tank were comparable to the complete mixed tank. This shows that representative slurry samples can be obtained from an unmixed slurry tank when profiles in the entire vertical column are sampled. Samples from the unmixed tank suggest sedimentation with a higher content of DM, TP, and VS being found at the bottom compared to the top of the tank. The pH of the slurry changed after sampling and should be monitored closely depending on the purpose of the measurement. These findings emphasize the importance of careful sampling and storage protocols to ensure accurate slurry analysis for nutrient management.

Acknowledgements

This research was funded by the Ministry of Food, Agriculture and Fisheries of Denmark (journal no.: 33010-NIFA-21-767) and the Danish Agricultural Agency (journal no.: 33010-NIFA-21-767).

References

Jensen, O. N., et al. 2021. Fast and accurate quantification of nitrogen and phosphorus constituents in animal slurries using NMR sensor technology. ACS Omega, 6(27), 17335–17341. https://doi.org/10.1021/acsomega.1c01441

Sørensen, M. K., et al. 2015. NPK NMR Sensor: Online Monitoring of Nitrogen, Phosphorus, and Potassium in Animal Slurry. Analytical Chemistry, 87(13), 6446–6450. https://doi.org/10.1021/acs.analchem.5b01924

15. Using bioslurry and Bioslurry Enriched Compost to boost yields and improve soils: perspectives for East Africa

Lamichhane, M.[a]*, Langeveld, J.W.A.[a], Lazarus, A.[a], Spieringhs, W.[b], van Nes, W.[b], Lengkeek, A.[c], Capurso, A.[c], Kinusu, K.[d], Wahome, S.[d], Kintu, F.[e] & Muvule, M[e].

Biomass Research, Netherlands[a]; SNV, Netherlands[b]; DIBCoop, Netherlands[c]; ABPL, Kenya[d]; BSUL, Uganda[e]
*Corresponding author, email: manisha@biomassresearch.eu

Introduction

While biodigesters primarily serve as a source of biogas, digestate (bioslurry) and compost made with bioslurry (Bioslurry Enriched Compost or BEC) offer valuable yet underutilized benefits for soil health, crop productivity, and environmental sustainability. To date, adoption of biodigesters remains low due to high installation costs, limited awareness, and inadequate market development. Currently, there are 22,000 and 6,000 functional biodigesters respectively in Kenya and Uganda, respectively with limited attention for bioslurry use. Only 1–5% of biodigester owners are engaging in bioslurry trade. The Organic Fertilizer Valorisation Implementer (OFVI) project addresses these issues through knowledge transfer and support to enhance bioslurry and BEC adoption for improving soil health and crop production.

Methodology

Field surveys were conducted to assess biodigester functionality, bioslurry storage, and application practices, followed by a validation workshop to confirm these findings. The impact of different fertilizers, composition of bioslurry and BEC, nitrogen requirements for maize in Kenya and Uganda were determined. The bioslurry and BEC needed to replace mineral fertilisers was calculated. Soil organic matter buildup and its effects on long-term soil health were analyzed. Stakeholder testimonies were collected to assess the other indirect effects.

Results and discussion

The initial outcomes in Kenya indicate that the biodigesters functionality was at 79–88%, primarily using dairy cattle, other cattle and some swine manure. Fresh bioslurry application was declining, while liquid storage increased, and composting to date still is at a very low level. Vegetables, maize, bananas, Napier grass, and coffee were the main crops benefiting, reducing fertilizer costs and improving yields. Biodigester functionality in Uganda is 60-69%, using feedstock similar to Kenya. Direct application was declining, while dried storage increased, and composting remained limited. 88–95% of households reported reduced fertilizer costs, and nearly all reported improved crop quality.

Mineral fertilizers boost yields in short-term but degrade soil over time. In contrast, bioslurry and BEC enhance soil texture, water retention, and reduce erosion. They also provide a more significant short term effect than farmyard manure and compost, balancing both short-term and long-term benefits. The bioslurry required to replace chemical fertilizer for maize was 5.3 tons/ha in Kenya and 2.4 tons/ha in Uganda. Accumulated soil organic matter after 15 years of application of bioslurry was modelled to result in a reduction of soil erosion by 25% in Kenya and 12% in Uganda in maize cropping systems. Over time, the required quantity of bioslurry and BEC decreases due to gradual nutrient release, making them more sustainable than chemical fertilizers. Bioslurry has been generating potential businesses as farmers report longer crop shelf life and shorter cropping cycle.

Conclusion

Bioslurry and BEC effectively meet crop nitrogen needs while enhancing long-term soil health and providing additional benefits. Local stakeholders and businesses have expressed interest to scale up the findings and outcomes of OFVI project. However, these findings need to be validated through field trials which are often time consuming and resource intensive. The field validation may provide new insights for the further scale-up of the use of bioslurry and BEC.

References

African Biodigester Component (ABC), 2025. https://english.rvo.nl/subsidies-financing/see-clean-cooking/abc

Global Yield Gap and Water Productivity Atlas(GYGA). Available URL: www.yieldgap.org (accessed on 02/27/2024)

Ludemann, C., et al. 2024. A global FAOSTAT reference database of cropland nutrient budgets and nutrient use efficiency (1961-2020): Nitrogen, phosphorus and potassium. Earth System Science Data 16:1, 525-541.

16. Anaerobic digestate: a promising organic fertiliser for smallholder farmers in West Africa

Lamichhane, M.[a]*, Langeveld, J.W.A.[a], Lazarus, A.[a], Spieringhs, W.[b], van Nes, W.[b], Lengkeek, A.[c], Capurso, A.[c], de Jager, A.[d], Salissou, A.[e] & Somda, S.[f]

Biomass Research, Netherlands[a]; SNV, Netherlands[b]; DIBCoop, Netherlands[c]; SNV, Mali[d]; SNV, Niger[e]; PNB, Burkina Faso[f]

*Corresponding author, email: manisha@biomassresearch.eu

Introduction

In West Africa, biodigesters are primarily used to produce biogas for energy needs. However, they have implications for waste management, human health, gender equity, and environmental protection. Many households see high costs as the main obstacle to installation, partly due to a lack of awareness of the 'secondary benefits'. The use of digestate, either directly ('bioslurry') or after being composted (bio-slurry enriched compost, 'BEC') as organic fertiliser is one such benefit that is often overlooked. Surveys in Burkina Faso show that fewer than 3% of biodigester owners trade organic fertiliser, indicating it's not perceived to have monetary value. The Organic Fertiliser Valorisation Initiative (OFVI) of the African Biodigester Component (ABC), active in West Africa in Burkina Faso, Mali, and Niger, works in sensibilisation around the value of bioslurry and BEC.

Methodology

The field surveys were conducted to determine baseline conditions surrounding biodigester ownership and operation, as well as the use of digestate. The next stage involved desk reviews of the composition and impacts (on soil and crops) of bioslurry and BEC, as well as mineral fertiliser alternatives. These reviews supported the development of a model of the long-term impacts of bioslurry and BEC on soil erosion and nitrogen mineralisation. Throughout the project, partners also collected impromptu information from farmers related to their experiences using bioslurry and BEC.

Results and discussion

Initial outcomes from OFVI project in Burkina Faso showed 93-97% of biodigester owners used bioslurry themselves, either directly as fertiliser or to produce BEC. In Mali, this figure was 100%. In Burkina Faso, maize and millet yields increased by 15% and 22% respectively with BEC, and 85% of respondents reported it 'very effective'. In Mali, 80% of users said that it increased yields, and users reduced their use of mineral fertilisers by 15-50%.

While mineral fertilisers produce the strongest immediate benefit in terms of nutrient availability, organic fertilisers, especially BEC, provide organic matter. This results in long-term improvements in soil health, including erosion reduction. In Niger, 940 kg of bioslurry per hectare matches the current rate of nitrogen inputs to sorghum. In Mali and Burkina Faso, 4000-4500 kg/ha are required to do so. These rates were modelled to result in a 4% reduction in the annual rate of soil erosion in sorghum in Niger after 15 years of consistent application. In Mali and Burkina Faso, the same was modelled to result in erosion rate reductions in sorghum of 17% and 19%, respectively. Farmers using digestate also report that their crops have better quality, higher yield and longer shelf life. These qualities mean that farmers can ask a higher price and accumulate more income.

Conclusion

These outcomes indicate that bioslurry and BEC are promising organic fertilisers in West Africa, where they can improve crop yields and combat the effects of nutrient mining and soil degradation. The next step is to validate these results with field trials, though this will be challenging given that the key findings of this analysis are concerned with long-term benefits in the soil. Nonetheless, local stakeholders, including owners of household-level and mid-scale (food processing facilities) digesters have expressed interest.

References

African Biodigester Component (ABC), 2025. https://english.rvo.nl/subsidies-financing/see-clean-cooking/abc

Ludemann, C., et al. 2024. A global FAOSTAT reference database of cropland nutrient budgets and nutrient use efficiency (1961-2020): Nitrogen, phosphorus and potassium. Earth System Science Data 16:1, 525-541.

Van Bussel, L.G.J., et al.. 2015. From field to atlas: Upscaling of location-specific yield gap estimates. Field Crops Research. 177, 98-108.

17. Agronomic potential of compost extracts: Microbiological characterization and effects on plant growth

Lorente-Escánez, D.[a*], Martínez-Gallardo, M.R.[a], Suárez-Estrella, F.[a], Jurado, M.M.[a], López-González, J.A.[a], Toribio, A.J.[a]., Jiménez, R.[a], Lerma-Moliz, R.[a] & López, M.J.[a]

Unit of Microbiology, Department of Biology and Geology, CIAIMBITAL, ceiA3, UNIGreen, University of Almería, Almeria, Spain [a]; [*]Corresponding author, email: dle511@ual.es

Introduction

Despite their indispensable role in sustaining current agricultural production rates, the widespread use of chemical fertilizers has raised concerns due to numerous environmental and health issues (Dhankhar et al., 2023). The use of compost has gained importance as a natural fertilizer, offering a sustainable solution to enhance soil quality boosting plant health, and supporting the circular economy (De Corato, 2020). Numerous studies have highlighted the potential of compost extracts (CEs) as a sustainable strategy for increasing the yield of various crops. CEs are rich in assimilable elements and metabolites that stimulate plant growth. Additionally, they serve as a source of microorganisms that can improve essential nutrient cycling, ensuring their availability to crops (Garg et al., 2024). The aim of this study was the microbiological characterization of a catalog of aqueous CEs, produced from various raw materials and extraction protocols, to subsequently evaluate the impact of their application on tomato plants. This evaluation focused on the microbial diversity of the rhizosphere, as well as their effect on plant growth and nutritional status.

Methodology

Two types of compost of different origins were used to obtain the extracts: one derived from plant residues and the other from olive-oil mill waste. These were subjected to three extraction protocols (CEP1, CEP2, and CEP4) under different incubation conditions. The microbiological characterization of the CEs was performed through plate quantification of general microbial groups (Total aerobic mesophilic bacteria and total fungi) as well as specific groups associated with plant protection and growth promotion (chitinolytic and glucanolytic microorganisms, siderophore producers, and phosphate-, calcium-, and potassium-solubilizing microorganisms). The phytotoxicity of the extracts was assessed through a germination assay using watercress seeds. Subsequently, an *in vivo* trial was conducted to evaluate their fertilizing capacity in *Solanum lycopersicum*. In this experiment, microbial groups present in the substrate were quantified to determine their effect on the rhizosphere microbiome. Finally, the impact of the CEs on phosphate (Pi) content in plant tissues and general growth parameters of tomato plants was analysed.

Results and discussion

The results highlighted that the extraction protocol used has a significant influence on the abundance of the microbial groups evaluated in the CEs. In general, longer incubation times at moderate temperatures (CEP-4) resulted in extracts with a higher overall microbial load and a greater presence of microorganisms with biological activities related to plant growth promotion. Germination assays confirmed that the CEs did not induce any phytotoxic effects on plant growth. Furthermore, the use of extracts obtained through specific extraction protocols (CEP-1 and CEP-4) enhanced plant development. The *in vivo* application of compost extracts led to an increase in the abundance of the evaluated microbial groups in the rhizosphere of treated plants. Additionally, compost extracts promoted the growth of the evaluated tomato plants and resulted in increased Pi levels in roots and leaves at varying degrees.

Conclusion

The use of compost extracts obtained through specific extraction protocols proved to be an effective alternative for enhancing tomato plant growth and nutritional status, additionally contributing to the enrichment of the rhizosphere with beneficial microbiota.

Acknowledgements

This work was supported by the COMPOBIOTICS project (PID2023-149455OB-I00), supported by Ministry of Science, Innovation and Universities (Spain).

References

Dhankhar, N., et al. 2023. Impact of increasing pesticides and fertilizers on human health: A review. Materials Today: Proceedings.

De Corato, U. 2020. Agricultural waste recycling in horticultural intensive farming systems by on-farm composting and compost-based tea application improves soil quality and plant health. Science of the Total Environment. 738, 139840.

18. “Soil improver N mineralization predictor”, a Farmmaps application to predict nitrogen mineralization from organic fertilizer based on the SNOMIN model

Vaessen, H. [a], Pronk, A. [a], Maestrini, B.*[a], Deolu-Ajayi, A.O. [a], Schut T.[a], Mildau, K. [a], Pavlidi E[b], Christopoulou M.[b], Ganschow S.R.[c] , Schutter, de Schutter L. [a], Berghuijs H. [a]

[a] Wageningen University & Research, Netherlands, [b] Municipality of Egaleo, c Municipality of Hamburg, *Corresponding author, email: bernado.maestrini@wur.nl

Introduction

Predicting nitrogen (N) mineralization from organic fertilizers is one of the major barriers to their efficient usage, as N mineralization depends on weather, and soil properties like organic matter and moisture content that are variable between and within crop growing seasons. To facilitate farmers in the management of N, we developed an application that predicts nitrogen mineralization from a set of soil improvers based on the dynamic soil N model SNOMIN (Berghuijs et al., 2024). This app gives insight on available N for crop use throughout the year , depending on the type of soil improver and timing of application.

Methodology

We developed an application based on the soil nitrogen model SNOMIN and made it available for farmers on Farmmaps platform (*farmmaps.eu*). SNOMIN is a soil Carbon and N model based on Janssen model (Janssen, 1984), NDICEA (van der Burgt et al., 2006), MINIP-C and MINIP-N (Heinen & de Willigen, 2005). The main addition of SNOMIN to these models is the possibility of simulating C(carbon) and N dynamics in different soil layers. C and N dynamics are driven by mineralisation of soil N and C, and the stoichiometry of soil microbial biomass. Model input parameters for SNOMIN were measured in the lab for 3 different soil improvers coming from composting facilities of members of the living labs of the BIN2BEAN project in Amsterdam, Hamburg and Egaleo as well as, 8 different soil improvers from partners of the EconNutri project. To estimate input parameters for specific soil improvers, C-decomposition and N-mineralization of the compost was measured by incubating a mix of soil and compost.

Results and discussion

Preliminary results from the variability in SNOMIN input for the different compost will be presented at the conference along with a description of the app.

Acknowledgements

This project has received funding from the European Union’s Horizon 2022 research and innovation program under grant agreement No 101081858 (ECONUTRI) and No 101113011 (BIN2BEAN)

References

Berghuijs, H. N. C., Silva, J. V., Reidsma, P., & de Wit, A. J. W. (2024). Expanding the WOFOST crop model to explore options for sustainable nitrogen management: A study for winter wheat in the Netherlands. European Journal of Agronomy, 154. https://doi.org/10.1016/j.eja.2024.127099

Heinen, M., & de Willigen, P. (2005). Vergelijking van de organische stofmodellen MOTOR en MINIP. Alterra. https://edepot.wur.nl/17572

Janssen, B. H. (1984). A simple method for calculating decomposition and accumulation of `young’ soil organic matter. In J. F. Tinsley J. and Darbyshire (Ed.), Biological Processes and Soil Fertility (pp. 297–304). Springer Netherlands. https://doi.org/10.1007/978-94-009-6101-2_26

van der Burgt, G. J. H. M., Oomen, G. J. M., Habets, A. S. J., & Rossing, W. A. H. (2006). The NDICEA model, a tool to improve nitrogen use efficiency in cropping systems. Nutrient Cycling in Agroecosystems, 74(3), 275–294. https://doi.org/10.1007/s10705-006-9004-3

19. Composting strategies with WWTP and DWTP sludge in a closed system: the case of EMASESA's Plant in Seville (Spain)

Molina, E.[a], Palenzuela, M.V.[a], Sánchez, F.[b]; Ramos, V.[c], Gutiérrez, J.C.[a], Ramos, E.[a], De la Torre, M.J.[a]; Peinado, R.[b]; Rosal, A.[a*]
[a]Department of Molecular Biology and Biochemical Engineering. Pablo de Olavide University. Seville, Spain.
[b]Agricultural Chemistry, Soil Science and Microbiology Departament. University of Cordoba. Campus of Rabanales, Córdoba, Spain.
[c]Institute of Fat, Higher Council for Scientific Research (CSIC). Seville, Spain. *Corresponding author, email:emolneg@alu.upo.es

Introduction

In Europe, approximately 9 million tons (dry matter basis) of sewage sludge are generated annually [1]. The average consumption of drinking water in Europe is 120 litres per day, which represents a sludge generation of between 2% and 5% of the total treated water[2]. This massive amount of waste has a significant environmental impact, and various strategies are being explored to minimize it. The valorization of wastewater treatment plant (WWTP) sludge through composting is a sustainable option that is commonly used and under study for optimization, aiming to recirculate the organic matter and nutrients contained in these residues by applying the resulting compost to soils. However, in the case of drinking water treatment plant (DWTP) sludge, its usual fate after dewatering is landfill disposal. There is no available literature on the feasibility of incorporating this type of waste into composting processes. This study aims to assess, at an industrial scale, composting processes under different operating conditions, considering turning frequency and volumetric mixtures of urban pruning waste (P), WWTP sludge (LD), and DWTP sludge (LT).

Methodology

The sewage sludge was provided by the company EMASESA (Seville), and the trials were conducted at their new composting facilities, which consist of a fermentation plant and a maturation plant, both equipped with forced aeration systems The experiments were designed as industrial-scale windrows, which were placed inside the fermentation plant for 21 days before being transferred to the maturation hall, where they remained for 57 days. The windrows were composed of LD:LT:P at the following volumetric ratios: 1:0:1 (P1), 1:0:1.5 (P2), 1:0.3:0.7 (P3), 1:0.5:1 (P4), 1:0:1 (P5), and 1:0:1.5 (P6), respectively. In the fermentation plant, all windrows were turned weekly using a mechanical shovel, except for P5 and P6, which were turned twice per week. In the maturation plant, the turning frequency was the same for all cases, with one turning every two weeks. The composting process lasted 90 days, and samples were collected at five specific time points (initial, 13, 27, and 56 days, and final compost). Physicochemical parameters (internal temperature, pH, electrical conductivity, C/N ratio, FTIR, heavy metals), biological parameters (self-heating), and microbiological parameters (*Salmonella* spp., *E. coli*) were analyzed, as these are commonly used as monitoring variables for composting processes and quality indicators. The analyses were conducted following the methodologies recommended by legislation (RD 506/2013) or those commonly employed by internationally recognized research centres. One-way analysis of variance (ANOVA) and LSD test for $p<0.05$ were used to evaluate significant differences in the mean values of each parameter between treatments.

Results and discussion

In all the cases studied, thermophilic temperatures (>45°C) and sanitation conditions (T≥55°C maintained for 48 hours between turnings and at least three times during the process) were achieved. However, these T were reached earlier and maintained for a longer time in the case of P2, P5 and P6. The C/N ratio, the self-heating test and the FTIR spectra showed the increase in maturity of the material in all the trials, although this was more pronounced in the case of the P6 trial. Finally, the analyzed heavy metal concentrations complied with the restrictive limits required by Spanish regulations (RD 506/2013).

Conclusion

Under the imposed operating conditions, although characteristic thermal profiles of the composting processes were obtained in all cases, the thermophilic phase was reached in a shorter time in the trial with a higher proportion of pruning and turning frequency. Additionally, this trial also allowed for more pronounced sanitation conditions compared to the rest. On the other hand, the incorporation of WWTP sludge as a partial substitute for urban pruning has not prevented the viability of the co-composting process at the proportions studied and with the imposed turning frequency.

Acknowledgements

The authors are grateful for the funding received through the TED2021-129208B-100 Project by MICIU/AEI/10, 13039/501100011033 and by the European Union Next Generation EU/PRTR to FR-R and EMC and for the collaboration of EMASESA for the development of these experiments in its COPERO environmental facilities in Seville.

References

[1] EurEau. Waste Water Treatment—Sludge Management. Available online: https://www.eureau.org/resources/briefing-notes/5629-briefing-note-on-sludge-management/file

[2] European Comisión. Parlamento Europeo Available online: https://environment.ec.europa.eu/topics/water/drinking-water_en

20. Valorization of wine industry residues through sustainable processes: composting vs vermicomposting

Molina, E.[a], Palenzuela, M.V.[a], Sánchez, F. [b], Ramos, V.[c], Gutiérrez, J.C. [a], Ramos, E. [a], De la Torre, M.J.[a], Peinado, R.[b], Rosal, A.[a*]
Department of Molecular Biology and Biochemical Engineering. Pablo de Olavide University. Seville, Spain; [b]Agricultural Chemistry, Soil Science and Microbiology Departament. University of Cordoba. Campus of Rabanales, Córdoba, Spain; [c]Institute of Fat, Higher Council for Scientific Research (CSIC). Seville, Spain. *Corresponding author, email: emolneg@alu.upo.es

Introduction

Wine industry wastes represent both environmental and economic challenges due to their accumulation in the agri-food industry. Currently, in Spain alone—the world's third-largest wine-producing country—it is estimated that around 5 million tons of pruning grapevines, grape pomace, and wine lees are generated annually [1]. Strategies such as composting and vermicomposting offer sustainable alternatives for managing these residues by converting them into fertilizers or soil amendments, taking advantage of their organic matter and nutrient content. However, integrating these processes within the circular economy framework of the wine sector is not without risks, both economically and environmentally. A deeper understanding of their dynamics is needed to enhance the quality of the final products. In this study, we have evaluated, on one hand, the feasibility of these processes for treating such residues and, on the other, the agronomic quality of their resulting products (compost, vermicompost).

Methodology

The wine industry residues were provided by Bodegas Alvear in Montilla (Spain) and Bodegas Viña de Alange in Almendralejo (Spain). Two pilot-scale experimental trials were conducted: (1) composting in a trapezoidal windrow, composed of a mixture of pruning grapevines, wine lees, and grape pomace at a mass ratio of 1:1:2 (dry matter basis), respectively, and (2) vermicomposting in a bed (h=20 cm, volume=0.3 m^3) contained in a PVC container. The windrow was turned using a mechanical shovel and periodically watered to maintain moisture levels between 50–70% throughout the composting period (190 days). After 30 days of composting, 0.9 m^3 of the piled material was distributed to form three beds, into which 300 *Eisenia foetida* individuals were introduced for its vermicomposting (90 days). Samples were taken at five time points during the composting process (initial, thermophilic phase, end of the bio-oxidative phase, maturity, compost) and at two time points for the vermicomposting process (initial, vermicompost). In both trials, commonly used control variables were analyzed: physicochemical parameters (thermal evolution, pH, electrical conductivity, C/N ratio, functional groups—FTIR), biological parameters (self-heating, germination index), and microbiological parameters (*Salmonella* spp., *E. coli*). In the case of vermicomposting, worm biomass and population dynamics were also evaluated. Finally, the metal content was analyzed in both final products. A one-way analysis of variance (ANOVA) was performed to test the differences between the results obtained for the physicochemical parameters analysed in the amendments.

Results and discussion

In the composting process, the mass ratios of the residues used, along with the imposed watering and turning frequency, allowed thermophilic temperatures (>45°C) to be reached, ensuring sanitation conditions in accordance with EPA standards. In the case of vermicomposting, temperatures were maintained between 20–25°C, with moisture levels above 80%, conditions that do not adversely affect the development of the process. After the addition of the pre-compost material there was a significant decrease in the number of adult worms after 30 days of treatment ($F_{3,11}$= 20.38, p= 0.001), then there was no statistically significant change until the end of the experiment. In both trials, the C/N ratio decreased (<20), and both the Self-Heating Test (T max <25°C) and the FTIR spectrum indicated the progression of maturity. The germination index showed no phytotoxicity in either product, and the analyzed heavy metal concentrations allow the agricultural use of both compost and vermicompost, in accordance with legislation (RD 506/2013).

Conclusion

Under the operating conditions imposed in both experimental trials, the results indicate that these types of residues can be treated through composting and vermicomposting, yielding products suitable for agricultural application.

Acknowledgements

The authors are grateful for the funding received through the TED2021-129208B-100 Project by MICIU/AEI/10, 13039/501100011033 and by the European Union Next Generation EU/PRTR to FR-R and EMC and for the collaboration of EMASESA for the development of these experiments in its COPERO environmental facilities in Seville.

References

[1] Palenzuela, M. d. V., López de Lerma, N., Sánchez-Suárez, F., Martínez-García, R., Peinado, R. A., & Rosal, A. (2023). Aroma Composition of Wines Produced from Grapes Treated with Organic Amendments. *Applied Sciences*, *13*(14), 8001. https://doi.org/10.3390/app13148001

21. Scalable assessment of sustainable by-product bioconversion processes for fertiliser production

Ramos-Bueno, R.[a*], González-Fernández, M.J.[a], Martínez-Gaitán, C.[a], Gázquez, I[a]

Foundation of Auxiliary Industry of Agriculture Tecnova, Spain a; *Corresponding author, email: rramos@fundaciontecnova.com

Introduction

Population growth is leading to an increase in resource consumption, which is translating into an accelerated increase in the generation of agri-food waste. This problem requires sustainable actions to reduce food waste and achieve the Sustainable Development Goals. The valorisation of agri-food by-products has become one of the priorities of the European Commission, and the extraction of biocompounds/biosolutions and their applications in different sectors can be an economically and environmentally viable alternative. In this sense, GO DEMOEXTRACT, a regional consortium made up of 3 technological centres and 3 agri-food companies, is responding to this need, with the objective of demonstrating the viability of two bioconversion processes of agri-food by-products for the development of high added-value ingredients for agronomic purposes. To achieve this objective, a wide range of by-products from citrus, olive, fruits and vegetable industries will be studied to identify their content of main active molecules. Then, valorisation strategies will be optimised in the context of circular bioeconomy and efficient use of resources.

Methodology

For agronomic goals, two bioconversion processes are being developed at different scales with the use of different by-products from the selected agro-industries (previously processed as a part of a cascade valorisation system or without processing). One of the bioconversion strategies is based on edible insect breeding of Tenebrio molitor specie to transform, through the feeding process, the selected wastes into two high added value bio-based fertilizers to make soil amendments (insect biomass and insect frass). The second one is an additive composting process with biochar and citrus peel and olive wastes to study its impact on process behaviour and quality of the final product. These amendments will be tested in an isolate environment and under controlled conditions through assessing soil and plant in vitro trials to define doses of application and their operating method. Finally, these fertilisers will be validated under controlled conditions in experimental greenhouses.

Results and discussion

During the first stage of the project, a selection of different wastes from the targeted agro-industries have been selected and fully characterised to know its composition and the potential to be included in the cascade valorisation strategies in the scope of the project. For agronomic purposes, two concentrated sugar extract from peach and apricot wastes (fractions from the first extraction cascade process with high potential to be included in human and animal nutrition) and three citrus peels, two olive processing and horticultural fruit wastes (without previous treatment) are being used as supplementary ingredients in experimental insect feeding. Additionally, these wastes are being included in different proportions in tomato and cucumber composting processes at lab and pilot scale. Different parameters are being evaluated such as composting time reduction, improvement of the final product and reduction of process related issues (undesired anaerobic decomposition, leachate production and temperature instability).

Conclusion

As a starting point, it can be concluded that the use of different agro-industrial wastes seems to be valuable to get high-added value ingredients and biosolutions with an enriched composition compared to the use of just one type of waste. These mixed of nutrients can promote and facilitate the bioconversion strategies, and hence, the quality of the final products.

Although no definitive conclusions can be drawn due to the lack of current data at a developmental stage, it is expected that sustainable bio-based fertilisers will be obtained for soil amendment practices.

Acknowledgements

DEMOEXTRACT project has received funding from the supra-autonomous Operational Groups of the European Innovation Partnership for Agricultural Productivity and Sustainability (AEI-Agri), within the framework of the Strategic Plan for the CAP in Spain (PEPAC).

22. Physical attributes of common pelletized bio-based fertilizers in EU

Seppänen, Ari-Mattia
Natural Resources Institute LUKE Finland, Finland

Introduction

Bio-based fertilizers (BBFs) have established a stable role in European agriculture as more environmentally friendly option compared to mineral fertilizers. However, as no standardisation exists for these products, new products enter the market annually with variable nutrient content and physical formulation. This poster presents the physical attributes of commercially available pelletized bio-based fertilizers (BBFs) and discusses the correlations observed between these attributes and the deviations among them.

Methodology

The sample collection was conducted in collaboration with the Lex4Bio Horizon 2020 project's trials, which focused on novel nitrogen-rich bio-based fertilizers (Müller et al., 2024). Thirteen pelletized BBFs, commercially available in large quantities in 2021, were collected from various locations across Europe. The samples included raw materials commonly used in BBFs, such as poultry manure and slaughterhouse by-products, including meat, bone meal and feather meal.

The analysis of physical attributes was carried out at Luke's Biopaja, a research platform for biogas and BBF at Jokioinen, Finland. Dry matter (DM) of BBFs was determined at 105 °C by TGA701 (Leco). Flexural strength was measured using the Mecmesin MultiTest 2.5-dV MkII low-force materials tester with a 3-point flexural test. The mechanical durability of the samples was assessed using the tumbler test according to ISO 17831. Compressive strength was determined with the Kahl Herkules M Hardness Tester. Dimensional measurements were taken manually with a digital vernier caliperaccording to ISO 17829. Correlations between the attributes were analysed using a paired t-test.

Results and discussion

Overall, the pelletized BBFs were durable (durability >85%), their diameter ranging from 4.0 to 5.5 mm and length from 3 to 12 mm. Their bulk density exceeded 630 kg/m3. While bulk density and diameter were fairly similar, larger differences were observed in DM content, pellet length, durability, flexural and compressive strength with certain products. The majority of the products attributes aligned with the medians of the attributes though the greatest deviations were found in flexural and compression strength. Statistical analysis revealed positive correlation (Pearson correlation $r > 0.60$, $p < 0.05$, $n = 13$) between length and durability; flexural and compressive strength; compressive strength and durability; DM content and bulk density.

Conclusion

The results suggest that, even without established standards, pelletized BBFs physical attributes do follow certain trends across the EU. While some products stand out with e.g. longer pellet length, lower DM content or higher compression strength, the majority of the products analysed were similar to each other. This raises questions such as i) which factors drive these trends and ii) is there research behind how these attributes affect fertilizer performance (e.g. evenness of the spreading patterns). Comparable research forms a basis for the standardization of these attributes, leading to a more uniform product range of BBFs in Europe and globally.

References

Müller, B., et al. 2024. Agronomic performance of novel, nitrogen-rich biobased fertilizers across European field trial sites, Field Crops Research, Volume 316. https://doi.org/10.1016/j.fcr.2024.109486.

23. Fertilizer quality in source-separated dairy cattle systems

Smit, H.J.*, Boxmeer E.G.G., Galama, P.J., Schilder, H.

Wageningen Livestock Research, The Netherlands. *Corresponding author, email: harm.smit@wur.nl

Introduction

In the search for low-emission livestock systems technical innovations push towards separation of urine and feces, leading to multiple fertilizer products. In earlier research it was found that these products have a different agronomical quality (van Boxmeer et al., 2023). The current project was to find out what the variability and persistence of the fertilizer quality of these innovative dairy systems is over a growing season.

Methodology

In the period from February 2024 to November 2024 samples were taken from five dairy systems. All fertilizer products that were produced were sampled. In total 5 samples per dairy system were taken and analysed over the growing season. Samples were analysed for Dry matter (DM), Organic matter (OM), Nitrogen (N), Mineral Nitrogen (N_{min}), Phosphate (P_2O_5) and Potassium (K_2O) to determine the agronomical quality of all fertilizer products.

Table 1. *Average fertilizer quality and variability (SD in brackets) of manure products from five dairy systems.*

Name	Products	DM g/kg product	OM g/kg DM	N g/kg DM	N_{min} g/kg DM	P_2O_5 g/kg DM	K_2O g/kg DM
1.Slatted floor with air scrubber	Slurry	100.6 (±5.7)	801.6 (±61.9)	38.3 (±3.3)	9.9 (±4.9)	16.2 (±1.6)	36.2 (±15.6)
	AS[1]	171.2 (±12.6)	-	187.4 (±16.2)	192.2 (±18.1)	0.0 (±0.0)	1.1 (±0.3)
2.Mono-manure-digester with processing	Solid digestate	339.5 (±13.3)	856.3 (±43.3)	25.5 (±0.7)	8.7 (±0.6)	24.5 (±2.0)	14.0 (±0.5)
	AS[1]	297.4 (±5.3)	-	204.2 (±2.9)	208.6 (±5.8)	0.0 (±0.0)	0.0 (±0.0)
	Effluent	41.4 (±4.0)	632.4 (±30.2)	74.3 (±13.0)	39.6 (±10.2)	27.9 (±4.2)	104.1 (±6.5)
3. Source separation and fermentation	Urine	27.3 (±0.9)	408.3 (±37.8)	102.7 (±4.8)	89.2 (±4.6)	4.7 (±0.7)	288.6 (±6.4)
	Fermented manure	160.7 (±16.4)	644.2 (±218.9)	25.8 (±3.4)	6.6 (±1.0)	11.9 (±1.8)	25.8 (±2.7)
4. Source separation mono-manure digester with processing	Solid digestate	302.9 (±31.1)	873.4 (±94.9)	22.0 (±1.4)	8.7 (±0.9)	16.6 (±1.9)	13.9 (±1.1)
	AS[1]	204.1 (±25.1)	-	191.1 (±37.7)	196.4 (±39.9)	0.1 (±0.0)	0.8 (±0.2)
	Effluent	48.2 (±0.1)	582.6 (±3.5)	83.3 (±3.8)	50.5 (±4.5)	23.4 (±0.0)	98.8 (±6.5)
5. Source separation with rubber floor	Urine	38.8 (±6.6)	639.4 (±120.7)	65.2 (±5.8)	44.2 (±3.3)	13.9 (±2.3)	117.3 (±11.0)
	Feces	106.8 (±9.0)	646.2 (±281.7)	32.4 (±2.2)	7.9 (±0.4)	13.8 (±0.4)	27.8 (±2.3)

[1]AS: Ammonium Sulphate

Results and discussion

Table 1 shows the average concentration of DM, OM, N, Mineral N, P_2O_5 and K_2O of the different fertilizer products in five innovative dairy systems. All systems produce two or three different fertilizer products, that show distinct differences in fertilizer quality. The solid digestates show a high organic matter content (>850 g/kg DM), whereas the fermented manure showed comparable results as slurry. The Ammonium sulphate (AS) in all three systems with an air scrubber or ammonia stripper contained mainly mineral Nitrogen with around 200 g N_{min}/kg DM. The concentration of N_{min} per kg product varied between systems (3,2% -6,2%), mainly due to the DM content of the product. Urine and effluent fractions contain relative high concentration of Potassium. Analysis is needed how these products reach the RENURE-criteria and how all products could fit into a balanced fertilizer scheme on the dairy farm.

Acknowledgements

This research was carried out in the context of the Topsector project Betere Stal, Mest, Oogst and paid for by the provinces of North Brabant, Gelderland, Overijssel and Limburg and the Ministry of LVVN, The Netherlands.

References

Van Boxmeer, E.G.G., H. Schilder, N. Verdoes, P.J. Galama, G.C.C. Kupers, 2023. Samenstelling mestproducten uit innovatieve stalsystemen in de melkvee-, varkens- en kalverhouderij; Betere stal, betere mest, betere oogst. Wageningen Livestock Research, Rapport 1410. https://doi.org/10.18174/588047

24. Nutrient-concentrated liquid fraction from pig slurry as an alternative fertilizer for rainfed wheat; impact on production and grain quality

Solé, P.[a*], Caballé, I. [a], Masferrer, G. [a], González, E. [a] & Domingo-Olivé, F. [a]

Institute of Agrifood Research and Technology (IRTA), Catalonia [a]; *Corresponding author, email: pau.sole@irta.cat

Introduction

In the north-east of the Iberian Peninsula, especially in Catalonia and Aragon, there has been an increase in pig farm concentration in zones that far exceed the capacity of the nearby agricultural fields to receive all the slurry produced (Giménez et al., 2021). The solid-liquid separation process has long been used in some local farms to solve this issue, but in some cases the liquid fraction obtained exceeds the necessities of nearby fields, and the cost of transporting it long distances ramps up. This can be solved by concentrating the nutrients of the produced liquid fraction. This treated liquid fraction (LFt) is obtained using an ultra-filtration process and a reverse osmosis of the original liquid fraction.

This experiment aims to evaluate the effects of using LFt as a fertilizer for rainfed winter cereal crops, quantifying its effects on grain yield and quality of the crop when compared to traditional fertilization strategies (untreated pig slurry and mineral fertilizer).

Methodology

The field experiment is conducted at the IRTA-Mas Badia Experimental Station in Girona, Catalonia. The area has a subhumid Mediterranean climate, which allows to grow winter arable crops under rainfed conditions. The soil in the trial is classified as a Typic Xerofluvent and has a loamy texture in the topsoil (0-30 cm). The experiment consisted of elemental plots of 30 m^2 (3 m x 10 m). In each of the treatments a different fertilizer was used: Untreated pig slurry (PS) (170 kg N/ha), untreated PS (130 kg N/ha), LFt (170 kg N/ha), LFt (130 kg N/ha), mineral fertilizer (170 kg N/ha) and control without application. The trial design is a random block with three replicates. Crop in the trial was winter wheat.

We evaluated wheat grain yield and quality (protein) for each elemental plot. Nutritional status of the wheat crop was also measured using an NDVI sensor at 5 times: the first when the crop was at the tiller stage (BBCH: 16/23), the second at the beginning of shoot development (BBCH: 31), the third at the flag leaf stage (BBCH: 39), the fourth during earing (BBCH: 51) and the fifth at the end of flowering (BBCH: 71).

Results and discussion

The NDVI values remained significantly higher in all the treatments when compared with the control in all the development stages. At the beginning, the higher NDVI was obtained in the mineral and 170 kg N/ha PS treatments, and the subsequent values were similar or slightly lower. For the treatments where LFt was applied, the initial values were lower than for the previous treatments, but they increased with crop development. From starting shoot development, the treatment with 170 kg N/ha of LFt had the higher NDVI values. After earing, the NDVI values for the treatment with 130 kg N/ha of LFt reached the same values than the mineral and 170 kg N/ha with PS treatments.

Yield for the PS at 170 kg N/ha and LFt at both 170 and 130 kg N/ha treatments were higher than that in the other ones, including the mineral fertilizer one (p-value: 0.0087). The higher protein content was measured in the LFt 170 kg N/ha treatment, followed by the mineral treatment. The protein content in both PS treatments was significantly lower than the one in the LFt 170 kg N/ha (p-value 0.0013).

Conclusion

The use of LFt is a good alternative to the use of untreated PS in the regions where there exists a high pig farm concentration. As proven in this work, the use of LFt, compared to untreated PS, does not cause any decrease in yield and, if it is well managed, it has the potential to produce grain of greater quality than the use of PS.

References

Giménez, R., et al. 2021.The pig sector in Spain: characterization, production, trade, and derived environmental problems. TERRA. Revista de Desarrollo Local. 8, 194–230.

25. Evaluation of bioactive extracts from olive oil mill wastewater sludge in the agri-food sector: phyto-promoting and phytoprotective effect

Suárez-Estrella, F.[a *], Martínez-Gallardo, M.R.[a], Jurado, M.M.[a], López-González, J.A.[a], Sáez, J.[b], Moral, R.[b], Barba, F.J.[c] & López, M.J.[a]

Unit of Microbiology, Department of Biology and Geology, CIAIMBITAL, ceiA3, UNIGreen, University of Almería, Almeria, Spain [a]; Research group in Innovative Technologies for Sustainable Food (ALISOST), Department of Preventive Medicine and Public Health, Food Science, Toxicology and Forensic Medicine, Faculty of Pharmacy and Food Sciences, Universitat de València, Burjassot, (Valencia), Spain[b]; Department of Agrochemistry and Environment, CIAGRO, Miguel Hernández University, EPS-Orihuela, (Alicante), Spain[c].
[*]Corresponding author, email: fsuarez@ual.es

Introduction

Olive oil wastewater sludge (OMWs) can be a source of extraction of bioactive compounds, as they are rich in oil, and other high value-added compounds such as proteins, vitamins, minerals, fibers, along with a significant amount of polyphenols, which can be used as food additives and/or for the development of nutraceuticals (Chemat et al., 2020). The novelty and at the same time the main objective of this work was to evaluate the effect of this type of bioactive compounds in agri-food uses, in order to establish their potential biostimulant, biocontrol and biofertilizing capacities.

Methodology

Eco-Innovative extraction processes like pulsed electric fields (PEF), pressurized liquid extraction (PLE), supercritical fluid extraction (SFE), microwave-assisted extraction (MAE) and ultrasound-assisted extraction (UAE) in the presence of various solvents were developed and optimized. After obtaining the bioactive extracts, the phytotoxic effect on water cress seeds was evaluated by priming techniques, and the Germination Index calculated following the formula described by Zucconi (1981). In parallel, validation of the suppressive effect of bioactive extracts was carried out in vitro on different phytopathogenic bacteria and fungi. Finally, the selected bioactive extracts were applied via radicular after germination of tomato seedlings. After one month, the growth-promoting character of the extracts were determined as well as the plant health status and the suppression of aerial and vascular plant pathogens.

Results and discussion

As expected, the phytotoxicity of the bioactive extracts of OMW sludge varied according to the origin of the samples, the extraction method and the concentration of the extract in compounds of phenolic nature. In general terms, phytotoxicity disappeared when the extracts were diluted 100-fold. On the other hand, the seed priming technique with the bioactive extracts generally caused a slight decrease in the germination rate in some cases. However, bioassays performed in pathogen-tomato pathosystems revealed a phytopromoting effect of the extracts named FATED15 and ASE3CTED20. In addition, a mitigating effect on damage caused by phytopathogenic fungi should be noted.

Conclusion

Bioactive extracts from OWMs could be used in the development of new products of agricultural interest, thus responding to society's demand for phytostimulants and biopesticides to reduce the negative effects of agrochemicals on the environment and animal health.

Acknowledgements

This work was supported by the OLIVE_RELIFE project (TED2021-129481B-C3), funded by the Spanish Ministry for Ecological Transition and the Demographic Challenge.

References

Chemat et al. (2020). A review of sustainable and intensified techniques for extraction of food and natural products. Green Chem, 22: 2325-2353.

Zucconi (1981). Evaluating toxicity of immature compost. Biocycle, 22 (2): 54-5

26. Olive mill wastewater sludge composting enhanced through biochar and phenolic degrading microorganisms Inoculation

Mira-Urios, M.A.[a*], Sáez Tovar, J.A.[a], F.J. Andreu-Rodríguez[a] , Suárez-Estrella, F.[b], Toribio, A.[b], Barba F.J.[c], Martínez-Terol, S.[c] , Moral, R.[a]

Centro de Investigación e Innovación Agroalimentaria y Agroambiental (CIAGRO-UMH), Universidad Miguel Hernández, Carretera de Beniel Km 3,2, Orihuela, Alicante 03312, España[a]; Unidad de Microbiología, Departamento de Biología y Geología, CITE II-B, Universidad de Almeria [b]; [1] Grupo de investigación en Tecnologias Innovadoras para Alimentación Sostenible (ALISOST), Universitat de València [c];

[*]Corresponding author email: miguel.mirau@umh.es

Introduction

Olive mill wastewater sludge (OMW) is the main waste obtained from three-phase olive mills that has been produced in some extent in all Mediterranean countries. The management and treatment of OM2 is an environmental challenge. Although it is high in nutrients, OMW has shown of difficulties to be composted due to its high phenolic content and antimicrobial and phytotoxic characteristics. For this work, several composting strategies have been stablished to improve the biodegradation of this wastes. Co-composting using cow manure, application of biochar at 5% f.w. and bioaugmented inoculating microbial communities with phenolic degrade capacities isolated from OMW ponds have been proposed and tested in order to obtain an agronomically valuable product.

Methodology

8 different composting piles were prepared using two different mixtures: a) P1 to P4 prepared with OMW 30% f.w., Cow manure 60% f.w. and vineyard pruning 10% f.w.; and b) P5 to P8 prepared with OMW 50% f.w., Cow manure 40% f.w., and vineyard pruning 10% f.w. Two piles received a Biochar addition of 5% f.w. (P2 and P6), two piles were inoculated with a microbial community (P3 and P7), and two piles received both treatments: Biochar 5% f.w. and microbial inoculation (10^7 Log UFC) (P4 and P8). The composting process was carried out from March to July of 2024 in the Compolab facility of the UMH-EPSO (Orihuela, Spain). The Bio-oxidative phase finished after 115 days of composting and all piles stayed in maturation for 60 days. All piles were turned every 15 days and watered as necessary to keep optimal moisture conditions. All piles were sampled at the beginning of the process, after 30, 60, 90 and 120 days from the beginning and after maturation phase.

Results and discussion

During composting process an increase in pH values were observed due to the metabolism of organic acids and ammonia production during microbial organic matter hydrolysis (Enaime et al.,2020), especially in piles prepared with higher proportion of OMW. Regarding OM degradation, the piles with Inoculation treatment and without biochar application showed the significant higher mineralization. The input of recalcitrant carbon with Biochar application likely slowdown the biodegradation process. Finally, the Piles that combined Biochar application with the inoculation achieved the highest reduction in phenolic compounds (>40 % in Pile prepared with mixture 2). Additionally, these piles seemed to reduce the phytotoxic effect of OMW, as shown the higher germination index determined in final compost.

Conclusion

The application of Biochar and the microorganism not showed differences on the characteristics of the final compost. However, the combination of both strategies showed a synergistic effect that caused a reduction in high phenolic compounds of compost. Although the validation of these composts in crop application must be carried out to ensure this reduction in ecotoxicity.

Acknowledgements

This work is part of the I+D+I project TED2021-129932B-C21, financed by AEI and the European Union NextGenerationEU/PRTR.

References

Enaime, Ghizlane, Abdelaziz Baçaoui, Abdelrani Yaacoubi, Majdouline Belaqziz, Marc Wichern, and Manfred Lübken. 2020. “Phytotoxicity Assessment of Olive Mill Wastewater Treated by Different Technologies: Effect on Seed Germination of Maize and Tomato.” *Environmental Science and Pollution Research* 27(8):8034–45. doi: 10.1007/s11356-019-06672-z.

27. How to manage beef cattle manure in farm? A proposal for optimized composting in Mediterranean environment

Moral, R.[1], Calvet, S.[2], Orden, L.[1], Andreu-Rodriguez J.[1], Barber, X.[3], Perez-Espinosa, A.[1], Rubio, R.[1], Sanchis E.[2], Martinez-Sabater, E.[1], Sáez-Tovar J.A.[1], Estelles, F.[2]

[1] Centro de Investigación e Innovación Agroalimentaria y Agroambiental (CIAGRO-UMH), Universidad Miguel Hernández, Carretera de Beniel Km 3,2, Orihuela, Alicante 03312, España. [2] Instituto de Ciencias y Tecnología Animal, Universidad Politécnica de Valencia, Camino de Vera s.n., 46022 Valencia, España. [3] Unidad de Estadística Aplicada, Centro de Investigación Operativa, Universidad Miguel Hernández de Elche, Elche (Alicante), España

Livestock activities are increasingly in the centre of climate-derived guidelines linked to ammonia and GHG emissions. Organic matter (OM) and therefore manures as the main source of OM in Europe is also claimed as one of the best available practice for soil health and conservation. In these apparent paradox farmers must claim its key role as OM producers by means of adopting virtuous manure management in farms to produce even more and better OM for European soils. In this line PROVACUNO association, Universidad Politecnica de Valencia (UPV) and Miguel Hernandez University (UMH) has developed a systematic research together with Spanish farmers in order to stablish several practices to develop advanced composting procedures to obtains not only high-quality compost but also in environmentally friendly conditions in terms of GHG emissions. In this work, optimization procedures were stablished based on: i) optimized blends of raw materials to be composted by increasing the C to N ratio or specific ingredient; ii) use of additives to reduce ammonia and GHG emissions by using biochar or other additives blends; iii) covering the composting piles; iv) optimized management procedures during composting. The composting validation was developed in COMPOLAB composting plan at Miguel Hernandez University. Composting emissions and final product assessment were done during standardized triplicates composting procedures of 166 days of duration. In the following table we showed the main results on gases emissions compared with mono-ingredient composting (just beef cattle manure):

Composting optimization	NH_3	N_2O	CO_2	CH_4	GWP
Increase of C to N ratio	-70% a -52%	-70% a -52%	-10% a +40%	-60% a -36%	-61%
Use of olive oil residue	-15%	-15%	+20%	+25%	-15%
Addition of biochar (1%)	-15%	-15%	+4%	-5,7%	-15%
Addition of additive blend*	-6,4%	-6,4%	+21%	-3,4%	-6,3%
Use of pile coverage**	+11% / -90% / -93%	+11% / -40% a -60%/ -85%	+40% / -70% a -2% / nd	+16% / nd/ -30%	+11% / -35% / -60%

*blend made with biochar, almond powder, an inorganic P-rich material and a pH regulator; ** three types of coverage are included: Non-woven polypropylene fabric/Semipermeable membrane/Waterproof coverage.

28. Precipitation of carbonates in digestates with $CaCl_2$ before separation can reduce the amount of sulphuric acid needed for acidification of the liquid fraction

Sørensen, P.[a*] & Dold, C.[a]

Department of Agroecology, Aarhus University, Denmark [a]; *Corresponding author, email: ps@agro.au.dk

Introduction

In Denmark about 35% of all manures are anaerobically digested in biogas plants. Digestates have a high pH causing high risks of ammonia emission by surface application. Ammonia emissions can be reduced by acidification, but large amounts of acid are needed due to a high content of buffering carbonate. The most common and affordable option for acidification is sulphuric acid, which additionally provides plant-available sulphur, an important macronutrient for many crops. However, it may also lead to surplus sulphate, which could surpass the permitted limit of sulphur application in some countries. Another option is to precipitate part of the carbonates with Ca in the form of $CaCl_2$, thereby lowering the pH in digestates. Yet, this method is not well investigated. The aim of this study was to test the effect of $CaCl_2$ addition on pH in digestates and to quantify the amount of sulfuric acid needed for acidification after $CaCl_2$ treatment of digestates prior to separation by centrifugation.

Methodology

Different rates of $CaCl_2$ (20-80 meq kg^{-1} corresponding to 2.22 – 8.88 kg ton^{-1}) were added and mixed with a digestate from a biogas plant at Aarhus University, Denmark and compared with the similar digestate without additions (n=3). Thereafter, the digestates were stored at 5°C for at least 24 hours before separation in a laboratory centrifuge at about 5000g, which is comparable to a decanter centrifuge. Concentrated sulphuric acid was diluted 1:10 with deionized water. The liquid fraction was then titrated with the diluted sulfuric acid until pH 5. The resulting titration curves were used to quantify the amount of sulfuric acid needed to reach pH 6.0 and 5.5, respectively, and the amounts were compared to the quantities needed for untreated and unseparated digestates. The dilution of sulphuric acid was accounted for in the calculation.

Results and Discussion

The addition of $CaCl_2$ reduced pH in the digestate proportionally to the amount added from pH 8.25 to 7.26 by the highest rate. While the amount of concentrated sulphuric acid needed to adjust to pH 6.0 in untreated digestate was 4.6 l ton^{-1}, the amount reduced to 3.8 l ton^{-1} after separation of digestate without $CaCl_2$ addition. By adding $CaCl_2$ at the highest rate of 8.88 kg ton^{-1} before separation, the amount of sulphuric acid needed to reach pH 6 in the liquid fraction was further reduced to 2.0 l ton^{-1}. For acidification to pH 5.5, 5.4 l ton^{-1} was needed for untreated digestate and 2.3 l ton^{-1} for the liquid fraction after addition of the highest rate of $CaCl_2$.

Note that the current price of 1 l conc. sulfuric acid is approximately half of 1 kg $CaCl_2$, and 1-3 kg $CaCl_2$ is needed to replace 1 l conc. sulfuric acid. Therefore, using $CaCl_2$ is likely not economically viable at present compared to using only sulphuric acid. Yet, using high rates of sulphuric acid can cause environmental problems owing to higher sulphate leaching, and the use of $CaCl_2$ could be a mitigation option. It is currently uncertain how the pH of $CaCl_2$-treated digestates changes during storage, and further studies are needed for additional evaluation of the technique, in both laboratory- and production-scale. Also, the effect of chloride addition with $CaCl_2$ application needs to be studied, as some crops such as potatoes do not tolerate high applications of chloride.

Conclusion

The liquid fraction of digestates can be acidified with less amounts of sulfuric acid by adding $CaCl_2$ prior to separation. This reduces the problems with surplus sulphate addition but comes with higher economical costs than acidification with only sulphuric acid.

Acknowledgements

The work was financially supported by the LOWHIGH project funded by *AgriFoodTure*, *Innovation Fund Denmark*, and *The European Union NextGenerationEU*.

29. Evaluating the phosphorus release efficiency of duo-biochar to spring wheat

Christina van Midden*, Suzanne Higgins, Deb Jaise, Rajan Ghimere, Juan Frene, Nitesh Kasera, David O'Connel, Sofia Vitsa, Sushil Adhikari

*Corresponding author, email: Christina.VanMidden@afbini.gov.uk

Introduction

High legacy soil phosphorus (P) inputs from slurry, organic manures and inorganic fertilisers above what is required for agronomic production, continue to be an issue in intensively managed agricultural areas within Northern Ireland, Ireland and North America. This has created soils with surplus P which threatens water quality. In 2018, DAERA reported that 67% of rivers in Northern Ireland failed to meet the EU Water Framework Directive target for 'good' or 'high' quality. Whilst soils are high in phosphorus, the amount that is available to plants is low, due to the fixation of ortho-phosphorus into soil constituents. Whilst fertilisers are used to provide plants with available P, this rapid fixation results in 70-90% of applied P becoming plant unavailable (Ziadi et al 2013). Therefore, solutions are required to both retain excess P in the soils, thereby protecting freshwater and coastal habitats, and act as a slow-release fertiliser to provide plants with sufficient P when most needed during the mid and late growth stages. Biochar, a carbonaceous material produced from the thermochemical conversion of biomass, is highly porous with an array of functional groups and inorganic compounds that can absorb and co-precipitate P in the network of pores. However, a meta-analysis by Tesfaye et al (2021) showed that the positives effects of biochar on soil available P were evident in soils with a low phosphorus content. For biochar to be more effective in the high P soils, biochar doping is a proposed solution. This modification of biochar by doping it with metals, such as Mg and Fe, increases the phosphorus absorption capacity due to changes in specific surface area, pore volume and functional groups (Qu et al. 2024). This experiment aimed to test the effects of Fe-doped biochar on crop production and water quality, whilst also using stable isotope-P labelled biochar to quantify the P release from biochar into the plant.

Methodology

Two glasshouse experiments were set up in Northern Ireland and New Mexico to test the effects of iron-modified biochar and unmodified biochar on the phosphorus desorption dynamics and uptake in spring wheat. The treatments were soil only control, pristine biochar and Fe-modified biochar replicated 4 times. Biochar made from hardwood biomass was modified with iron and then loaded with isotope-labelled P. Biochar was applied to pots filled with 10 kg of soil on a 0.5% w/w basis. All pots received fertilisers to ensure plants were not nutrient limited as they grew. At 40-, 80- and 120- days following sowing, pots were leached with deionised water and the leachate measured for total and soluble reactive phosphorus. A sub-sample was preserved for stable-isotope analysis. Following leaching, crop and soil samples were taken and biochar separated from the soil, to measure the total and bioavailable phosphorus in each fraction. Analysis of stable isotope on these samples was also measured to quantify the amount of P released by the biochar and determine the proportions that are lost to leaching, soil fixation or taken up by the crop.

Results and Discussion

The results from the Northern Ireland experiment will be shown here. However, data collection is currently underway, and as yet no results have been generated to provide a discussion.

30. Effectiveness of Mg-modified willow based biochar on phosphorus sorption, plant growth and leachate of perennial ryegrass

Vitsa S.[a*], Jaisi D. [b], Adhikari S.[c] , Ghimere R.[d], Higgins S.[e] , van Midden C.[e] and O'Connell D.[a]

Department of Civil, Structural and Environmental Engineering, Trinity College Dublin, Ireland [a] ; University of Delaware, USA [b]; Auburn University, USA[c]; New Mexico State University [d]; Agri-food and Biosciences Institute, UK[e];
[*]Corresponding author, email: vitsas@tcd.ie

Introduction Phosphorus (P) is an essential and limiting element for plant productivity and soil fertility. However, excessive phosphate-based fertilizers and manures have been applied to promote plant growth, resulting in high P runoff and leaching causing surface water eutrophication (Yan et al., 2020). In addition, high input of inorganic fertilizers leads to soil P immobilization, binding it with soil minerals and reducing bioavailability, with only 20-30% being absorbed by crops, while the rest precipitates in less labile forms (Mat Hassan et al., 2012; Peng et al., 2023). Therefore, it is vital to adopt sustainable and effective agronomic approaches to improve P use efficiency and meet the dynamic needs of plants. Biochar is a carbon-rich material which is used as soil amendment as it mitigates nutrient leaching and improves crop performance. It is also a promising adsorbent due to its large surface area and pore structure. Functionalization of biochar with metal salts results in improved properties and more efficient P adsorption and desorption capacity. Therefore, biochar can be modified Mg^{2+} salts, inducing Mg-P formation on the surface, improving its adsorption capacity and slow P release properties. The aim of this study is to evaluate the effect of Mg-modified biochar on P adsorption, as well as plant growth and leachate in a perennial ryegrass greenhouse experiment.

Methodology Willow-based biochar was produced in a TLUD kiln and post-treated with $MgCl_2.6H_2O$. The adsorption capacity of the pristine and modified biochar was tested in batch adsorption experiments. Three different rates of pristine and Mg-modified biochar (0.5%, 3%, 5% w/w) were applied to perennial rye in a greenhouse experiment. There are 9 treatments replicated 3 times. Pre-sowing soil samples were analysed to determine soil properties. In addition, plant growth will be assessed by measuring plant height and dry weight. Plant analysis will also perform to measure P concentration in shoots and roots, to evaluate P uptake. Three leachate samples (close to the roots, the middle and bottom of the pot) will be taken from each pot to examine P leaching.

Results and discussion The Mg-modified biochar exhibited higher P adsorption capacity of 0.17, 1.6, 8 and 16.5 mg g-1 in solutions of 1, 10, 50, 100 mg PO4-P/L, respectively, compared to pristine biochar (0.02, 0.48, 6.5, 13.6 mg g^{-1}). According to a preliminary experiment, the modified biochar resulted in higher dry weights, as well as higher P concentration in shoots and roots, enhancing P uptake by 48% and 23.9%, respectively, compared to pristine biochar. In a study with perennial rye, it was observed that Mg-modified biochar led to slow and long-term PO_4^{3-} release, promoting plant height and dry weight (He et al., 2022). In this study, P concentration will be also measured in leachate samples to assess the ability of the modified biochar to reduce P losses. The experiment is currently underway and so all results will be discussed in the poster. Mg-modified biochar exhibits dual functions of high P adsorption capacity and slow P release, improving P use efficiency.

Acknowledgements This research is part of a US-Ireland partnership project titled 'Dual-Function Engineered Biochar for excess soil phosphorus sorption with subsequent slow release for cost effective and sustainable crop production'. The project is funded by the Department of Agriculture, Food and the Marine (DAFM-ROI), Department of Agriculture, Environment and Rural Affairs (DAERA – NI) and the National Institute of Food and Agriculture (NIFA – USA).

References

He, Q., et al. 2022. Analysis of the simultaneous adsorption mechanism of ammonium and phosphate on magnesium-modified biochar and the slow release effect of fertiliser. Biochar. 4(1), 25.

Mat Hassan, H., et al. 2012. Growth, P uptake in grain legumes and changes in rhizosphere soil P pools. Biology and Fertility of Soils. 48(2), 151–159.

Peng, Y., et al. 2023. Metal oxide modified biochars for fertile soil management: Effects on soil phosphorus transformation, enzyme activity, microbe community, and plant growth. Environmental Research. 231, 116258.

Yan, X., et al. 2020. Soil Phosphorus Pools, Bioavailability and Environmental Risk in Response to the Phosphorus Supply in the Red Soil of Southern China. International Journal of Environmental Research and Public Health. 17(20), 7384.

31. Effect of liquid-separated dairy manure in a sugar beet rotation with maize and soybean

Wilson, M.L.[a*]

University of Minnesota, USA; *Corresponding author, email: mlw@umn.edu

Introduction

As large dairies (>10,000 cattle) move into western Minnesota, USA, a consistent supply of manure is available that was not historically present. These dairies are using a new technology to separate solids from liquids in the manure, and the impact on nutrient availability in this region's climate and soil types is unknown. Understanding this is particularly important for sugar beet (*Beta vulgaris*) growers in the region due to the effect that late season nitrogen (N) availability in the soil has on the sugar content of their crop (high late season soil nitrate levels typical results in reduced sugar production). Where in the crop rotation (typically soybean-maize-sugarbeet) should this manure be applied to maximize the beneficial properties while minimizing risk?

Methodology

A three-year crop rotation including sugar beet, maize (*Zea mays*), and soybean (*Glycine max* L.) was set up at two locations (west central and northwestern Minnesota, USA) with each crop present each year and then rotated accordingly in subsequent years. Two rates of liquid separated dairy manure from a nearby commercial dairy were applied in the first year (in the fall prior to planting of each crop) and compared with standard synthetic fertilizer-only practices (fertilizers were applied each spring prior to planting). The two manure application rates were approximately 140,309 l ha^{-1} (Manure high rate - supplied about 218 kg first-year available N ha^{-1}) or approximately 93,540 l ha^{-1} (Manure low rate - supplied approximately 168 kg first-year available N ha^{-1}). If additional fertilizer was needed to meet crop needs, it was applied in the spring prior to planting. In following years, only fertilizer was applied according to soil test phosphorus (P) and potassium (K) levels or state N guidelines (considering manure N credits if applicable) for each crop. At the end of each growing season, each crop was taken to harvest and evaluated for yield. Sugar beet was also evaluated for sugar content and quality.

Results and discussion

The manured treatments typically resulted in similar or higher yields than synthetic-fertilizer-only for corn and sugar beet during all three years of the rotation. For soybean, yields were significantly decreased by manure application at one site in the first year and generally unaffected at the second site. In the second and third years, there were no differences in soybean yield across nutrient treatments.

Acknowledgements

Funding provided by the Sugarbeet Research and Education Board of Minnesota and North Dakota, USA.

32. Accounting for legacy fertilizer values in soils long-term receiving animal manures for 4R nutrient management

Zhang, T.Q.[a*], Wang, Y.T.[a] & Xu, S.W.[b]

Harrow Research and Development Centre, Agriculture and Agri-Food Canada, Canada[a]; Molden Research and Development Centre, Agriculture and Agri-Food Canada, Canada[b]; *Corresponding author, email: Tiequan,Zhang@agr.gc.ca

Introduction

Cropping systems receiving manure applications have different fertilizer requirements than those with commercial chemical fertilizer (CCF) applications alone. As a result, current 4R practices developed under field conditions where CCF were applied only often cause fertilizer to be applied in excess of crop needs in manured cropping systems. This would lead to decreased farming profitability and meanwhile increase adverse environmental impact. This study, therefore, aimed to quantify the impact of long-term manure application history on 4R fertilizer management, in comparison with cropping systems with CCF application history.

Methodology

Three bulk soil samples (i.e. $soil_{pig}$, $soil_{cattle}$, and $soil_{CCF}$) were collected from three adjacent field sites (a clay loam, a corn-soybean rotation), which had previously received pig manure, cattle manure, and CCF applications, respectively, for over 10 years. They were then used to determine crop responses (e.g. yields, nutrient uptake and removal) under four different CCF N application rates in the greenhouse.

Results and discussion

Three tested soils had different crop response curves under different CCF application rates. When no N fertilizer was applied, both $soil_{pig}$ and $soil_{cattle}$ produced 32.7% and 13.4% higher crop yields, respectively, compared the soil previously receiving CCF. Such yield increases were obviously caused by residual effect of previous long-term manure applications. Based on the yield response curves, residual fertilizer N values varied with manure types applied. After long-term manure applications, $soil_{pig}$ and $soil_{cattle}$ had residual N of 121 and 39.5 kg N ha^{-1}, respectively, compared with $soil_{CCF}$, which were directly available for crop uptake. Using winter wheat as test crop, Suarez-Tapia et al. (2018) had similar results that long-term cattle slurry applications contributed to residual N of 36 kg ha^{-1} in the year following the manure cessation. Our results also showed that long-term pig and cattle manure applications increased crop yield potential by 19.1% and 9.1%, respectively, which may have been caused by improved soil health due to the addition of organic matter. In our study, the maximum yield of $soil_{pig}$ and $soil_{cattle}$ were up to 37.4 and 34.3 g per pot, respectively, while it was only 31.4 g per pot for the soil previously receiving CCF. The fertilizer application rates of $soil_{pig}$ and $soil_{cattle}$ at maximum crop yields were 219 and 172 kg N ha^{-1}, respectively, in comparison to 213 kg N ha^{-1} with $soil_{CCF}$.

Conclusion

Over 10-yr pig and cattle manure applications contributed to 39.5-121 kg residual N per hectare, which were directly available for crop uptake. Meanwhile, manure applications also increased crop yield potential by 9.1-19.1% in our study. In $soil_{pig}$ and $soil_{cattle}$, the fertilizer application rates at maximum yields were 219 and 172 kg N ha^{-1}, respectively, while it was 213 kg N ha^{-1} with $soil_{CCF}$.

Acknowledgements

Research funding from SCAP-Swine Cluster and Grain Farmers of Ontario is acknowledged.

References

Suarez-Tapia, A., et al. 2018. Residual N effect of long-term applications of cattle slurry using winter wheat as test crop. Field Crops Res. 221, 257–264.

33. Soil properties and crop growth as affected by co-application of biochar and paper mill biosolids

Ziadi, N.*, Gagnon, B. & Manirakiza, E.

Quebec Research and Development Centre, Agriculture and Agri-Food Canada, 2560, Hochelaga Blvd, Quebec City, Quebec, Canada, G1V 2J3
*Corresponding author, email: noura.ziadi@agr.gc.ca

Introduction

The use of biochar, a recalcitrant carbon-rich pyrolysis product, as a soil amendment is gaining interest due to its potential to mitigate climate change and reduce greenhouse gas emissions. Paper mill biosolids (PB), on the other hand, present interesting opportunities to be used in agriculture. Indeed, both products can improve soil fertility and crop growth and their benefits are well known when applied separately. Their co-application, however, has been little investigated, especially under field conditions and consequently further studies are needed. The objectives of this study were to assess the effect of biochar co-applied with PB on soil properties, especially soil C, N and P contents, and on crop growth including yields and nutrient concentration. The residual effect of this co-application was also investigated.

Methodology

A field study was initiated in 2018 on a site located at the Research Farm of Agriculture and Agri-Food Canada, near Quebec city, Canada. The soil, an imperfectly drained, was a Chaloupe loam with 353 g sand and 162 g clay kg^{-1} dry soil. A randomized complete block design with four replicates and seven treatments was used: i) wood biochar at 10 and 20 Mg dry wt. ha^{-1}; ii) PB at 12 Mg dry wt. ha^{-1}; iii) wood biochar at 10 and 20 Mg dry ha^{-1} co-applied with 12 Mg dry PB ha^{-1}; iv) mineral NP fertilizers only; and v) unamended control. Field crops consisted of a rotation of grain corn-soybean spring wheat. The different amendments were manually applied at the beginning of experiment, before corn planting, and incorporated at 10-cm depth with a rotary tiller. From 2018 to 2023, crop yield, nutrient concentrations as well as soil properties were evaluated.

Results and discussion

Our results indicated that the co-application of biochar and PB decreased corn yield by 1.0 Mg ha^{-1} compared with biochar or PB applied alone in the year of application, but these amendments did not affect soybean yields. In the following year (2019), the previous biochar addition increased soybean yield by 0.6 Mg ha^{-1} but had little effect on corn. Previous biochar addition alone or in combination with PB also increased wheat yield in the third year but not thereafter. For all the years, biochar addition induced a large increase in soil Mehlich-3 P. However, soil NO_3-N availability was reduced by the combined application. Despite an addition of 4.5 Mg organic C ha^{-1} for the combined application of PB and biochar, only a tendency effect ($p= 0.10$) was detected on soil total C and N throughout the study.

34. Municipal waste management through decentralised composting: advantages and limitations of these emerging composting models

Álvarez-Alonso, C.[a*], Pérez-Murcia, M.D.[a], Manrique, N.[a], Martínez-Sabater, E.[a], García-Rández, A.[a], Gómez, C.[a], Orden, L[a], Agulló, E.[a], Irigoien, I.[b], López, M.[c], Andreu, J.[a], Paredes, C.[a], Pérez-Espinosa, A.[a], Moral, R.[a] & Bustamante, M.A.[a]

CIAGRO-UMH, Universidad Miguel Hernández, EPS-Orihuela, Ctra. Beniel Km 3.2, 03312 Orihuela, Alicante (Spain)[a]; Dpto. de Agronomía, Biotecnología y Alimentación UPNA- Universidad Pública de Navarra, 31006, Pamplona, Navarra (Spain)[b]; Dept. d'Enginyeria Agroalimentària i Biotecnologia (DEAB), Escola Superior d'Agricultura de Barcelona. Universitat Politècnica de Catalunya (UPC). Esteve Terradas, 8, 08860, Castelldefels, Barcelona (Spain)[c]; *Corresponding author, email: cristina.alvareza@umh.es

Introduction

Circular economy in the context of municipal organic waste management has favoured the emergence of novel composting models, such as community composting and decentralised urban composting in small installations. These models facilitate the localized management and valorisation of organic waste streams, thereby addressing the challenges posed by conventional centralised composting installations. Nevertheless, the absence of standardisation and the lack of monitoring of the process and of the end-product obtained can potentially compromise human health and the environment. This study is based on a comprehensive analysis of four composting scenarios from these decentralised management models

Methodology

Four composting processes (two from the community composting model and two from decentralised composting facilities), using as raw materials the organic fraction of separately collected municipal waste together with urban pruning waste, were assessed during three composting cycles. The thermal profile and humidity were monitored during the processes and in each composting scenario and process cycle, four samples were collected at the different composting stages (initial, thermophilic, final bio-oxidative and maturity) and characterised physico-chemically, chemically and biologically.

Results and discussion

Both models showed a good development of the composting process, reaching thermophilic temperatures from the beginning, which ensures compost sanitisation (Bustamante et al., 2012). However, community composting required greater control of the process to ensure the thermophilic stage than decentralised urban composting plants, which showed a more standardized process. Concerning compost quality, the composts obtained from both models showed a good degree of maturity and stability, with absence of phytotoxicity and pathogens, and an optimal fertilising capacity for their agricultural use (Naher et al., 2018). However, the pathogen recontamination in community composting and the presence of inert materials in the decentralised plants were the main limitations observed in these composting scenarios, which can be avoided with a good control of the process and of the input materials.

Conclusion

The utilisation of sustainable organic waste management methodologies, such as decentralised urban composting and community composting, ensure environmental benefits within a circular economy framework. These management models not only allow the management of urban organic waste streams, but also the obtaining of high-quality, mature and stable composts with favourable agronomic characteristics, thereby guaranteeing their use in agriculture and reducing the consumption of inorganic fertilizers. Nevertheless, it is imperative to monitor the process and the raw materials used, as well as to characterise the final compost to avoid potential risks to human health and the environment.

Acknowledgements

This research has been financed in the framework of the research project NEOCOMP (ref. PID2020-113228RB-I00) funded by MCIN/ AEI /10.13039/501100011033 and was supported by the Spanish Ministry of Science and Innovation via pre-doctoral contract to the first author (FPU21/01207). The authors also wish to thank the Consorcio de Residuos V5-COR and JoseneaBio S.L.U. and Pallars Jussa Composting Plants for their participation in this study.

References

Bustamante, M.A., Restrepo, A.P., Alburquerque, J.A., Pérez-Murcia, M.D., Paredes, C., Moral, R., Bernal, M.P., 2012. Recycling of anaerobic digestates by composting: effect of the bulking agent used. J. Clean. Prod., 47: pp. 61-69.

35. Effects of recovered P fertilisers from sewage sludge and P solubilizing bacteria inoculation on a *Lactuca sativa* crop

Valverde-Vozmediano, L.[a*], Martínez-Sabater, E.[a], Bustamante, M.A.[a], Sánchez-Méndez, S.[a], Pérez-Murcia, M.D.[a], Álvarez-Alonso, C.[a], Andreu, J.[a], Orden, L[a] & Moral, R.[a]

CIAGRO-UMH, Universidad Miguel Hernández, EPS-Orihuela, Ctra. Beniel Km 3.2, 03312 Orihuela, Alicante (Spain)[a]

[*]Corresponding author, email: l.valverde@umh.es

Introduction

Phosphorus is an essential nutrient in plant nutrition that currently mainly proceeds from a mineral source: phosphate rock. However, phosphate rock is only highly concentrated in a few countries. This reality makes Europe highly dependent on imports. Additionally, a more efficient and sustainable use of P in soils is necessary. For these reasons, it is essential to find new alternative and sustainable P sources, such those obtained from organic wastes through P recovery processes (Vanotti et al, 2019). Therefore, the main aim of this work was to compare the fertilising potential of P minerals recovered from sewage sludge and other alternative P sources in relation to conventional P fertilisers in a *Lactuca sativa* var. baby leaf crop, also considering the effect of using or not the inoculation of P-solubilizing bacteria.

Methodology

The assay was conducted indoors under controlled production conditions (T 21ºC, moisture 60%, 12h artificial light cycles) in pots with 1500 g of two types of clay-loam soils that only differed in the pH (pH 8.5 and 6.5). The P treatments used were the following: i) inorganic treatments: monoammonic phosphate (MAP), triple superphosphate and phosphate rock (PR); ii) organic treatments: bone mill (BM), commercial struvite (STR) and three P recovered struvite-like minerals obtained from different sewage sludge samples. P treatments were applied at an only dose of 80 kg P_2O_5 ha^{-1}. N was supplemented as urea at a dose of 150 kg ha^{-1}. 1 g (on a dry matter basis) of compost was added to the pots to benefit bacterial growth. Treatment application took place at day 0 prior to the plantation of the seedlings. The treatments were evaluated in triplicate. After obtaining cell biomass of the P-solubilizing bacteria through the microorganism culture (10^6 UFC/g fresh soil), it was inoculated in the soil through the irrigation water at day 10 after plantation. Plant harvest were conducted when plant reached the commercial size, at day 50. After this, a second growing cycle was performed planting new lettuce seedlings into the same soils resultant from the first growing cycle without any new treatment application, in duplicate. During both growing cycles, the chlorophyll content and the green cover factor were measured non-destructively each 15 days. At harvest, yield was assessed and tissue total P content was determined colorimetrically after nitric-perchloric digestion, while soil available P was determined using the Olsen method (Vico et al., 2020).

Results and discussion

For the first cycle of the study, plants grown at soil of pH 8.5 performed better in terms of yield (expressed as grams of fresh biomass) than plants grown at soil of pH 6.5. At both pH conditions the 3 P recovered minerals, inorganic MAP and STR showed the best yield results. In this cycle, no significant differences were found between inoculated and non-inoculated plants. At the end of the second cycle, BM and PR treated plants grown at soil of pH 6.5 had the best yield results. For all treatments, inoculated plants had better yield results than non-inoculated plants.

Conclusion

The results obtained have shown that at both pH soil conditions the P fertilisers recovered from sewage sludge showed the best results concerning plant yield, similar to those obtained with commercial mineral fertilisers, such as commercial struvite and monoammonic phosphate, which indicates the viability of these sustainable P sources for the crop production of lettuce. Moreover, the beneficial effects of inoculation with P-solubilizing bacteria were not observed in both cycle, which could due to the high dependence of the microbial activity on the plant and soil growing conditions.

Acknowledgements

This work has been developed with funds from the FERTILAB Project (PLEC2022-009252) financed by the Science Ministry from the Spanish Government MICIU/AEI/10.13039/501100011033 and the European Union, Next Generation EU/PRTR.

References

Vanotti, M.B., Szogi, A.A., Moral, R. 2019. Extraction of amino acids and phosphorus from biological materials using sugars (acid precursors). US Patent Application SN 16/406,707. US Patent & Trademark Office.

36. Pyrolysis and hydrothermal carbonization of digestate solids effects on product characteristics, soil nitrogen dynamics and carbon mineralisation

Pantelopoulos, A.[a*], Sindhøj, E.[b], Valetska, O.[a], Herrmann, A.[a], Aronsson, H.[a]

Department of Soil and Environment, Swedish University of Agricultural Sciences, Sweden[a]; Department of Agriculture and Food, RISE Research Institutes of Sweden, Sweden[b]; [*]Corresponding author, email: athanasios.pantelopoulos@slu.se

Introduction

Treatment of the solid fraction of digestate is typically necessary to enhance its transportability over long distances and reduce potential environmental risks associated with its use. The adopted cascade of treatments for the solid digestate can significantly affect the composition of the final products and alter their potential to act as organic fertilizers. The aim of this study was to evaluate the effect of pyrolysis and hydrothermal carbonization on the characteristics of the derived chars and evaluate the carbon mineralization and net nitrogen (N) release potential of the products as well as their respective effects on soil microbial community composition.

Methodology

Inorganic N release dynamics and carbon dioxide (CO_2) emissions from digestate solids and derived chars were evaluated in an aerobic incubation using sandy loam soil. Centrifuge-separated solids (CS) were pyrolyzed under oxygen-limited conditions at either 400°C or 550°C, yielding two distinct biochars, namely, BCS400 and BCS550, respectively. Hydrochar (HCS) was produced from CS through hydrothermal carbonization at 200°C for 60 minutes. All solid treatments were applied to pre-incubated soil at a 1% rate (dry weight basis) either alone (No-N) or combined with mineral N fertilizer (Min-N, as NH_4NO_3, equivalent to 200 kg N ha^{-1}) or liquid digestate (Org-N, equivalent to 200 kg N ha^{-1}). All treatments were triplicated and replicated eight times to allow destructive sampling for assessing soil inorganic N content, pH, P-AL, and dissolved organic carbon. Soil mixtures were maintained in the dark at 20°C under stable moisture conditions (60% of the soil's water holding capacity). For each N addition scenario, net mineral N release was calculated by subtracting the inorganic N content of the respective control soil and normalizing by the total N applied with the treatments. Carbon mineralization was expressed as the difference in CO_2-C emissions between each treatment and its corresponding control, as a percentage of the total C applied. Treatment-induced changes in the soil's microbial community composition were assessed through phospholipid fatty acid (PLFA) analysis. Heat dissipation from the soil treatments was measured using an isothermal calorimeter (TAM Air) during the initial 42-hour period.

Results and discussion

Pyrolysis decreased the total N content in the derived biochars as the operating temperature increased, leading to a mean total N decrease of 3% in BCS400 and 24% in BCS550 compared to the untreated solids. Similarly, HCS showed a 21% reduction in total N content compared to the raw counterparts. The total carbon content of the products peaked in HCS, which exhibited a 6.3% up-concentration compared to CS, followed by BCS400 with a 3.2% increase in C, while BCS550 showed a 2.7% C loss. The H/C and O/C ratios differed significantly among the chars, decreasing in the order HCS > BCS400 > BCS550. There was a net N release in the untreated digestate solids, with an average of 19% of the total soil-applied N present in inorganic form by day 180 of the incubation, across all N addition scenarios. For the HCS and the biochars, N was immobilized. In the No-N addition scenario, 13.3%, 5.5%, and 2.8% of the total N applied was immobilized in HCS, BCS550, and BCS400, respectively. In general, across N fertilization scenarios, the magnitude of net N immobilization decreased in the order No-N > Min-N > Org-N, for all treatments. Cumulative CO_2-C emissions, within each N fertilization case, decreased in the order HCS>CS > BCS400 > BCS550. Increased N availability promoted CO_2-C emissions from each biochar treatment, with the highest respective emissions demonstrated at the Org-N case, while no significant effect of N addition was evident for the untreated solids and the hydrochar treatments. Soil heat dissipation was highest in the HCS and BCS400 treatments, across all N fertilization scenarios, while BCS550 showed consistently the lowest respective values.

Conclusion

The study demonstrates the low potential of the solid digestate derived products (HCS, BCS550 and BCS400) to release N to the soil solution, compared to the untreated solids. Biochars application might contribute to sustaining soil organic carbon levels due to their low C mineralization. However, hydrochar application to soil should be planned to avoid overlapping plant growth with the extensive N immobilization induced by the treatment. The effects of the treatments on soil microbial community composition will be presented at the conference.

37. U.S. Manure Nutrient Trends (2012-2022)

Bohl Bormann, N.L..[a*], Wilson, M.L.[a] , Cortus, E.L. [a], Janni, K.A. [a], Silverstein, K.A.T.[a] & Gunderson, L.M.[b]

University of Minnesota, USA[a]; Minnesota Department of Agriculture, USA[b]; *Corresponding author, email: nlbb@umn.edu

Introduction

ManureDB, a United States (U.S.) manure nutrient database developed by the University of Minnesota, contained over 400,000 samples across 1998-2023 by 2024. The goal was to examine if concentrations of nitrogen (N), phosphorus (P_2O_5), potassium (K_2O), and total N component, ammonium-N (NH_4-N) had significant trends over the years 2012-2022. Understanding trends in manure characteristics can help farmer benchmarking, modelling, and manure management planning.

Methodology

Eight animal manure categories within ManureDB were selected to represent high value livestock and poultry commodities for 2012-2022. For these manure selections (i.e., beef solid, chicken-broiler solid, chicken-layer solid, dairy solid, turkey solid, beef liquid, dairy liquid, and swine liquid) there was no housing, bedding, treatment, or life stage differentiation (Bohl Bormann, 2023; Bohl Bormann, 2024). This review focused on the nutrients of N, P_2O_5, K_2O, and the total NH_4-N. The U.S. was divided into regions based on U.S. Climate Hubs. Only regions with at least 500 total samples total and samples each year were included. Only the Southeast (SE), Midwest (MW), and Northeast (NE) regions met those parameters. The non-parametric Mann-Kendall trend test was used using the 'MannKendall' function in R (McLeod, 2022; R Core Team, 2023). For each animal manure category, region, and analyte combination a test statistic and 2-sided p-values were calculated resulting in either an increasing, decreasing, or no significant trend.

Results and discussion

The solid manures had significant nutrient increasing or decreasing trends 25% of the time and the liquid manures had significant nutrient trends 18% of the time for all the region-animal manure categories spanning 2012-2022. The only significant trend for beef solid manure was a decreasing trend in the SE region for NH_4-N. Both the Chicken-Broiler SE and NE regions had significant decreases in NH_4-N, and only the SE had an increasing trend for K_2O. The SE region for Chicken-Layer had decreasing trends for NH_4-N, P_2O_5, and K_2O. For dairy solid manure, the MW region only had a decreasing trend for P_2O_5, while the NE region had decreasing trends for N and NH_4-N. Turkey solid manure only had significant trends for P_2O_5, with the MW increasing and the SE decreasing. Beef liquid manure had no significant trends. For dairy liquid manure, only the NE region had significant decreasing trends for all four nutrients. For swine liquid manure, only the SE region had significant increasing trends for NH_4-N.

Conclusion

With over 325,000 samples, ManureDB offered a robust look into modern livestock manure nutrient concentrations across the U.S and analyte trends. Standardizing nomenclature and adding more sample metadata will improve ManureDB's dataset functionality. Including species, life stage, manure storage type, treatment, and bedding information will aid in manure characteristic comparisons. As ManureDB grows, manure nutrient trends can be used for better nutrient management plans and policy needs that consider these trends.

Acknowledgements

U.S. Department of Agriculture (USDA) NIFA Award 2020-67021-32465 and Cooperative Ecosystem Studies Unit program [grant no. NR253A750008C001] from the USDA — Natural Resources Conservation Service

References

Bohl Bormann, N.L., Wilson, M.L., Cortus, E.L, Silverstein, K., Janni, K., and Gunderson, L., 2023. ManureDB, 1998-2023 cumulative file. University of Minnesota. http://manuredb.umn.edu/ Accessed: 2025-02-10.

Bohl Bormann, N.L., Wilson, M.L., Cortus, E.L, Silverstein, K., Janni, K., and Gunderson, L., 2024. R Code, Data, and Output Supporting: Nutrient Data from U.S. Manure Systems. Retrieved from the Data Repository for the University of Minnesota (DRUM), https://doi.org/10.13020/sce9-s034

McLeod, A. I., 2022. Kendall: Kendall Rank Correlation and Mann-Kendall Trend Test (2.2.1) [Computer software]. https://cran.r-project.org/web/packages/Kendall/index.html

R Core Team, 2023. R: A language and environment for statistical computing (4.3.2) [Computer software]. R Foundation for Statistical Computing. https://www.R-project.org/

38. Biothermal treatments applied to beer bagasse: composting and vermicomposting

Palenzuela, M.V.[a*], Molina, E.[a] Sánchez, F.[b]; Ramos, V.[c], Ramos, E.[a], De la Torre, M.J.[a]; Gutiérrez, J.C.[a], Peinado, R.[b]; Rosal, A.[a*]

[a]Molecular Biology and Biochemical Engineering Department. Pablo de Olavide University. Seville, Spain. [b]Agricultural Chemistry, Soil Science and Microbiology Departament. University of Cordoba. Campus of Rabanales, Córdoba, Spain. [c] Fat Institute, Higher Center for Scientific Research. Seville, Spain; *Corresponding author, mvpalrui@po.es

Introduction

Spain is the second largest beer producer in Europe with 37.5 million hectolitres per year. This represents around 2.2 million tonnes of bagasse waste per year, most of which is currently used as livestock feed, although other recovery options are beginning to gain momentum [1]. Among them, composting and vermicomposting processes represent an effective alternative for organic waste management, thus avoiding landfill. The physicochemical characteristics of bagasse do not allow its direct treatment by these methods, and it is necessary to initially provide some kind of structuring agent, which allows increasing the porosity and improving the C/N ratio, among other variables [2]. In the present work, two pilot-scale processes have been studied, composting and vermicomposting, with a mixture of bagasse and wheat straw, in order to compare the quality of both systems and the potential of the products for subsequent agricultural valorisation.

Methodology

Two experiments were designed, one for composting and the other for vermicomposting, with mixtures of bagasse and wheat straw in the mass ratio 4:1 (d. m.), respectively. The bagasse residue was supplied by BEER&DREAMS CO. of Seville and the straw by a private farm, located in the municipality of Dos Hermanas (Seville). The composting was carried out in a trapezoidal windrow (h= 1.5 m, volume around 3 m3), which was turned and watered weekly, thus achieving an average moisture content of around 55% in the process. In the case of vermicomposting, this was carried out in three 44-litre PVC boxes. In each of the boxes, 3 kg (30% humidity) of bagasse-straw mixture from the pile with 21 days of pre-composting, and 100 adult earthworms (clitellated) of the *Eisenia foetida* species from the research group's own breeding farm, were placed. Both trials were terminated 84 days after the start of the composting treatment. Physicochemical, biological and microbiological parameters that are usually used as control variables were analysed and, in addition, the quality of the products was evaluated based on the analysis of parameters required by Spanish legislation (RD 506/2013). To evaluate the significant difference in the average values of each parameter during composting and vermicomposting, ANOVA analysis of variance and LSD test for $p<0.05$ were used.

Results and discussion

At the operating conditions studied, in composting, thermophilic temperatures were reached for more than 4 weeks, conditions considered acceptable for the sanitisation of the material, and in the case of vermicomposting, the pH slightly increased to a value close to neutrality. As for the C/N ratio, although its initial value (16.3) was not in the range considered optimal (20-35), this was not a handicap for being able to reach thermophilic T (>45 ºC) in just three days. Regarding the vermicomposting process, the density of the number of adult worms remained practically constant, with no statistically significant difference. On the other hand, the population density of juveniles increased and peaked at 64 days, as did the population of coconuts. The C/N ratio of compost (8.9) and vermicompost (8.6) were within the range imposed (C/N<20) by legislation (RD 506/2013). The GI analysis of the final products reported values of 81.3% and 95.4% for compost and vermicompost, respectively.

Conclusion

The experimental designs proposed, on a pilot scale, have reproduced the thermal behaviour of these processes on an industrial scale. The quality parameters analysed for compost and vermicompost comply with the limits established by RD 506/2013, and as for the metal content, the concentrations analysed allow them to be classified in category B, which means that both products can be used in agriculture.

Acknowledgements

The authors are grateful for the funding received through the TED2021-129208B-100 Project by MICIU/AEI/10, 13039/501100011033 and by the European Union Next Generation EU/PRTR to FR-R and EMC and for the collaboration of EMASESA for the development of these experiments in its COPERO environmental facilities in Seville.

References

[1] Statista, 2022: https://es.statista.com/estadisticas/476539/produccion-anual-de-cerveza-en-espana/#statisticContainer

[2] Assandri, D.; Pampuro, N.; Zara, G.; Cavallo, E.; Budroni, M. 2021. Suitability of composting process for the disposal and valorization of brewer's spent grain. Agriculture, 11, 2. DOI: https://doi.org/10.3390/agriculture11010002

39. Study on the incorporation of hydrolysed sludge in co-composting processes: the case of EMASESA. (Seville, Spain)

Palenzuela, M.V.[a*], Molina, E.[a] Sánchez, F.[b]; Ramos, V.[c], Gutiérrez, J.C.[a], Ramos, E.[a], De la Torre, M.J.[a]; Peinado, R.[b]; Rosal, A.[a]
[a]Molecular Biology and Biochemical Engineering Department. Pablo de Olavide University. Seville, Spain.
[b]Agricultural Chemistry, Soil Science and Microbiology Departament. University of Cordoba. Campus of Rabanales, Córdoba, Spain. [c]Fat Institute, Higher Center for Scientific Research. Seville, Spain.
*Corresponding author, email:mvpalrui@upo.es

Introduction

Sewage sludge is the main waste produced in urban wastewater treatment plants. In Spain, around 1.2 million tonnes are generated per year (in dry matter) [1]. WWTPs, producers of this urban waste, must ensure its correct management, its main destination being: incineration with energy recovery, soil bioremediation and agricultural application. Among the different treatment options, thermal hydrolysis is only analysed as a measure to increase the performance of subsequent anaerobic digestion and the final digestate is normally fed into the agricultural soil, with the consequent problems of bad odours, instability of the material and potential pollutants in terms of emerging organic compounds. There is hardly any literature on composting processes with this type of hydrolysed waste. In this study, the effect of incorporating sludge treated by a combination of thermal hydrolysis/anaerobic digestion into co-composting processes with unhydrolysed sludge and urban pruning, of industrial interest of the Empresa Municipal de Aguas S.A. (EMASESA) of Seville (Spain), is analysed.

Methodology

The sludge was provided by EMASESA and the experimental trials were designed in its environmental composting facilities. Five semi-industrial scale experiments were designed, with mixtures at different proportions of sludge from anaerobic digestion (L1), sludge from combined thermal hydrolysis/anaerobic digestion (L2) and urban pruning (P) as a structuring agent. The volumetric ratios L1:L2:P were 1:0:1 (P1), 0:1:1:1 (P2) 0.75:0.25:1 (P3); 0.5:0.5:1 (P4) and 0.25:0.75:1 (P5). All piles were composted using a trapezoidal pile system (h=1.5 m and Volume= 8 m^3) with turning by mechanical shovel. The frequency of turning and irrigation was weekly during the first month and, subsequently, aeration and humidification were carried out every two weeks until the end of the process (115 days). Five samplings were carried out, at the beginning of the process, at 18, 52, 94 and 115 days. The quality of the processes and products was analysed on the basis of physicochemical, biological and microbiological parameters, according to the methodology required or recommended in Spanish legislation (RD 506/2013) or that used by centres of recognised prestige. The differences between the results obtained for each treatment were tested by one-way ANOVA for $p<0.05$. The data on organic matter losses during the processes were fitted to a kinetic function, using the Marquardt-Levenberg algorithm.

Results and discussion

The results have shown that the volumetric proportions of sludge and pruning used for each pile and the frequency applied for turning and watering have allowed reaching T>40°C after two weeks of composting, being the case of the P5 pile the one that has presented the highest exothermic index (EXI2=101.449oC2), followed by P2 (EXI2=88.388oC2). On the other hand, the reduction in the percentage of organic matter was greater in P5 (23.4 percentage points) while P2 showed the least reduction in this percentage (14.3 points). Precisely, in the case of P5, with a higher L2/L1 ratio than the rest, it presented the highest exothermic ratio (EXI2/FB = 1845). In all cases, the C/N ratio analysed in the compost was lower than that determined at the beginning of the process, typical of organic matter degradation, and the values were lower than 16, with the compost from the P5 trial having the lowest ratio (13.1). The results obtained in terms of OM, C/N ratio, *E. coli*, and *Salmonella spp* comply with the requirements of Spanish regulations (RD 506/2013), except for those obtained in trials P3 and P4, with respect to pathogen content. Regarding the GI, the compost from trial P2 (91.0%) was higher than the rest, which was around 80%, with no significant differences between the compost from trials P1, P3, P4 and P5. Finally, regarding the metal content (Cd, Cr VI, Cr, Cu, Pb, Zn, Ni, Hg), the compost from trial P1 presented concentrations that allowed it to be classified in B category, while the rest in C category according to RD 506/2013.

Conclusion

At the operating conditions imposed, all the experiments designed have allowed the development of processes in which thermophilic T has been achieved. The results showed that the hydrolysed sludge presented a significant microbiological activity, despite its combined treatment of thermal hydrolysis and anaerobic digestion, making it advisable to compost it before direct application. In all case studies, the compost has met the physicochemical and microbiological parameters required by legislation, except in the case of P3 and P4. The degradation kinetics was higher in the case of the P5 pile.

Acknowledgements

The authors are grateful for the funding received through the TED2021-129208B-100 Project by MICIU/AEI/10, 13039/501100011033 and by the European Union Next Generation EU/PRTR to FR-R and EMC and for the collaboration of EMASESA for the development of these experiments in its COPERO environmental facilities in Seville.

References

1. Ministerio para la Transición Ecológica y el Reto Demográfico (MITECO). Lodos de Depuración de Aguas Residuales. https://www.miteco.gob.es/es/calidad-y-evaluacion-ambiental/temas/prevencion-y-gestion-residuos/flujos/lodosdepuradora.html

40. Characterization of pig slurry by productive category in Galicia (Spain)

Besteiro, R.[a], Báez Bernal, M.D.[a], García Pomar, M.I.[*a], Castro Ínsua, J.F.[a] & Pereira, D.[b]

Centro de Investigacións Agrarias de Mabegondo - AGACAL, Spain[a]; Asociación Galega de Produtores de Porcino[b], Spain; [*]Corresponding author, email: dolores.baez.bernal@xunta.gal

Introduction

In terms of meat production, pig farming is the third most important sector in Galicia (NW Spain). The slurry generated in the production process is relevant for other sectors, as it is one of the sources of organic fertilizers for grasslands and forage crops of dairy farms. Knowing the composition of this slurry is not only a legal requirement but also essential to achieve efficient and environmentally sustainable management during its agronomic valorization.

Methodology

In 2024, 210 slurry samples were collected from as many pig farms according to the productive category: fattening (FT: 148), weaned piglets from 6 to 20 kg (WP: 7), mixed-cycle farms (MC: 19), farrowing to finishing farms (FF: 7), sows with piglets up to 6 kg (S6: 10), and sows with piglets up to 20 kg (S20: 19). Samples were analyzed to obtain values of % dry matter (DM) by gravimetry; Ca, Mg, P, and K content in g kg^{-1} of DM using the ICP-AES technique, total N in g kg^{-1} of DM by distillation, and pH by potentiometry. Mixed linear models with a "gamma" distribution and a logarithmic link were used for testing the influence of the farm type, except for pH, where a "Gaussian" distribution with an exponential transformation of the response variable was used. The random effect used was the person responsible for sample collection. The inclusion of the fixed effect "sampling season" was also tested.

Results and discussion

Farm type is able to explain only between 3% and 18% of the total variability of the samples for the different variables. The sampling season had no effect on the analyzed values, although it had some, non-significant, on the N content. Dry matter proportion in the slurry was lower for the S6 and S20 slurries (1.35% and 1.83%) compared to the FT and WP farms (4.53% and 7.75%), while the MC and FF farms had intermediate values (3.42% and 3.79%). The N content was lower in the WP and FT categories (72.1 and 99.8 g kg^{-1}) and higher in S6 (163.g kg^{-1}). The highest P values were recorded in the MC (25.6 g kg^{-1}) and S20 (26.4 g kg^{-1}) categories, while the lowest values were found in the WP and FT categories (16.4 and 19.1 g kg^{-1}), which were significantly lower than those in S20. Regarding K content, the S6 and S20 categories had the highest values (92.8 and 70.7 g kg^{-1}), and WP and FT had the lowest (41.5 and 51.8 g kg^{-1}), although statistically there were no differences between any of the groups due to the high variability in the results. For Mg, the category had no influence on the average value (13 g kg^{-1}), while for Ca, the MC and S20 categories had the highest values (37.15 and 39.8 g kg^{-1}), with WP having the lowest values (18.1 g kg^{-1}). pH values were very similar, with the WP slurry (6.9) being significantly lower, followed by FT (7.6), MC (7.8), FF and S20 (7.9), and S6 (8.0).

Described values are consistent with those reported by Fernández (2023) in the same region, although with a much smaller sample size. He reported higher MS values and lower levels of N, K, Mg and Ca. These values are also consistent with those described in our unpublished previous works. The MS content for FT was lower than the 9% described by Parera et al. (2019) in Catalonia, with lower N and K content (71.7 and 46 g kg^{-1}) and similar P content (21 g kg^{-1}) compared to what are reported here. Considering that the amount of N and P excreted per animal per year will be similar across the production systems of both regions, the relationship between higher MS and lower N makes sense.

Conclusion

The slurries from the WP and FT categories had the highest MS values, the lowest N, P and K content values and slightly lower pH values when compared to the slurries from S6 or S20. In most of the analyzed variables, the MC and FF slurries presented intermediate values. Season had no influence on the average values. Characterization of pig slurry in Galicia according to production category represents a significant step forward in implementation of management and fertilization plans for slurry, adjusting application rates to the needs of crops and increasing nutrient use efficiency.

References

Fernández, M. 2023. Gestión agronómica y ambiental de purines de cerdo. Tratamientos en fosa y digestión anaerobia. Diss. Universidade de Santiago de Compostela.

Parera, J., et al. 2019. Cuantificación y caracterización de purines porcinos en explotaciones de engorde. In: XVIII Jornadas sobre Producción Animal, Zaragoza, pp. 54-56.

41. Advancements in biogas digestate management: Multi-step separation for nutrient recovery and environmental sustainability

Ghorbani, M.* & Møller, H. B.

Department of Biological and Chemical Engineering, Aarhus University, Blichers Allé 20, 8830 Tjele, Denmark; *Corresponding author, email: m.ghorbani@bce.au.dk

Introduction

The European Commission aims to boost biomethane production via anaerobic digestion (AD) to 35 billion cubic meters by 2030, posing challenges in managing digestate byproducts (Carraro et al., 2024). Direct field application of digestate risks spreading pathogens and diseases. Denmark alone produces 15.8 million metric tons of digestate annually, mainly from manure (EBA, 2024) whereas most of it is applied without further treatment. Separating solid and liquid fractions is essential for efficient resource use, reducing transport costs, and enhancing nutrient recovery. This study analyzes the physicochemical and rheological properties of digestate fractions from a three-step separation process involving a screw press (SP), decanter (DC), and centrifuge (CF) and explores their applications in sustainable agriculture.

Methodology

Untreated digestate (UD) from a biogas plant in Foulum, Aarhus, Denmark, was stored and sequentially processed through three separation steps. First, SP with 0.25 mm and 0.5 mm sieves separated the digestate in liquid (SP_L) and solid (SP_S) fractions. Next, the liquid fraction was processed in a DC, yielding a digestate liquid (DC_L) and solid (DC_S) fraction. Finally, the liquid fraction from the DC was centrifuged, producing a mixed liquid-solid (CF_{L+S}) and a final liquid (CF_L) fraction. Samples were analyzed for total solids (TS), volatile solids (VS), elemental composition (ICP-OES), ion chromatography (IC), ammonium nitrogen (NH_4^+-N), CHNS analysis, particle size, and viscosity.

Results and discussion

The study showed a decline in TS from 4.45% in UD to 3.67%, 2.93%, and 2.23% after separation by SP, DC, and CF, respectively. Similarly, VS decreased from 73.92% in UD to 68.86%, 66.92%, and 61.71% following the same separation steps. ICP analysis revealed a decrease in most micro- and macronutrient concentrations in the liquid fractions, except for potassium (K) and sodium (Na), which increased due to their higher solubility in liquid phases. Heavy metals, particularly aluminium (Al), dropped by 69% in the final liquid fraction (CF_L), as most heavy metals were mainly retained in the solid fractions. Chloride ions (Cl^-) increased in the liquid fractions, while phosphate (PO_4^{3-}) and sulfate (SO_4^{2-}) ions were more concentrated in the solids. NH_4^+-N showed no significant differences. Nitrogen (N) increased in the liquid fractions, while C/N and C/H ratios decreased. The separation process reduced the smallest 10% of particles from 5.62 µm in UD to 0.69 µm in CF_L, enriching ultrafine particles. The median size dropped from 77.31 µm to 2.42 µm, and the largest 90% decreased from 594.42 µm to 66.67 µm, confirming the effective removal of coarse particles and boosting the specific surface area by 7.7-fold. Additionally, viscosity results showed that the flow behavior index improved from 0.52 in UD to 1.17 in CF_L, while the consistency coefficient decreased by up to 81-fold, indicating enhanced fluidity.

Conclusion

This study provides valuable data for biogas digestate management and aids practitioners in selecting appropriate separator techniques, enhancing nutrient recovery. Three separator technologies were explored. The solid fractions have potential applications in biochar production, composting, pelletized fertilizers, soil amendment, and re-digestion in AD. The liquid fractions are ideal for biofertilizers, fertigation, hydroponic solutions, and irrigation. Future research should focus on cost-effective, eco-friendly separation technologies and assess the long-term effects of separated products and their environmental impacts.

Acknowledgements

This work was carried out as part of the Danish-funded project GIGA ('Maksimal klima- og gødningseffekt af afgasset biomasse'), supported by the Ministry of Food, Agriculture, and Fisheries of Denmark (GUDP).

References

Carraro, G., et al. 2024. Solid-liquid separation of digestate from biogas plants: A systematic review of the techniques' performance. J. Environ. Manage. 356, 120585.

EBA, 2024. https://www.europeanbiogas.eu/wp-content/uploads/2024/03/Exploring-digestate-contribution-to-health-soils_EBA-Report.pdf.

42. Efficacy of on-farm screw and screen-press slurry separators on the composition of separated liquid and solid cattle slurry fractions

Pinder, AP[a]*, Jones, DL[a], Williams, AP[a], Langley-Randall, J[b], Sagoo, E[b], Thorman, RE[b], Chadwick, DR[a]

Bangor University, UK[a]; ADAS, UK[b]; *Corresponding author, email: a.pinder@bangor.ac.uk

Introduction

Optimising nutrient use efficiency of organic resources is essential for pollution reduction and to reduce dependency on inorganic fertilizers, supporting UK environmental policies including Net-Zero greenhouse gas emissions by 2050. Separating livestock slurry into solid and liquid fractions can enhance management efficiency through reduced storage and transport costs. The process generates a high dry matter (DM), high phosphorus (P), low readily available nitrogen (N) solid fraction, and a low DM, low P, high readily available N liquid fraction. While the liquid fraction's improved soil infiltration can decrease ammonia volatilization and increase N availability, it may result in increased nitrous oxide emissions and nitrate leaching. Frequent slurry applications can also lead to P accumulation in the soil, increasing water pollution risks. This study assessed the effectiveness of on-farm separation in fractionating DM, plant-available N, and P pools in cattle slurry, as part of a broader investigation into the agronomic and environmental impacts of slurry separation.

Methodology

Samples of whole slurry and the separated solid and liquid fractions were collected from 40 commercial cattle farms. Representative samples were collected from the inflow (reception pit) and outflows (liquid and solid fractions) as the separators were running. Samples (1 kg) of the whole slurry, separated liquid and separated solid fractions were then mixed thoroughly and sub-samples were analysed for DM content, pH, NH_4^+, NO_3^-, total N, P, K, S, Mg, Ca, Cu and Zn, by an accredited commercial analytical laboratory (NRM Cawood, Scientific, UK). More detailed P analysis was conducted at Bangor University using a modified Hedley fractionation method (Li et al., 2020), to determine the effect of slurry separation on the different P pools. Background information was gathered from the participating farms, such as their size, slurry management, slurry separator type, and reasons for purchasing the type of slurry separator.

Results and discussion

On the 40 participating farms, 35 used screw-press separators and 5 used screen-press separators, suggesting a current preference for screw-press separators by cattle farmers in the UK. One farm operated both a screw-press and a screen-press separator, hence data will be available to compare separation efficacy with the same dairy cow slurry. Slurry fractions have been obtained from 16 farms to date (10th February 2025) and analyses are ongoing and will be completed by May 2025. The efficacy of slurry separation will be presented in this poster, with a particular focus on the plant available N, DM content and P pools.

Conclusion

The information generated will underpin future advice for farmers. There may be implications for management of the separated solid fraction, should the plant available N content exceed 30%, as has been seen previously in separated solid fractions in pig slurry and digestate. The slurry from some of the commercial cattle farms will be used in field plot-scale experiments in this project to assess the ammonia and greenhouse gas emissions as well as N and P use efficiencies of the separated slurry fractions.

Acknowledgements

This research is supported by the Defra-funded project: Evaluating the agronomic and environmental impacts of slurry and digestate separation.

References

Li, Y., et al. 2020. Acidification and anaerobic digestion change the phosphorus forms and distribution in particle fractions of cattle slurry and phosphorus dynamics in soil after application. Biosyst. Eng. 200, 101-111.

43. Hydrothermal Carbonization of Liquid Dairy Manure: A Sustainable Approach for Phosphorus Recycling via Hydrochar

Islam, Mohammad Nazrul [a], He, Brian [b] & Chen, Lide [a*]

[a] Department of Soil and Water Systems, Twin Falls Research and Extension Center, University of Idaho, Twin Falls, Idaho 83301, USA
[b] Department of Chemical and Biological Engineering, University of Idaho, Moscow, Idaho 83844, USA
*Corresponding author, e-mail: lchen@uidaho.edu

Introduction

Phosphorus (P) is an essential nutrient for agricultural productivity; yet it is a finite resource, and supply will fall short of the rising demand after 2040 (Cordell et al., 2009). To address P depletion, efforts have focused on recycling P from waste sources like sewage sludge and animal manure. In this case, dairy manure, a nutrient-rich byproduct presents both an opportunity and a challenge due to its potential for nutrient runoff and water pollution. Hydrothermal carbonization (HTC) is an emerging thermochemical process that converts organic waste into hydrochar, offering a promising route for P recycling. Therefore, by processing dairy manure through HTC, P can be concentrated in the hydrochar, potentially producing a slow-release fertilizer. This study explored the effect of the combination of HTC temperature and processing time on optimizing P recovery from dairy manure, highlighting its potential as a sustainable strategy for nutrient recycling.

Methodology

Raw liquid dairy manure was collected from a local dairy located in Southern Idaho, USA and used for HTC experiments. The HTC was performed in a batch reactor, purchased from Parr Instruments Company (https://www.parrinst.com/) with an internal working volume of 0.3 L, maximum pressure of 30 MPa and maximum temperature of 350 °C. To evaluate the combined effect of temperature and time, the hydrothermal severity factor (f(T,t)) was used, following methodologies used by other researchers (Spitzer et al. 2023). The total number of 9 different pairs of temperature and reaction time were investigated, ranging from 200-250 °C and 30-90 min, with each condition performed in duplicate. The physiochemical properties of the raw manure and hydrochar, as well as hydrochar yield, P recovery, and P transportation were analysed.

Results and discussion

We observed that hydrochar yield decreased with an increasing HTC temperature and reaction time, dropping from 72.82% at 200°C for 30 min to 47.92% at 250°C for 90 min. This reduction was attributed to the degradation of organic matter under a high temperature and longer reaction time. On the other hand, total P content in hydrochar increased from 6.7 to 11.58 mg P/g with increasing process severity, likely due to several reactions that can occur during HTC, including P precipitation, polymerization, and/or condensation (Martinez et al. 2025). Since the most abundant metal in either raw manure or hydrochar was Ca, P was precipitated in hydrochar primarily as Ca-P compounds. This finding was consistent with P distribution analysis, which showed a decrease in non-apatite inorganic P and increase in formation of more stable apatite P (> 90% of the total P) with increasing process severity. The highest P recovery (~ 95%) was observed at 225 °C for 60 min.

Conclusion

This study demonstrates that HTC is an effective method for P recovery from dairy manure. The process severity significantly influenced hydrochar yield, P recovery and P distribution. The formation of stable apatite P suggest that P in hydrochar could be a promising slow-release fertilizer. These findings highlight that HTC could be a sustainable approach to P recycling, offering both agricultural and environmental benefits by reusing manure P and mitigating P-related water pollution.

Acknowledgements

This work is partially supported by USDA NIFA (award number 2021-67022-35504) and the University of Idaho P3R1 grant.

References

Cordell, D., et al. 2009. The story of Phosphorus: Global Food Security and Food for Thought. Global Environ. Change 19 (2), 292-305.

Spitzer, R.Y., et al. 2023. Hydrothermal carbonization reaction severity as an indicator of human-excreta-derived hydrochar properties and it's combustion. Sci. Total Environ. 872, 162176.

Martinez, C.O., et al. 2025. Influence of temperature and reaction time on nutrient conversion and metal interactions during hydrothermal treatment of pig manure. Sci. Total Environ. 958, 177853.

44. Coagulation/flocculation treatment of pig slurry using tannin- based polymer for subsequent microalgae growth

Escudero- Campos, L. [a], Riaño, B.[b,] Álvarez- Castellanos, M.P.[c] & Muñoz, R.[d]

[a]Kerbest Agrosuit S.L, Av. Juan Carlos I, 30. 05002, Ávila, Spain. (laura.escudero@kerbest.com); [b]Agricultural Technological Institute of Castilla y León (ITACyL). Ctra. Burgos, km. 119.47071, Valladolid, Spain; [c]Center for Analysis of the Natural Environment. Universidad Católica de Ávila. Ávila, C/ Canteros, s/n, 05005, Spain; [e]Institute of sustainable Processes. Paseo Prado de la Magdalena 3-5, 47011. Valladolid, Spain.

Introduction

Spain leads pigmeat production with 24.2% of total EU production (MAPA, 2023). Intensive pig meat production is associated with the management of the slurry (organic waste generated by the animals) produced. After a solid-liquid separation process of the raw slurry, the liquid fraction can be subjected to different treatments to remove organic matter and nutrients. Microalgae represents a low-cost alternative for swine manure treatment while obtaining a valuable biomass. Due to its humic acid and solids content, the slurry is highly coloured, which prevents light from entering and makes dilution with water essential for the development of microalgae biomass. Clarification of the liquid fraction would reduce water use, increasing the sustainability of the process. Inorganic iron and aluminium are the most commonly coagulants/flocculants used for wastewater. However, these inorganic products leave non-biodegradable salt residues after treatment that can have serious consequences for human health (Walton *et al.*, 2013). For this reason, flocculants based on natural plant-derived polymers such as tannins are presented as an alternative due to their high biodegradability and effectiveness (Arismendi *et al*., 2018; Gabriel *et al.,* 2019). The aim of this work was to determine the influence of product doses, agitation rate and sedimentation times on clarification of slurry for the subsequent growth of microalgae.

Methodology

Swine manure was collected from the reception pond of a white layer pig sow farm with a capacity for approximately 3000 animals located in Villanueva de Gómez (Ávila, Spain). The slurry was filter using a ramp filter with a mesh size of 0.270 mm. This slurry had the following characteristics: 1117 mg/L NH_4^+-N, 269.7 mg/Kg P, 6450 (NTU) and 12.2 g/Kg total solids (TS). The tannin-based flocculant-coagulant used was HYGREEN GT25 (Derypol, Spain), a liquid product extracted from *Acacia mearnsi.* To determine the optimal coagulation/flocculation conditions, product doses of 5%, 10%, 15% and 20% (v/v), agitation speeds of 45, 120 and 200 rpm and settling times of 30 minutes, 1 and 2 hours were tested. Turbidity and TS removal efficiencies were determined.

Results and discussion

Among the conditions studied, the highest TS removal was obtained with a Hygreen GT25 doses of 15% (v/v). The turbidity removal, however, was higher for the highest product dose, reaching 98.2% for the 20% (v/v) dose. The optimal stirring speed and time was 15 minutes at 120 rpm and the optimum settling time was 2 hours.

Conclusions

The reduction of turbidity and slurry TS for subsequent microalgae cultivation using tannin-based flocculants without adding water is possible. Further microalgae growth kinetics trials are needed to confirm the feasibility of nutrient and carbon recovery via microalgae cultivation.

Acknowledgements

This work has been co-funded by the Agricultural Technological Institute of Castilla y León through the call 2023, Atracción de Talento. CIRCULARFARMS EXP 7/2023-ATI. NOS IMPULSA, JUNTA DE CASTILLA Y LEÓN.

References

Arismendi, W., *et al* 2018. Modified tannins and their application in wastewater treatment. Water Science and Technology. 78, 115-1128.

Gabriel, M., *et al.*2019 Use of organic coagulant/flocculant for treatment of effluents generated in intensive rearing of swine. Environmental Quality Management. 29, 149-15.

MAPA, 2023. https://www.mapa.gob.es/en/ganaderia/estadisticas/indicadoressectorporcino2023_tcm38-564427.pdf

Walton, J.R., 2013. Aluminum's involvement in the progression of Alzheimer's disease. J. Alzheimer's Dis. 35 (1), 7-43.

45. Growth of autochthonous microalgae in pig effluent after a nitrification - denitrification process: a case study in Castilla y León (Spain).

Escudero- Campos, L. [a], Riaño, B.[b,] Álvarez- Castellanos, M.P.[c], Molinuevo, B.[d] & Muñoz, R.[e]

[a]Kerbest Agrosuit S.L, Av. Juan Carlos I, 30 Esq. C/Paramera. 05002, Ávila, Spain. (laura.escudero@kerbest.com); [b]Agricultural Technological Institute of Castilla y León (ITACyL). Ctra. Burgos, km. 119. Finca Zamadueñas. 47071, Valladolid, Spain; [c]Center for Analysis of the Natural Environment. Universidad Católica de Ávila. Ávila, C/ Canteros, s/n, 05005, Spain; [d]Dept. of Agroforestry Sciences. University of Valladolid. Avenida de Madrid, 57, 34004, Palencia, Spain. [e] Dpt. Chemical Engineering and Environmental Technology. University of Valladolid. Paseo Prado de la Magdalena 3-5, 47011. Valladolid, Spain.

Introduction

Castilla y León is the third most important Spanish region in terms of pig production. The Nitrates Directive (91/676/EEC) (UE, 1991) limits the application of manure as fertilizer to 170 kg N/ha/year in nitrate vulnerable zones, which corresponds to 14,414 km^2 in Castilla y León. In this context, treatment solutions should be implemented to manage the excess of nutrients in intensive livestock production areas. Among those, one of the most commonly used treatments for swine manure is nitrification-denitrification (N-dN). This process allows nitrogen (N) removal in the form of gaseous nitrogen. A post-treatment stage to improve the quality of the effluent after the N-dN process could be the cultivation of microalgae. Microalgae are gaining importance in the context of circular economy as their application to livestock effluents provides simultaneous O_2 production, CO_2 abatement and nutrient recycling through N and phosphorus (P) assimilation (Iniesta- López *et al.,* 2025). The aim of this work was to study the growth kinetics of a bloom of autochthonous microalgae isolated from pig slurry effluent after N-dN treatment and to evaluate their capacity for bioremediation of this effluent.

Methodology

The N-dN effluent was collected from two 140 m^3 reactors operating at a sow farm with a capacity of 3000 animals located in Ávila (Spain). The main characteristics of the N-dN effluent were: pH 7.67; 170 mg N/L ammoniacal nitrogen (NH_4^+-N); 1160 mg/L soluble chemical oxygen demand (sCOD) and 300 mg/L soluble P (P_s). A duplicate test (E1 and E2) was carried out in two 75 L channel reactors each operated under greenhouse conditions with a duration of 25 and 30 d, respectively. The channel reactors were inoculated using a 1:3 dilution (microalgae: N-dN effluent) with an average of 0.2 g/L microalgae dry weight as inoculum. To evaluate algal growth, the total solids (TS) content of the medium was analysed. To evaluate the treatment of the N-dN effluent, samples were taken and pH, NH_4^+-N, COD and P_s were determined.

Results and discussion

The maximum concentration of microalgae reached in tests E1 and E2 was approximately 1 g /L in 25 days of cultivation. The maximum temperature reached was 9°C, as the tests were conducted in the winter months. Removal efficiencies of up to 48% of sCOD and up to 91% of Ps were observed, while no NH4+-N removal was detected. These results differ from those obtained by Zheng et al. (2017) for swine wastewater, where they obtained a concentration of 0.45 g/L in 7 days at 25°C and lower removal efficiencies (10% for NH4+-N, 9% for TP and 5% for COD).

Conclusions

The cultivation of microalgae in pig effluent after n-dN treatment without addition of water was feasible. It will be necessary to continue these trials during the summer months when temperatures inside the greenhouse are higher.

Acknowledgements

This study is part of the project "Improving manure management practices on pig farms through the implementation of different treatment processes to reduce emissions into the atmosphere," co-financed by the European Union through the FEADER funds. B. Molinuevo-Salces thanks AEI for funding, through RYC-2020-029030-I/AEI/10.13039/501100011033.

References

European Union (1991). Council Directive 91/676/EEC of 12 December 1991 concerning the protection of waters against pollution caused by nitrates from agricultural sources. Official Journal of the European Communities, L 375, 1-8.

Iniesta- López, E., et al. 2025. Transforming waste management: Converting pig slurry into clean energy and biomass through integrated MFC-microalgae systems. Journal of Water Process Engineering. 69.

Zheng, H., et al. 2018. Balancing carbon/nitrogen ratio to improve nutrients removal and algal biomass production in piggery and brewery wastewaters. Bioresource Technology. 249, 479-486.

46. Exploring sustainable fungicides against *Fusarium culmorum*, based on VFAs from cheese whey and wine lees

Buzón-Durán, L.[a], García-González, M.C.[a], Sánchez-Báscones, M.[a], Tshemese, Z.[b], & Molinuevo-Salces, B.[a]*

Department of Agroforestry Sciences, ETSIIAA, Universidad de Valladolid, Avenida de Madrid 44, 34004 Palencia. Spain [a]
Department of Chemistry, Durban University of Technology, Steve Biko Campus, Durban, 4001, South Africa [b]
*Corresponding author, email: beatriz.molinuevo@uva.es

Introduction

Dairy and wine industries produce substantial waste, including cheese whey and wine lees. These wastewaters contain various contaminants while posing risks to ecosystems if untreated. Volatile fatty acids (VFAs) are valuable chemical compounds produced from these wastewaters through anaerobic digestion. This study aims to valorise cheese whey and wine lees by producing VFAs through anaerobic fermentation. It explores the antifungal potential of VFAs, produced from cheese whey (CW) and wine lees (WL), against *Fusarium culmorum*, a major cereal pathogen.

Methodology

The study evaluated the antifungal activity of VFAs derived from CW and WL against Fusarium culmorum using mycelial growth inhibition tests. VFAs effluents were collected and subjected to UV light or heat (50°C for 30 min). The resultant effluents of the UV pretreatment, the heat pretreatment and a control with no treatment were tested. Mycelial growth inhibition assays were conducted using PDA plates with varying VFAs concentrations. Plates were inoculated with F. culmorum and incubated at 26°C for 7 days. EC50 and EC90 values (effective concentrations for 50% and 90% growth inhibition) were determined.

Results and discussion

Both pretreatments, namely heat and UV reduced total VFAs amounts for both CW and WL. The UV pretreatment caused a greater reduction in VFAs than the heat pretreatment. Heat pretreatment was more effective for microbial inactivation due to its ability to disrupt cellular integrity by denaturing proteins. UV pretreatment's effectiveness was limited by its shallow penetration depth and potential absorption by VFAs, reducing its efficacy against embedded pathogens. Heat pretreatment effectively eliminated heat-sensitive microorganisms, while UV mainly targeted nucleic acids, and shielded microbes can evade its effects. Research suggested that heat pretreatment reduces bacterial and fungal contamination in effluents containing VFAs and using both treatments together could improve results. The contamination from other microorganisms could lead to non-conclusive results. Mycelial growth inhibition tests showed that VFAs from cheese whey (CW) and wine lees (WL) reduced Fusarium culmorum growth. Untreated VFAs didn't achieve full inhibition at the tested concentrations. UV pretreatment fully inhibited growth at 4000 µg COD-VFAs/mL (for CW) and 3500 µg COD-VFAs /mL (for WL), while heat pretreatment was more effective, achieving full inhibition at 2000 µg COD-VFAs /mL (for CW) and 2500 µg COD-VFAs /mL (for WL). Contamination occurred in untreated effluents and at low concentrations of pretreated effluents. Heat-pretreated VFAs showed the lowest EC50 (682 µg· COD-VFAs /mL) and EC90 (1880 µg·COD-VFAs /mL) values, indicating higher efficacy. The study's minimum inhibitory concentrations (MIC) resulted align with other research on plant end-products and volatile organic compounds against Fusarium. Environmental factors influence VFAs efficacy, and VFAs could be a sustainable alternative to synthetic fungicides due to their lower MICs.

Conclusion

VFAs produced from cheese whey and wine lees showed potential as a sustainable alternative to synthetic fungicides against *Fusarium culmorum*. This approach contributes to waste valorisation and reduces the environmental impact of both wastewater and conventional fungicides.

Acknowledgements.

VALORACIDS project (PID2023-149196OB-I00). B. Molinuevo-Salces thanks AEI for funding, through RYC-2020-029030-I/AEI/10.13039/501100011033.

References

Buzón-Durán, L., et al. 2020. Antifungal Activity against Fusarium culmorum of Stevioside, Polyphenols and Silver Nanoparticles. Agronomy 10, 1361.

Cárdenas-Laverde, A.L., et al. 2021. In Vitro Antifungal Activity and Chemical Composition of Piper auritum Kunth Essential Oil against *Fusarium oxysporum* and *Fusarium equiseti*. Plants 10, 1159

Search for antagonistic microorganisms derived from anaerobically digested slurries (ADSs) against several tomato diseases & Testing of effective bacteria

Chen R, Irie M
Tokyo University of Agriculture , Japan

Introduction

In the contemporary context of a mounting global demand for sustainable agriculture and green production technologies, the conversion of agricultural waste into high-value resources has become a research priority0[1]. Anaerobically digested slurry (ADS), a by-product of livestock manure methane fermentation, is rich in nitrogen, phosphorus, potassium, and bioactive compounds, offering dual potential as both fertilizer and a biocontrol agent[2][3]. However, its complex composition and technical challenges, such as storage difficulties and heavy metal risks, limit its adoption in Japan[3]. Tomato production faces severe threats from soil-borne diseases (e.g., Fusarium wilt, early blight), exacerbated by overreliance on chemical pesticides [4]. This study investigates ADS-derived microbial antagonism to suppress tomato diseases, aiming to validate its "waste-to-disease-control" feasibility and advance circular agriculture.

Methodology

Target Tomato pathogens: Cladosporium fulvum (leaf mold), Botrytis cinerea (gray mold), and Alternaria solani (early blight), sourced from the Japanese gene bank. ADS Sources: Pig manure and two dairy cow manure-derived ADSs.

Experiment 1: Dual Culture Method ADSs and pathogens were co-cultured on Potato Dextrose Agar (PDA) at 25±1°C for 20 days. Pathogen suppression was quantified using the Pathogen Suppression Value (PSV) method [5].

Experiment 2: Dual Culture Method Using Bacteria Isolated from ADSs Bacteria were isolated from the ADSs and tested for their inhibitory effects against the three target pathogens using confrontation cultures on PDA and general-purpose agar media. Observations were made every 10 days, and inhibitory effects were assessed by comparing the pathogen growth in treated samples to control groups. The inhibitory effects were further verified using the PSV method[5].

Experiment 3: Cultivation Test Using Effective Bacteria. Effective bacteria identified in Experiment 2 were cultured in liquid media and subsequently loaded onto ADS solutions or rice husk biochar carriers and applied to soil at 1%, 7.5%, and 15% (w/w) using Micro-Tom tomatoes as a test crops. The experiment comprised 20 pots (5 replicates per treatment, including controls). Soil samples were analyzed periodically for microbial community shifts and disease suppression efficacy.

Hypothetical Results and discussion

The results from Exp.1 confirm that all three types of ADSs used in this study exhibit inhibitory effects against the three tested tomato pathogens. Building upon these findings, Exp.2 aims to identify and isolate the bacterial strains within ADSs that contribute to pathogen inhibition. It is expected that antagonistic bacteria, particularly those belonging to the Bacillus genus, will produce antimicrobial substances that directly disrupt fungal pathogens such as Botrytis cinerea. The confrontation culture method will be used to screen for the most effective bacterial strains, which will then be selected for further evaluation in the cultivation experiment.Exp.3 will focus on assessing the practical application of these selected strains in tomato cultivation.

Conclusion

This study highlights ADS's dual functionality: nutrient supply and biocontrol via antagonistic microorganisms. Identified strains hold potential as bio-pesticides or organic fertilizer additives, enabling integrated waste management and sustainable agriculture. Future work should optimize microbial formulations and assess long-term environmental safety to maximize scalability. The results contribute to advancing circular agriculture and achieving carbon-neutral agricultural goals.

References

Baştabak, B.,Koçar, G.2020. A review of the biogas digestate in agricultural framework. Journal of Material Cycles and Waste Management. Volume 22, 1318–1327.

[1]. Mao, C., et al. 2015. Review on research achievements of biogas from anaerobic digestion. Renew. Sustain. Energy Rev. 45, 540–555.
[2]. Yu, F.B., et al. 2010. Concentrated biogas slurry enhanced soil fertility and tomato quality. Acta Agric. Scand. Sect. B Soil Plant Sci. 60, 262–268.
[3]. Nakamura, M., 2011. *Study on the Use of Methane Fermentation Digestate as Liquid Fertilizer and Its Environmental Impact.*

***B*ull. Natl. Inst. Rural. Eng. Japan**, **50**, 1–57. (In Japanese)
[4]. Gao, X.-H., Zhang, Y.-P., & Liu, Z.-H. 2015. Effects of cultivating years on soil ecological environment in greenhouse of Shouguang City, Shandong Province. *Acta Ecologica Sinica*, *35*(5), 1452–1459. (in Chinese)
[5]. Kinooka, Y., & Noguchi, K. 2013. Method for evaluating pathogen suppressing force of agricultural land and material for use in agricultural land, and crop cultivation system using the same, (in Japanese)

NIR estimation of key parameters for a more sustainable raw organic waste direct application to agricultural soils

Barber, X.[a], Martín-Pozuelo, J.[a], Martinez-Sabater, E.[b*], Orden, L.[b], Marks, E.[b], Pérez Murcia, M.D.[b], Franco, J.[c], Samper, A[c], Ruiz-Canales, A.[b], Andreu, J.[b] & Moral, R.[b]

Unidad de Estadística Aplicada, Centro de Investigación Operativa, Universidad Miguel Hernández de Elche, Elche (Alicante), España[a]; Centro de Investigación e Innovación Agroalimentaria y Agroambiental (CIAGRO-UMH), Universidad Miguel Hernández, Carretera de Beniel Km 3,2, Orihuela, Alicante 03312, España[b]; SAV, Agricultores de la Vega de Valencia, Plaza Tetuan, 46003 Valencia, Spain[c]; [*]Corresponding author, email: e.martinezs@umh.es

Introduction

The application of sewage sludge as a fertiliser in agricultural soils facilitates the recycling of essential nutrients, in particular nitrogen and phosphorus, as well as the supply of organic matter. Furthermore, its use in agriculture is emerging as an efficient strategy for soil carbon sequestration, in line with the recommendations of the IPCC (2021), which recognises waste management as a key activity for climate change mitigation. The estimation of key parameters in terms of agronomic and environmental requirements based on the use of near infrared spectroscopy (NIRS) may be an interesting approach to solve current management problems.

Methodology

For the development of the NIRS estimation tool, 40 different samples of sewage sludge from wastewater treatment plants (WWTP) in the Valencian Community were used. Different parameters were determined such as pH, electric conductivity, organic total matter, total carbon, total nitrogen, macronutrients, micronutrients and heavy metals. The same samples were scanned with a Fourier transform NIRS spectrometer (MPA, Bruker Optik GMBH, Germany) in the range of 12,000 to 3800 cm-1 producing spectra with 2126 points per sample, where each spectrum is the average of three consecutive scans of the same sample. Different modelling approaches were studied: partial least square regression, principal component regression, regression ridge and least absolute shrinkage and selection operator regression. In addition, different NIR signal pre-processing alternatives were studied: Standar Normal Variate (SNV), Multiplicative scatter correction (MSC), signal smoothing, first and second derivative of the signal using the Savitzky-Golay algorithm (SG1, SG2 and SG3, respectively). The models were calibrated by cross-validation and the fit of each model was analysed in order to determine the model with the best fit.

Results and discussion

Most of the optimal models found show a value for the R^2 coefficient greater than or equal to 0.8. Of these, 52.94% were PLS models applied to one of the pre-processed signals (44.44% SG2, 22.22% SG3 and SNV, and 11.11% SG1). Likewise, 47.06% of the remaining optimal models have been obtained by Ridge and Lasso regressions (23.53% each). The results obtained reflect an R^2 coefficient value of less than 0.8 for the following parameters: calcium (0.580), sodium (0.782), copper (0.787) and lead (0.315).

Conclusion

NIR signals have proven to be very useful in the prediction of chemical compounds and especially the use of AI can significantly improve the very high estimation capability contributing to the improvement of agronomic sludge management. However, it is essential to consider and compare the results of different modelling alternatives, as these can offer considerable differences in the quality of the fit.

Acknowledgements

This project is funded by the INNEST/2023/115 project of the Valencian Innovation Agency (IVACE+).

References

IPCC (Intergovernmental Panel on Climate Change) Chapter 7: The Earth's Energy Budget, Climate Feedbacks and Climate Sensitivity. In Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change; Cambridge University Press: New York, NY, USA, 2021; p. 132.

47. Future-proof composts and soil amendments to cope with intensified droughts

Baert, L.[a*], Meka, S. N. R .[a], Bommisetty, H.[a], Colin, K.[a], Sleutel, S.[b], Cornelis, W.[a]

SENSE, department of Environment, faculty of Bioscience Engineering, Ghent University, Belgium [a]; SOFER, department of Environment, faculty of Bioscience Engineering, Ghent University, Belgium [b]; [*]Corresponding author, email: lotte.baert@ugent.be

Introduction

This study aims to enhance the resilience of the soil against prolonged droughts by increasing the soil water holding capacity. Composts and other soil amendments have the potential to improve soil water retention. This study investigates seven compost types and six ecological soil amendments including biochar, biosolids, chitin, seaweed-, alfalfa- and flax fibre powder, and compares the functioning of the products to each other under diverse environmental conditions.

Methodology

In a greenhouse pot experiment, different doses of composts and soil amendments were tested. Tests were carried out on drought-sensitive sandy loam, loamy sand and sandy soils under a 'dry' and 'moist' water regime. In total, 133 treatments were tested, each replicated three times. The drought sensitive crop, lettuce, was grown in every pot. Undisturbed soil samples were taken at harvest and analysed to obtain the soil moisture retention curve. This enabled to derive the macro- (> 30 µm), meso- (30 µm – 0.2 µm) and microporosity (< 0.2 µm), respectively providing information regarding the impact of the added products on the soil's ability to transmit water, its plant available water capacity and the fraction of bound water inaccessible to plants.

Results and discussion

The type of soil amendment or compost significantly affected the porosities when compared to the untreated control, yielding the most favourable outcomes for biosolids, seaweed powder, flax fibre, green compost and bark compost. Generally, enhanced effects were noted with product dose. The macroporosity increased for most treatments with soil amendments, while this effect was much less expressed, or even reversed for the compost treatments. Almost all treatments resulted in enhanced microporosities, stressing the importance of water adsorption on the products. The mesoporosity was mostly lowered when treatments were applied on the loamy sand soil, while the opposite was observed for the sandy loam.

Generally, treatments applied on the sandy loam soil yielded the largest beneficial effects, with diminishing impact as soil texture became coarser. The dryer water regime mostly resulted in intensified effects on the macroporosity, while the microporosity was more affected under the wetter water regime.

Conclusion

This study utilizes an extensive dataset to investigate the effects of various ecological soil amendments and compost types on soil moisture retention. In addition to comparing the performance of different products, the study evaluates their effectiveness across diverse soil types and water regimes, stressing the importance of the environmental settings on the performance of the products.

48. Impact of soil amendments from food industry by-products on maize and winter wheat development and selected soil quality parameters – findings of a 2-year field experiment

Bauerle, A. [a*], Heiser, L. [a], Neuberger, M. [a] & Lewandowski, I. [a]

University of Hohenheim, Institute of Crop Science, Department Biobased Resources in the Bioeconomy, Germany[a]; *Corresponding author, email: a.bauerle@uni-hohenheim.de

Introduction

Soil is crucial not only for agricultural production but also for ecosystem functions like climate regulation, water and air quality management, biodiversity support, erosion prevention, and natural pest and weed control. However, the soil ecosystems across Europe are increasingly at risk from various factors leading to declining soil health, which restricts agricultural productivity and threatens important ecosystem services in the long-term. At the same time, large amounts of food industry by-products are currently underutilized and could serve as soil amendments by adopting circular economy principles. This issue is addressed within the four-year Horizon Europe project "DeliSoil" that focuses on delivering safe, sustainable, tailored and societally accepted soil improvers from circular food production processes for boosting soil health. This study is part of "DeliSoil" and aims to investigate the potential of using locally sourced food industry by-products as sustainable soil amendments and to evaluate their impact on soil quality and crop productivity by means of a field experiment. Soil samples are analysed for a varied spectrum of soil health parameters to give insight which ones show a timely response towards changes in soil status following application of amendments.

Methodology

In spring 2024, a field experiment was established with silage maize as test crop to evaluate the effects of different soil amendments on selected soil health parameters and maize performance at the University of Hohenheim in Stuttgart, Germany (48.714944, 9.214498). Four soil amendments, including processed and pelletized anaerobic digestates from mixed food waste, insect frass and bio-compost, were applied at two rates considered suitable for practical agricultural use (1 and 2 t ha^{-1}). These amendments, all sourced from the surrounding region, were compared to a commercial reference, mineral fertilizer, and an untreated control. The nitrogen applied with the amendments was considered and differences were applied as calcium ammonium nitrate to ensure the same nitrogen supply for all treatments.

Soil samples are collected at three different times during the growing season to assess soil quality parameters like organic carbon content, active carbon, cation exchange capacity, soil texture, macro- and micronutrient levels, pH and water holding capacity. Throughout the season, plant characteristics such as growth stage (BBCH), height, and SPAD chlorophyll index are monitored bi-weekly. Biomass yield of maize was determined at anthesis and at dough maturity. The experiment is continued with winter wheat, sown in October 2024.

Results and discussion

Initial analysis revealed that the different soil amendments tested in this study have varied impacts on maize yield, with some products showing significantly higher yield effects than others. This suggests that the choice of soil amendment can strongly influence crop productivity already in the first year. However, it is very likely that the mineral fertilizer applied with the amendments played a significant part in this, as the nitrogen in soil amendments was released more slowly. The cation exchange capacity in the soil showed a clearly visible change for the first two sampling dates.

The complete results from laboratory analysis of both soil and plant samples will not be available until spring 2025. The presentation is going to include findings of the first two years of field trials.

Conclusion

The first year findings will provide a first comprehensive evaluation of how each soil amendment affects both soil health and plant growth indicators, allowing for more precise recommendations on sustainable soil management practices. The field experiment continues for two more years to cover at least the mid-term effect of the amendments on soil health.

Acknowledgements

This study was carried out within a project funded by the European Union under the Horizon Europe Programme, Grant Agreement No. 101112855 (DeliSoil). Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or Research Executive Agency (REA). Neither the European Union nor the granting authority can be held responsible for them. Swiss partners (FiBL) have received funding from the Swiss State Secretariat for Education, Research and Innovation (SERI). The authors are grateful to Thomas Ruopp and Robin Treter for help with managing the field trial and to Thomas Karle for providing soil amendments.

49. Effects of seaweed fertiliser on perennial ley

Cabell, J.F.[a*], Almås, A.[b], Olesen, I.[c], Løes, A-K.[a]

[a]NORSØK, Tingvoll, Norway; [b]NMBU, Ås, Norway; [c]Nofima, Ås, Norway *corresponding author, joshua.cabell@norsok.no

Introduction

Seaweed has traditionally been used as a soil amendment in coastal areas, e.g. applied to potato plots. With growing interest in marine macroalgae, seaweed-derived biostimulants are gaining popularity, particularly in drought-prone regions. Macroalgae supply potassium (K) and other minerals, providing an alternative to finite and geopolitically challenging mineral K sources (Rawashdeh 2020). Perennial ley crops require substantial K inputs, extracting up to 300 kg ha^{-1} from the soil. However, brown macroalgae applications are regulated due to cadmium (Cd) content. This study at NORSØK (62.9°N, 8.2°E) examined the effects of high and moderate seaweed application rates on Cd and As concentration and evaluated ley yield potential.

Methodology

A high-rate demonstration trial tested the impact of a single application of seaweed containing the maximum Cd permitted over ten years on perennial ley survival. Seven types of raw or processed brown macroalgae were applied to a second-year grass-clover ley in spring 2023 at varying rates based on Cd content. Two adjacent control plots received no seaweed. The zero-control plot had not been fertilised since 2019. The positive control plot received seaweed material in 2020 (Løes et al. 2022). Application amounts ranged from 2 (dried products) to 20 (fermented kelp, 8% DM) kg material m^{-2}. Aboveground plant material (APM) was harvested in 2023 and 2024, for recording fresh and dry matter (DM) yields and chemical composition. A separate moderate-rate experiment assessed whether K supplementation with seaweed applied post-first cut improved ley yield compared with dairy cow slurry. Four seaweed treatments (two dried rockweed, two dried toothed wrack) were applied at 60 kg K ha^{-1}, with four replicates on 1.5 m × 7 m plots, corresponding to ~2.5 tons of material and 30 kg total N ha^{-1}. Fresh weight and DM yields were recorded on two dates.

Results and discussion

The high-rate application of fermented kelp (pH 4) suppressed all but perennial weeds. Other seaweed materials increased ley yields but reduced DM% in APM compared to the zero-control. The positive control yielded higher biomass than the zero control. In 2023, total DM yields were ~5 tons ha^{-1} for the zero control, 7 tons for the positive control, and 6-8 tons for the seaweed treatments, except fermented kelp (~4 tons ha^{-1}). The 2024 results showed similar trends, demonstrating a residual yield effect for most seaweed materials. The negative effect of the fermented kelp was likely due to a rapid infiltration to the root zone of a liquid with pH < 4 and high salinity. Cd application rates in 2023 did not correlate with Cd uptake in APM in 2023 or 2024 but increased As application elevated As concentrations in APM. The tetany ratio (K/(Ca + Mg), meq/kg DM feed) exceeded the risk threshold of 2.2 at the first 2023 cut but declined in later cuts. In the moderate-rate experiment, seaweed application did not affect DM% or yield in the second cut. In the third cut, DM% declined with seaweed application, whereas the average DM yield increased from 1.9 tons ha^{-1} for the control to 2.1 tons ha^{-1} with seaweed, on average.

Conclusion

The high-rate seaweed application did not increase Cd uptake in plants, though As uptake did increase. High uptake of K in the APM caused tetany ratio thresholds to be exceeded. Increased yields compared to the control demonstrate that a modest application of seaweed may provide significant yield increase, possibly explained by the additional K supply.

Acknowledgments

This study was part of the SeaSoil project, funded by the EU Horizon 2020 program (ERA-NET BlueBio cofund, Grant No. 817992) and the Research Council of Norway (No. 339232).

References

Løes, AK, I Ahuja, A deBoer, T Rittl 2022. Fertilisation Effects of Marine-Derived Residual Materials on Agricultural Crops. *NORSØK Report* 7 (13): 73 pgs. https://orgprints.org/id/eprint/45330/.

Rawashdeh, R A 2020. World Peak Potash: An Analytical Study. *Resources Policy* 69 (December):101834. https://doi.org/10.1016/j.resourpol.2020.101834.

50. Antifungal Potential Evaluation of Chitosan-Silver Nanoparticles Synthesized via Microwave Radiation and One-Pot Reduction Methods

Hosney, A.[a*], Matelionienė, N.[a], Urbonavičius, M.[b], Varnagiris, Š.[b], Draponskaitė, D.[a], & Barčauskaitė, K.[a]

Lithuanian Research Centre for Agriculture and Forestry, Lithuania[a]; Center for Hydrogen Energy Technologies, Lithuanian Energy Institute, Lithuania[b]; *Corresponding author: Ahmed Hosney, email: Ahmed.hosney@lammc.lt

Introduction

Utilizing shrimp biowaste for chitosan recovery and green synthesis of chitosan-based nanoparticles is an eco-friendly approach that offers sustainable waste management and develops anti-fungal potential in the field of agriculture. This study aimed to evaluate the antifungal activity of chitosan silver nanoparticles recovered from shrimp shells and synthesized using two distinct methods of microwave-radiation and one-pot reduction methods, targeting *Fusarium graminearum*, a significant fungal pathogen that infects agricultural crops.

Methodology

In the first approach, Ch-AgNPs were prepared using 40 ml of 1% chitosan solution and 40 ml of 10 mM $AgNO_3$, followed by dripping of 4 mL of 10% ascorbic acid as a stabilizing agent. Then the mixture was irradiated in the microwave at 600 W for 5 minutes to enhance silver nanoparticle formation and facilitate the colour change. On the other hand, the one-pot reduction method was applied to synthesize Ch-AgNPs by adding 40 ml of 1 mM $AgNO_3$ to the 40 ml of 1% chitosan solution and stirring for 30 minutes over an ice bath. This was followed by adding five drops of 0.1M $NaBH_4$ and stirring for 60 minutes to change the colour from yellow to brownish, reflecting Ch-AgNPs formation. The samples obtained from both methods were centrifuged for 3 hours at 2000 rpm and washed with distilled water to collect the nanoparticles. The antifungal activity of the obtained Ch-AgNPs was evaluated against the fungal growth of *Fusarium graminearum* by measuring the inhibition rates over one week at three varying concentrations (200 ppm, 500 ppm, and 1000 ppm). Metconazole and double distilled water were used as positive and negative controls, respectively.

Results and discussion

The microwave-radiation method for Ch-AgNPs synthesis at 1000 ppm represented higher inhibition rates in the range of 17.53% to 100%, whereas the samples obtained from 500 ppm showed lower to near moderate inhibition rates between 2.59% to 43.6%. While the Ch-AgNPs samples of 200 ppm did not exhibit any significant inhibitory effect against *Fusarium graminearum*. In contrast, the Ch-AgNPs samples obtained using one pot reduction method at 1000 ppm demonstrated lower inhibition rates ranging from 0% to 86.47%. Moreover, the samples obtained at 500 ppm concentration showed very low inhibition rates falling between 0% and 37.47%, even if, most samples were without any inhibitory effect. Furthermore, the Ch-AgNPs samples prepared at 200 ppm concentration via the one-pot reduction method did not show any antifungal activity against *Fusarium graminearum*.

Conclusion

The microwave radiation method produced more potent antifungal activity, with higher inhibition rates at all concentrations compared to one pot reduction method. Several samples of Ch-AgNPs at 1000 ppm concentration achieved 100% inhibition, reflecting the formation of Ch-AgNPs with stronger antifungal properties against *Fusarium graminearum*, likely due to the efficient reduction of silver ions by chitosan in the presence of ascorbic acid and microwave irradiation. Therefore, the microwave-radiation method is recommended for optimal antifungal performance. Further studies are needed to optimize reaction parameters and explore potential applications in the agronomy field.

Acknowledgements

This research was funded by the Research Council of Lithuania (LMTLT), under agreement No. S-MIP-23-6.

51. Multi-Year Soil Health Data Relating to Manure Land Application in Missouri

Lim T-T.[a*], Sarker M.[a], Davis M.[b], Reinbott T.[c], & Brandt D.[d]

Agricultural Systems Technology [a]; School of Natural Resources [b]; Agricultural Experiment Station [c]; Soil Health Assessment Center [d]; University of Missouri, USA; *Corresponding author, email: LimT@missouri.edu

Introduction

A Missouri team has been collecting and analyzing many soil health variables and manure land application data, based on samples collected under the Missouri Cover Crop Cost-Share Program and experimental plots. Manure application information has been requested along with the soil samples collected since 2016. This provides a unique opportunity to examine the overall effects of manure land application on soil characteristics, especially those that have more implication in soil health. This abstract presents the correlations between manure application and soil health indicators, and crop yield.

Methodology

Farmers in Missouri can apply to a cover crop incentive, and they are required to submit field information and soil samples. We assembled and analyzed the data of soil health related variables, field information, and manure application details of the samples sent in across Missouri. Manure data was collected since 2016 and included information such as manure type, application rate, and method applied. The soil health indicators analysed included soil aggregate stability, total organic carbon, active carbon, exchangeable cations, bulk density, water stable aggregates, and biological analysis based on phospholipid fatty acid (PLFA).

In addition to the state-wide soil samples, the team also conducted replicated tests on research plots at a research farm for the study. This is to better examine the effects of manure land application on soil characteristics under similar management and soil type, a set of. The research plots were 4.6mx12.2m, located at a Research Farm of University of Missouri, near Columbia. The control plots included corn/soybean rotation plots that received chemical fertilizer following agronomic rate. The treatments included either a) Rotation: corn/soybean and corn/soybean/wheat; b) Cover crop: minus and plus cover crop; and c) Fertilizer: minus (using chemical fertilizer) and plus manure application. Each of the treatment had four replicated plots, and the soil was Mexico Silt Loam. Soil samples (15-cm) were taken from each plot twice per year, to characterize the changes of soil health indicators.

Results and discussion

A total of 14,473 soil samples were collected from 2015 to 2021 across the state of Missouri. The surface application is the most commonly used method, followed by incorporation and injection. Results indicate that the manure application resulted in significantly higher amounts of potentially mineralizable nitrogen (2 out of 6 years), Bray-1 phosphorus (5 out of 6 years), and permanganate-oxidizable carbon (1 out of 6 years); lower effective cation exchange capacity (ECEC, 5 out of 6 years) and bulk density (2 out of 6 years); while the aggregate stability was highly variable for manure application. Manure type had no significant effects on soil properties except for ECEC and organic carbon, which were higher ($p<0.05$) for cattle and swine than poultry manure.

For the research plot data, crop rotation and fertilization (manure vs. inorganic fertilizer) had no significant effects on corn yield. On the other hand, cover crops significantly affected corn yield, that higher yield ($p<0.05$) was observed for plots treated with manure. For soybean yield, crop rotation had no significant impact, but some cover crop plots showed significantly ($p<0.001$) lower yield, likely because some of the cover crops were not fully decomposed at the time of soybean sowing, which affected soybean germination. In addition, manure application promoted the soybean yield, and the difference was significantly ($p<0.05$) higher. The cover crop and application of manure did not affect wheat yield.

Conclusion

The cover crop practice and manure land application are showing different impacts on soil health indicators and crop yields, especially on the data collected from the research plots. Data from management practices reveal notable variation in manure types and application rates across the state. The team expect to collect more soil samples across the state and continue with the field experiment at the university farm. Additional analysis such as soil quality index will be assessed following multi years of manure application, cover crops, and crop rotation treatments.

Acknowledgements

The authors acknowledge the help of the farm management team and funding support from the Missouri N340 Cover Crop Cost-Share Program.

References

MDNR, 2025. Missouri Department of Natural Resources. Missouri N340 Cover Crop Cost-Share Program, Soil and Water Conservation. https://dnr.mo.gov/document-search/cost-share-program-pub0624/pub0624

Lim, T.-T., Wang, A. H., Brandt D., Norkaew S., and Miles, R. 2018. Manure land application and soil health indicators. In Soil Health Nexus Web Resources, in collaboration with the North Central Region Water Network. https://soilhealthnexus.org/can-manure-improve-soil-health/

52. Assessing the Effectiveness of Amendments in Relation to Soil Properties: A Greenhouse Pot Experiment

Luppi, M.[a*], Koopmans, G.F.[a] , Corbetta, A., Cajas D.R.[b] , Morriën W.E. [b] & Schenkeveld, W.D.C.[a]

Soil Chemistry Group, Wageningen University, The Netherlands [a]; Plant-Soil Ecology group, University of Amsterdam, The Netherlands [b]; * Corresponding author, email: martina.luppi@wur.nl

Introduction

Conventional agricultural practices focus on maximizing the productivity of agricultural soils by creating optimal conditions for plant production. One of the most common agricultural practices is the use of mineral fertilizers and animal manure to supply nutrients and organic matter (OM). Despite the beneficial effects of these practices on plant growth conditions on the short-term, other critical functions of agricultural soils, such as water filtration, carbon sequestration, and nutrients and organic matter, and serving as a habitat for soil organisms, tend to become compromised (de Vries et al., 2023). By prioritizing the maximization of agricultural productivity, soil health has been neglected in the management of agricultural soils, leading to imbalance in nutrient management, loss of organic carbon, soil compaction, and overall soil degradation (Bedolla-Rivera et al., 2023). To improve specific soil functions, organic and inorganic soil amendments can be added to soil to alter chemical, physical and biological soil properties thereby enhancing soil health. However, the effectiveness of these amendments varies depending on soil characteristics (Iticha et al., 2024). Furthermore, application of an amendment may enhance one soil function, while negatively impacting other functions. For this reason, it is crucial to assess the effectiveness of soil amendments based on soil properties by understanding the underlying mechanisms. This study, therefore, aims to deepen our knowledge of the chemical and physical processes influenced by soil amendments to restore soil functions and enhance soil health.

Methodology

A short-term greenhouse experiment consisting of 320 pots was conducted to examine the effects of various amendments across four soils differing in soil properties. The selected amendments - Bokashi (B), fresh road-cuttings (R), wood fibre (W), clay (C), iron granulates (I), lime pellets (L), and rock flour (F) - were applied separately to each of the four soils with dosages recommended in literature. A control treatment without amendment was included as well. Each treatment was replicated ten times. Half of the pots were planted with faba bean (*Vicia faba L.*), while the other half was left unplanted. The soil water content of all pots was maintained at 60% of the maximum water holding capacity. After ten weeks, the plants and soils were harvested. Chemical and physical soil measurements related to specific soil functions were performed, including different soil pools of nutrients and heavy metals as well as soil properties like pH, OM, cation exchange capacity (CEC), and Al-/Fe- oxides. Also, the total elemental composition of the harvested plants was analysed after digestion.

Results and discussion

During our poster presentation, results regarding the effects of the soil amendments on plant-available nutrients and heavy metals will be linked to soil properties of the four soils. According to our preliminary findings, organic amendments increased plant-available nutrient and dissolved organic carbon (DOC) levels. The relative contributions of direct effects from the added organic amendments on plant-available nutrient contents and heavy metals versus indirect effects from altered soil properties by the same amendments, such as pH, will be disentangled. Lastly, the effects of the soil amendments on faba bean yield and uptake of nutrients and heavy metals will be shown.

Acknowledgements

We would like to thank our former PhD student Alessia Corbetta for sampling the soils and setting up, maintenance, and sampling of the pot experiments as well as the collection of preliminary data. This study was conducted as part of the project SoilProS.

References

Bedolla-Rivera, H. I., et al. 2023. Analyzing the Impact of Intensive Agriculture on Soil Quality: A Systematic Review and Global Meta-Analysis of Quality Indexes. Agronomy, 13(8).

de Vries, W., et al. 2023. Integrated assessment of agricultural practices on large scale losses of ammonia, greenhouse gases, nutrients and heavy metals to air and water. Science of the Total Environment, 857.

Iticha, B., et al. 2024. Combining lime and organic amendments based on titratable alkalinity for efficient amelioration of acidic soils. SOIL, 10(1), 33–47.

53. Laboratory assessment of new bio-based fertiliser from fruit and vegetable waste

Ramos-Bueno, R.[a*], Martínez-Gaitán, C.[a], González-Fernández, M.J. [a], Amery, F.[b], Ronchin, E.[c], Sinicco, T.[c], Mondini, C.[c], Kuiper, D. [d]

Foundation of Auxiliary Industry of Agriculture Tecnova, Spain [a]; Institute for Agricultural and Fisheries Research (ILVO), Plant Sciences Unit, Belgium [b]; CREA Research Centre for Viticulture and Enology, Italy [c]; CropEye Foundation, The Netherlands [d]; *Corresponding author, email: rramos@fundaciontecnova.com

Introduction

The sustainable valorisation of fruit and vegetable wastes has been included as one of the main European Commission priorities, being part of the EU´s Circular Economy Action Plan (CEAP). The importance of recycling these wastes is that it can lead to several additional benefits including the nutrient recycling through applying emerging recovery technologies such as anaerobic digestion followed by microbial biomass production, insect breeding, pyrolysis and composting. These technologies produce different solid building blocks (microbial biomass, insect biomass and frass, biochar and compost) with variable composition that can be used as fertilisers, but can more conveniently be used to design tailored-made soil amendments and bio-based fertiliser with the aim to cover the nutrients requirement and improve soil fertility of different agricultural European areas, as investigated in the RUSTICA project for the following regions: Flanders (Belgium), Almeria (Spain), Pays de la Loire (France) and Friuli Venezia Giulia (Italy). In this sense, as a first step of the fertiliser's evaluation and validation process, different laboratory assessments were carried out to optimize this tailored-made blends and define the different applications doses according to test regions demand.

Methodology

Two rounds of laboratory trials were performed to optimise the biochar content and evaluate the scope defined for 15 tailored-made blends. In these trials two soils from different regions were assessed; one soil coming from a vineyard located in Friuli Venezia Giulia (Italy) and another from a commercial greenhouse in Almeria (Spain). Briefly, the soils were thoroughly amended with the blends in triplicate and aerobically incubated in the dark at 20 °C for 30 days. In the first round of incubation the blends were added at a single dose to provide the same amount of available N, while in the second one several rates were used (from 7.5 to 22.5 ton/Ha). After 2, 7 and 30 days of incubation, soil samples were analysed for respiration rate, extractable NH_4^+, NO_3^-, P, organic C and N, Olsen P and soil microbial biomass.

Results and discussion

During the first round of trials, only one blend added to the Italian soil had a significant impact on soil properties, specifically on nutrient availability and microbial biomass size and activity. Similarly, the blends assessed in Spanish soil did not suggest an increase in the bioavailability of nutrients in the soil, neither an improvement of the microbial biomass content nor enzymes activities. Results of the first incubation round showed that the occurrence of biochar limited, at least in the short period, the capacity of the blend to provide nutrients and to boost microbial activity. During the second round, selected blends from round 1 with higher potential for field application and new redesigned ones (with lower share of or without biochar) were applied in different doses in a second round. For the Italian soil the new blends had a significant larger impact on soil nutrient availability and soil microbial pool content. Moreover, these new blends were characterised by high degradability when applied to the soil. On the other hand, the blends applied in the Spanish soil at the higher dose built up the organic nutrient content in the soil. In addition, these increments resulted in a high microorganism activity with a likely subsequent impact on the soil quality. However, increased nutrient availability could decrease in some cases the activity of the enzymes related to nutrient cycling in the soil.

Conclusion

In general terms, the results showed the occurrence of a linear positive and significant relationship (up to a blend dose of 22.5 ton/Ha), between the amount of blend added to the soils and the response of the soil parameters. Additionally, a differential impact of blends on soil properties was detected in both local soils according to the share in the blends of more degradable building blocks, such as insect and/or microbial biomass, and more resistant ones, such as compost and biochar. Among the building block assayed, the biochar component in the blends seemed to be the most relevant factor in determining the blend impact on soil properties.

Acknowledgements

This project has received funding from the European Union's Horizon 2020 Research and Innovation Programme under Grant Agreement No 101000527.

54. Recycling of food processing residues and the effect on soil health

Vistisen, E. F.[a*], Bruun, S.[a] & Hansen, V.[a]

Department of Plant and Environmental sciences, University of Copenhagen, Denmark [a]; [*]Corresponding author, email: efj@plen.ku.dk

Introduction

Soil erosion and compaction, loss of soil organic matter and nutrients caused by intensive land use, compromises the security of future food production. Therefore, a shift of agricultural practice is necessary. Where focus was previously on adding nutrients for plant growth, we now acknowledge the need for soil organic matter to maintain a good soil structure that can improve the ability of the soil to retain water and nutrients and prevent soil erosion.

Food processing residues (FPR) refers to a large range of products that can be recycled to the agricultural soil as soil improvers that contribute with nutrients but also soil health improvement. Soil improvers based on FPR would often require certain treatment to be readily applicable and save to use, such as anaerobic digestion or heat treatment.

A dual experiment consisting of a pot trial and an incubation study was conducted to examine the effect of diverse products based on FPR on nutrient release and on a range of physical, chemical and biological soil health parameters, and to quantify their fertilizing effect.

Methodology

A pot experiment and an incubation study were conducted using 16 products based on FPR in the equivalent of 150 kg total N ha^{-1}. Overall, the products come from meat -, insect -, and plant production. The tested products were raw and pelletized meat and bone meal, raw and heat-treated insect frass, biogas digestates with different fibre fractions (raw and pelletized) and compost.

The pot experiment was a nitrogen (N) omission trial, growing barley for 46 days, measuring growth parameters during growth, and root/shoot biomass, pH, electrical conductivity, and total N content after harvest, calculating N fertilizer replacement value (NRFV).

In the incubation study, water extractable phosphorus (P), mineral N, pH and electrical conductivity was measured three times during the 119 days study. For the last sampling point, soil microbial biomass carbon (SMB-C), respiration, water holding capacity (WHC) and cation exchange capacity (CEC) was also analysed.

Results and discussion

In the pot trial, the variation in chlorophyll content, total biomass and NRFV followed the same trend regarding the various products, with an NRFV ranging from 2 to 28 %. The different separation techniques of biogas digestate caused large variation in growth and NRFV, which were generally decreased by pelletizing, while heat treatment had limited effect.

For the incubation study, the variation and patterns of mineralization of N and P over time will be presented. The results of CEC, WHC and SMB-C will be in focus as the chemical, physical and biological properties of the soil.

Conclusion

Amendment with soil improvers produced from food processing residues revealed large variation in their effect on soil chemical, physical and biological properties and on growth of spring barley depending on the composition and quality of soil improvers.

Acknowledgements

The study was performed as part of the DeliSoil project, an EU Horizon project under the EU mission "A Soil Deal for Europe". The overall aim of the project is to identify and optimize food processing residues for improvement of soil health.

Occurrence of antibiotic-resistant bacteria in cattle excrement: potential transmission during application of manure to soil

Gregová, G.*, Szabóová, T., Dancová, N., Király, J., Hajdučková, V., Hudecová, P., Teleky, J.
University of Veterinary Medicine and Pharmacy in Košice, Slovak Republic,
*Corresponding author, email: gabriela.gregova@uvlf.sk

Introduction

Manure management is an important source of microbial pollutants such as enterobacteriae and staphylococci in livestock production systems. There is growing concern about the emergence of resistant bacteria, given the excessive use of antimicrobials in animals and their implications for human, animal, and environmental health. These possess risk to public health, especially when the microbial species involved have zoonotic potential, such as – MRSA (methicillin-resistant *Staphylococcus aureus*), MRCoNS (coagulase negative methicillin-resistant *Staphylococcus*) or ESBL (Extended spectrum β-lactamases) producing *E. coli* (Casey et al., 2013; Martins-Silva et al., 2023).
The manure contains antibiotic-resistant bacteria and resistance genes. The application to crop fields, where it may put community members at risk for antibiotic-resistant infections (Adkins et al., 2022).
The aim of this research was to assess the prevalence and antimicrobial resistance profiles of bacteria recovered from fresh cattle excrements and stored manure. In this work, we analysed the species distribution and antimicrobial susceptibility of *Staphylococcus* and *E. coli* species in cattle manure. The aim of this research was to assess the prevalence and antimicrobial resistance profiles of bacteria recovered from fresh cattle excrements and stored manure.

Methodology

Samples of organic material were collected into sterile plastic specimen boxes or using sterile cotton swabs. After dilution, samples were homogenized. For bacterial identification, classical cultivation methods were used: Mannitol salt agar, Columbia blood agar for staphylococci; and endoagar for *E. coli*. Suspected colonies were selected for further evaluation. Bacterial colonies were speciated using MALDI-TOF mass spectrometry. Minimum inhibitory concentration for determination of phenotype antimicrobial resistance was determined by a microdilution colorimetric method according to CLSI M100-ED33:2023 and EUCAST (version 13.0) using the Miditech system with an interpretive reading of MIC.

Results and discussion

Among staphylococcal isolates, *S. xylosus* strains were most frequently identified (90%), also *S. haemolyticus* and *S. chromogenes* isolates. The highest percentage of resistance was recorded in staphylococci to oxacillin, followed by rifampicin (over 50%), trimethoprim, gentamicin and ciprofloxacin (16%). CoNS isolates with the MRSCoNS resistance mechanism and multiresistance were recorded here. More than 50% of *E. coli* isolates were recorded to be resistant to ampicillin, streptomycin, tetracycline, cotrimoxazole and nalidixic acid (45%). ESBL and quinolone resistance mechanisms were present.
Comparing microbial contamination in fresh and stored excrements, lower numbers of the monitored bacteria were recorded in stored manure (a decrease of 1 to 2 log orders), but the percentage of resistance in isolates was comparable to that in fresh excrement.

Conclusion

The data point out the need of better implementation of microbiological safety treatments of manure.

Acknowledgements

This research was funded by grants APVV-23-0488 and KEGA 009UVLF-4/2025.

References

Adkins, P.R.F., Placheta, L.M. Borchers, M.R. Bewley, J.M. Middleton,J.R. Distribution of staphylococcal and mammaliicoccal species from compost-bedded pack or sand-bedded freestall dairy farms, Journal of Dairy Science, 105, 7,2022, 6261-6270,ISSN 0022-0302.

Casey JA, Curriero FC, Cosgrove SE, Nachman KE, Schwartz BS. High-Density Livestock Operations, Crop Field Application of Manure, and Risk of Community-Associated Methicillin-Resistant Staphylococcus aureus Infection in Pennsylvania. JAMA Intern Med. 2013;173(21):1980–1990. doi:10.1001/jamainternmed.2013.10408

Martins-Silva, P., Dias, C., Vilar, L.C. *et al*. Dispersion and persistence of antimicrobial resistance genes among *Staphylococcus* spp. and *Mammaliicoccus* spp. isolated along a swine manure treatment plant. *Environ Sci Pollut Res* **30**, 34709–34719 (2023).

CLSI M100-ED33:23. Performance Standards for Antimicrobial Susceptibility Testing, 33rd Edition. Wayne. PA: Clinical and Laboratory Standards Institute: 2023.

EUCAST tables of clinical breakpoints, version 13.0. (http://www.eucast.org).

Evaluation of the effect of the addition of wine vinasse on the co-digestion of slaughterhouse sludge and wastewater

Candel, M. [a*], Perez, M.[a] & Solera, R.[a]

Department of Environmental Technologies, IVAGRO, Faculty of Marine and Environmental Sciences (CASEM), University of Cádiz, Spain [a]; [*]Corresponding author, email: maria.candel@uca.es

Introduction

Anaerobic co-digestion allows the valorisation of waste by combining different organic substrates, thus improving biogas production, nutrient recovery and overall process stability [1-3]. The main objective of the study is to evaluate the effect of the addition of wine vinasse (V) to the co-digestion of slaughterhouse sludge (S) and wastewater (SW) on the performance of anaerobic digesters operating under mesophilic conditions at different hydraulic retention times (HRT).

Methodology

To carry out this study, the reactors are fed daily, and the pH of the effluent is determined, as well as the volume and composition of the biogas generated. To monitor the digesters, twice a week, analyses of the effluents from both reactors are performed for the following parameters: total and soluble chemical oxygen demand (tCOD) (sCOD), total and volatile solids (TS) (VS) and volatile fatty acids (VFA) [4].

Results and discussion

In terms of tCOD removal, the results show that with decreasing HRT the S:SW:V co-digestion system is more stable than the S:SW, reaching values of 56% and 48% respectively for a HRT of 15 days. On the contrary, in the case of the TS and VS the opposite occurs, the S:SW system reaches a higher percentage of solids removal, 52% and 49% compared to 52% and 42% for the S:SW:V fed digester. With regard to methane volume, the decrease in HRT causes an increase in the organic load in the feed, achieving higher methane generation in both reactors, being higher in the case of sludge and slaughterhouse waste. Finally, the methane yield with respect to added VS is higher in the S:SW:V (291.19 $mlCH_4/gVS_{added}$) feeding conditions for a 15-day HRT than in the S:SW system (155.41 $mlCH_4/gVS_{added}$).

Anaerobic co-digestion of slaughterhouse sludge and wastewater generates a higher volume of methane (334.08 $mlCH_4$/day) than in combination with wine vinasse (247.56 $mlCH_4$/day) operating at HRT of 15 days. In addition, it shows better depurative performances with respect to TS and VS. The addition of wine vinasse to co-digestion does not improve methane production, as although it contributes more SCOD than sludge and slaughterhouse wastewater, it reduces the total organic load supplied that can be transformed into methane.

Acknowledgements

This publication is part of the project PID2021-123174OB-I00, funded by MCIN/AEI/10.13039/501100011033/FEDER, EU. The authors would like to thank Spanish Ministry of Science and Innovation for the pre-doctoral contract associated with the project, PRE2022-104937 and the company Montesierra S.A. and the winery González-Byass for the supply of sludge, wastewater and wine vinasse.

References

Agabo-García C., et al. 2022. Anaerobic sequential batch reactor for CO-DIGESTION of slaughterhouse residues: Wastewater and activated sludge. Fuel. 255, 124575.

Sillero L., et al. 2023. Temperature-phased enhanced the single-stage anaerobic co-digestion of sewage sludge, wine vinasse and poultry manure: Perspetives for the circular economy. Fuel. 331, Part 2, 125761.

Sillero, L., et al. 2022. Improvement of the anaerobic digestion of sewage sludge by co-digestion with wine vinasse and poultry manure: Effect of different hydraulic retention times. Fuel. 321, 124104.

Methods S. 2012. Standard methods for the examination of water and wastewater. Water Res. 16, 1495–1496.

55. Factors influencing ammonia concentrations in finishing pig facility, Ireland

Aroh I.M.[a,b*], Clarke L.[a,c], McCutcheon G.[a], Curran T.P.[c]

Pig Development Department, Teagasc, Animal & Grassland Research & Innovation Centre, Moorepark, Ireland [a]; School of Biosystem and Food Engineering, University College Dublin, Belfield, Co. Dublin, Ireland [b]; Ballyhaise Agricultural College, Drumcrow, Ballyhaise, Co. Cavan, Ireland [c]; *Corresponding author, email: izuchukwumartin.aroh@teagasc.ie

Introduction

Ammonia (NH_3) and greenhouse gas emissions, including methane (CH_4) and nitrous oxide (N_2O) are receiving increased attention due to environmental and health concerns (Kriz et al., 2021). NH_3 is not only a significant air pollutant due to its strong odour and toxicity at high levels (Roney & Llados, 2004), but in Europe, animal production alone accounts for over 75% of NH_3 emissions. In Ireland, the agricultural sector contributes 98% of the total national NH_3 emissions, with pigs and poultry responsible for 7% (Kelleghan et al., 2021). This research focused on monitoring NH_3 concentrations within a pig research facility in Ireland. Using Off-axis Integrated Cavity Output Spectroscopy technology (LGR), the study examined NH_3 concentrations in a finishing pig building and its influencing factors.

Methodology

NH_3 concentrations were monitored continuously for 76 days (9th August – 23rd October 2024) in three Teagasc finishing pig rooms (Rooms A – 117 pigs, Room B – 112 pigs, and Room C – 102 pigs) using a Los Gatos Research (LGR) gas analyser. Indoor temperature and ventilation requirements were continuously monitored by the Big Dutchman system, and slurry height was measured weekly. Feed was consistent at 16% crude protein. Daily averages were used, and multiple linear regression (MLR) analysis was used to assess the relationship between NH_3 levels and influencing factors using R Studio.

Results and discussion

In Room A, the MLR analysis showed that the intercept for NH_3 concentration was 2.09 (±2.66 SEM), though this was not statistically significant ($p = 0.434$). Temperature had a significant positive relationship with NH_3 concentration, with an estimate of 0.21 (±0.022 SEM, $p = 3.51 \times 10^{-14}$). Slurry height also positively correlated with NH_3 levels, with an estimate of 0.046 (±0.00514 SEM, $p = 3.07 \times 10^{-13}$). In contrast, ventilation req. showed a significant negative relationship, with an estimate of -0.051 (±0.00564 SEM, $p = 1.44 \times 10^{-13}$). In Room B, the intercept was -11.28 (±2.70 SEM, $p = 7.98 \times 10^{-5}$), indicating a lower baseline NH_3 level. Temperature again showed a significant correlation (estimate = 0.23 ±0.02486 SEM, $p = 4.24 \times 10^{-14}$), as did slurry height (estimate = 0.0802 ±0.00741 SEM, $p = 7.69 \times 10^{-17}$). Ventilation requirement had a significant negative relationship with NH_3 concentration (estimate = -0.072 ±0.00645 SEM, $p = 1.90 \times 10^{-17}$). In Room C, the intercept was -2.44 (±1.75 SEM, $p = 0.168$), not statistically significant. Here, temperature had the strongest positive relationship among all rooms (estimate = 0.309 ±0.01348 SEM, $p = 4.56 \times 10^{-35}$). Slurry height remained a significant contributor (estimate = 0.0603 ±0.00423 SEM, $p = 8.93 \times 10^{-23}$), and ventilation requirement again had a notable negative relationship (estimate = -0.0788 ±0.00388 SEM, $p = 9.59 \times 10^{-32}$). Pu et al., (2021) found that reduced ventilation led to higher aerial pollutant levels in pig facilities.

Conclusion

Temperature and slurry height positively correlated with NH_3 concentration in all rooms. Ventilation requirement (%) negatively correlated with NH_3 concentration, helping to reduce it in all rooms. All variables are statistically significant, indicating their key role in influencing ammonia levels. Other influencing factors/measurement methods are continued to be explored further.

Acknowledgements

The authors acknowledge the funding from Teagasc and appreciate the farm staff for their great support.

References

Kelleghan, D. B., Hayes, E. T., Everard, M., & Curran, T. P. (2021). Predicting atmospheric ammonia dispersion and potential ecological effects using monitored emission rates from an intensive laying hen facility in Ireland. Atmospheric Environment, 247, 118214.

Kriz, P., Kunes, R., Smutny, L., Cerny, P., Havelka, Z., Olsan, P., Xiao, M., Stehlik, R., Dolan, A., & Bartos, P. (2021). Methodology for measurement of ammonia emissions from intensive pig farming. Agriculture, 11(11), 1073.

Roney, N., & Llados, F. (2004). Toxicological profile for ammonia.

Pu, S., Rong, X., Zhu, J., Zeng, Y., Yue, J., Lim, T., & Long, D. (2021). Short-term aerial pollutant concentrations in a Southwestern China pig-fattening house. *Atmosphere*, *12*(1), 103.

56. A meta-regression model to estimate the variation in ammonia emission fractions from fertilizer and manure across croplands in China

Cao, R.[a], Xu, W.[b *], Ros, G.H. [a] & de Vries, W.[a]

Earth Systems and Global Change Group, Wageningen University and Research, Wageningen, The Netherlands[a]; College of Resources and Environmental Sciences, National Academy of Agriculture Green Development, Key Laboratory of Plant-Soil Interactions of MOE, China Agricultural University, Beijing, 100193, China[b]; *Corresponding author, email: wenxu@cau.edu.cn

Introduction

Atmospheric ammonia (NH_3) plays a crucial role in the Earth's nitrogen cycle and its emission from agriculture has far-reaching impacts on both human and ecosystem health. Inventory studies have identified cropland fertilizer application and manure management as the primary contributors to NH_3 emissions in China. However, previous research on the factors influencing ammonia emissions from cropland has yielded inconsistent results in particular for the variation over space, with significant discrepancies in experimental findings and analytical approaches. The variation in emission factors across different climates, soil conditions, and application techniques further underscores the need for spatial explicit methods to estimate NH_3 emissions during manure and fertilizer use (Xu et al., 2024).

Methodology

We developed a meta-regression model to predict the NH_3 emission factor for manure and fertilizer use in croplands in China as a function of crop type, soil properties, and climate variables conditions based on 2549 field experiment datasets from 220 published studies. The NH_3 emission factor (i.e. the cumulative NH_3 emissions from the fertilized minus the emission of the unfertilized control plot divided by the N application rate) was estimated as:

$$lnEF = a_0 + a_1 \times fertilizer_{type} + a_2 \times App_{mode} + a_3 \times crop + a_4 \times Temperature + a_5 \times Precipitation + a_6 \times pH + a_7 \times CEC + a_8 \times Total\ N + a_9 \times Clay\ content + a_{10} \times bulk\ density + a_{11} \times N_{application\ rate} + +a_{12} \times Soil\ organic\ carbon$$

A meta-regression model was subsequently applied for all croplands across China, using spatially explicit information on crop type and he included soil properties, and climate variables, to quantify the spatial variability in emission fractions. Partial dependency plots and a variable importance analysis was done to assess how site properties control the emission fraction of NH_3, and subsequently analysed in view of potential measures reducing the NH_3 emission when fertilizers and manure are applied.

Results and discussion

Our findings indicate that rice exhibits the highest emission factor (EF) at 14.2%, followed by wheat (14.1%) and maize (7.2%), highlighting the necessity of employing crop-specific NH_3 EFs for accurate emission estimates. The EF across China ranges from 0.01% to 56.9%, exhibiting significant spatial variation. Furthermore, we observed significant spatial heterogeneity in NH_3 EFs across China, with notably higher values for rice in southern regions and elevated EFs for wheat and maize in northern China. Most important soil and climatic properties controlling EF were clay content and temperature. In detail, clay soils (soil with >40% clay fraction) showed on average 1.7% higher NH3 emissions than sandy soils (soil with <15% clay fraction). In normothermic climatic conditions (temperature > 10℃) was the EF on average 3.6% higher than on cold conditions.

Conclusion

These findings emphasize the need for region- and crop-specific mitigation strategies to reduce the ammonia emissions in China.

Acknowledgements

We gratefully acknowledge the China Scholarship Council (NO.201913043) for sponsoring this research.

References

Xu, P., et al. 2024. Fertilizer management for global ammonia emission reduction. Nature, 626(8000), 792-798.

57. Ammonia emissions of dairy systems with or without grazing: considering barn, storage and pasture

Edouard, N.[a]*, Delagarde, R.[a], Robin, P.[b], Vergé, X.[c] , Abdulwahab, M.O.[b] & Flechard, C.[b]

INRAE UMR PEGASE, France [a]; INRAE UMR SAS, France [b]; IDELE, France [c]; *Corresponding author, email: nadege.edouard@inrae.fr

Introduction

Dairy cattle are often fed on grazed pasture in Western Europe, with conserved forages and concentrates often used as supplements. Few studies have investigated the consequences of this combination on nitrogen use and losses, when cows divide their time between grazing, where urine and dung fall directly onto the ground, and animal housing, where manure needs to be managed and stored, leading to contrasted emissions to the environment. Our project focuses on strategies combining field grazing and conserved forages in dairy systems and their consequences on N flows and ammonia emissions. Several experiments were conducted to compare animal performance and ammonia emissions in full housing (FullHouse treatment) vs. part-housing-part-grazing (PartGraze treatment) vs. full grazing (FullGraze treatment) management systems in autumn 2022.

Methodology

In FullHouse, cows were housed in closed and mechanically ventilated rooms and fed *ad libitum* a total mixed ration (TMR) based on maize silage and concentrates (75:25 ratio). In FullGraze, cows grazed a lolium perenne-based temporary pasture day and night. Cows in PartGraze were housed as in FullHouse at night (other room), receiving 8 kg DM/day of TMR, and grazed the temporary pasture during 8 h/day between milkings. In FullHouse and PartGraze, manure was scraped twice a day; 25 kg of manure were collected on 4 successive scrapings in each period, and transferred to controlled pens. Ammonia emissions were measured in the barn and during manure storage from NH_3 spot concentration measurements with Dräger tubes and the application of the "Simplified Method", based on the carbon mass balance at the room or manure pen levels (Vergé et al., 2023). Field-scale ammonia emissions were determined by the aerodynamic gradient method using turbulence measurements and a Los Gatos Research quantum cascade laser analyser to determine vertical NH_3 gradients above the pasture. Field-scale emissions were also estimated with the Generation of Ammonia by Grazing (GAG) model (Moring et al., 2016). Ammonia emissions measured at the barn, storage and pasture levels in each treatment were added to estimate the range of potential NH_3 emissions (min and max when relevant considering errors on estimates) for FullHouse, PartGraze and FullGraze strategies.

Results and discussion

Total ammonia emissions were:
- 39-47 g NH_3/cow/day for FullHouse (i.e., 29-32 g from the barn and 10-15 g from manure storage respectively)
- 33-39 g NH_3/cow/day for PartGraze (i.e., 26-29 g from the barn, 6-9 g from storage and 0.6 g on the pasture respectively)
- 3.4 g NH_3/cow/day for FullGraze

For PartGraze strategy, barn and storage sources accounted for the largest share of ammonia emissions compared to the pasture source (< 2%). FullGraze had the lowest potential NH_3 emissions, in line with emission factors published in recent years (EMEP, 2019). Field scale ammonia emissions were however subject to large variations depending on animal weather conditions, stocking rate, pasture quality, (i.e., 0.6-27 g NH_3/cow/day on the same field on a 3-year campaign).

Conclusion

The most effective strategy in terms of ammonia mitigation was FullGraze. Although manure from an herbage-based diet has a greater emission potential compared to a maize-based diet, the reduced time spent in the barn led to slightly lower NH_3 emissions from PartGraze compared to FullHouse. Emissions during spreading must however also be considered.

Acknowledgements

The authors thank ADEME (EMIGRAZE project) and the EU FP7 program (CCC Farming project) for financial support.

References

European Environment Agency, 2019. EMEP/EEA air pollutant emission inventory guidebook 2013-Technical guidance to prepare national emission inventories.

Moring A., et al. 2016. A process-based model for ammonia emission from urine patches, GAG (Generation of Ammonia from Grazing): description and sensitivity analysis, Biogeosciences, 13, 1837–1861.

Vergé X., et al. 2023. Simplified method developed for estimating the on-farm GHG and NH3 emissions - Presentation and Results. 74th Annual Meeting of European Federation of Animal Science. Lyon, France.

58. Measurements of gaseous losses from organic residues as fertilizers

Dietrich, M.[a], Biatel, F. [a], Kozera, R. [a] & Foereid, B.[a*]

Norwegian Institute of Bioeconomy Research, Norway [a] *Corresponding author, email: bfoereid@gmail.com

Introduction

When organic residues are used as fertilizers, nitrogen losses can be as high or higher than when mineral fertilizers are used, including gaseous losses to the air (Charles et al. 2017; Wester-Larsen et al. 2022). To reduce losses, accurate assessment of losses with different managements and mitigation options are required, but measurements of losses to air are often expensive and labour intensive. Ammonia is the most important loss, whilst nitrous oxide is important because it is a greenhouse gas (GHG) and ozone depleting. Usually, GHG's and ammonia are measured separately with different methods, but when organic or ammonia-based fertilizers are used, both can occur simultaneously.

Methodology

We have developed an open dynamic chamber system based on Pape et al. (2009) that can sample both ammonia and GHG's, and have it analysed automatically. Different flow rates can be used so that both low and high concentrations can be measured, and flow rates can be set to alternate between high and low. The system was developed with low cost and versatility in mind. It has been tested with digestate in soil, both in the field and in pots in a greenhouse.

Results and discussion

Results from the tests will be presented and discussed. Ammonia and greenhouse gases can be measured simultaneously using this system.

References

Charles, A., et al., 2017. Global nitrous oxide emission factors from agricultural soils after addition of organic amendments: A meta-analysis. Agric. Ecosyst. Environ. 236, 88–98. Doi: 10.1016/j.agee.2016.11.021

Wester-Larsen, L. et al.., 2022. Potential ammonia volatilization from 39 different novel biobased fertilizers on the European market – A laboratory study using 5 European soils. J. Environ. Manag. 323, 116249. 10.2139/ssrn.4074926

Pape, L., et al., 2009. An automated dynamic chamber system for surface exchange measurement of non-reactive and reactive trace gases of grassland ecosystems. Biogeosciences 6, 405–429. 10.5194/bg-6-405-2009

59. Prediction of the ammonia emission potential based on the ALFAM2 model and meteorological projections for slurry spreading

Kupper, T.[a*], Urwyler, D. [b], Loser, S.[b] & Haeni, C.[a]

Bern University of Applied Sciences School of Agricultural, Forest and Food Sciences, Zollikofen, Switzerland [a]; Meteotest, Berne, Switzerland [b]; *T. Kupper, email: thomas.kupper@bfh.ch

Introduction

Field application of slurry is a major source of ammonia emissions from livestock production. Besides low emission techniques, timing applications to reduce emissions is a promising option. We established a web-based tool which is easy to use for farmers to identify time periods for field application of slurry with a low emission potential for any location in Switzerland.

Methodology

The tool consists of a Swiss map. To estimate emissions, we used the ALFAM2 model (Hafner et al., 2019), version 3.17. NH_3 emissions are calculated for each 1 km^2 grid in Switzerland based on actual meteorological projections from MOS (Multi-Model-Output-Statistics) for air temperature, wind speed and precipitation. For the required model input regarding slurry characteristics (content in dry matter, DM; Total Ammoniacal Nitrogen, TAN; pH) typical values for cattle slurry were used as default values: 4.5% DM, 1.05 g TAN/L, 7.2. A slurry application rate of 25 t/ha and trailing hose were chosen. The emission calculation over 48h is conducted at a time resolution of one hour over the next five consecutive days. It is updated hourly based on the most recent weather projection. The calculated emission data are then classified: the lowest 65% of emission values are assigned to a green symbol, the 15% highest values to a red one. The remaining 20% in between the green and red values are assigned orange. When tipping onto the map of the web surface at the location where the slurry application will occur, the symbols green, orange and red are displayed for each 1h interval over the next 5 days. These symbols are denoted 'Relative emission' and indicate one-hour intervals with relatively low (green), average (orange) and high (red) emissions. In addition, mean emissions for the period 1999 to 2022 were calculated for each 1 km^2 grid in Switzerland for each hour of the year based on air temperature data. The emission calculation was also done with the ALFAM2 model, 3.17 using the same default values as for the symbols 'Relative emission'. Since parameters other than air temperature were incomplete from 1999 to 2022, the default values 1.5 m/s for wind speed and 0 mm/h for precipitation were used. The hourly predicted emissions are compared with the averages 1999 to 2022 and assigned to the symbols green, orange and red for the 30%, the 31%-70% and the >70% percentiles of emissions, respectively. These symbols reflect the predicted emission level relative to the historical averages. They are denoted 'Historical emission' and displayed separately from the symbols 'Relative emission'.

Results and discussion

A test version of the tool is operative for 6 months (https://aero.meteotest.review/). Since then, periods occurred where the predicted emissions over 5 days were always higher than the historical average and thus, the symbols 'Historical emission' always displayed red. For farmers, who cannot postpone their application beyond the 5 days covered by the emission prediction, it is important to have the alternative classification 'Relative emission' which indicates time periods with relatively low emissions although the absolute emission level might be high. Model calculations based on meteorological data 1999-2022 indicate that a reduction in the range between approximately 2% and 11% of the total agricultural emissions can be achieved if the tool is employed and slurry is only applied during green time-periods with lowest emissions. The proportion of days which exhibit a time-period of ≥ 4h and ≥8h of consecutive hours with only green symbols for 'Relative emission', is approximately 45% and 30%. This suggests that the tool indicates sufficient time periods with a low emission potential where slurry application is feasible. We thus conclude that the tool can be effective to reduce emissions from slurry spreading. It would be a cost-effective measure with costs of between approx. 0.02 and 0.20 Euro per kg NH_3-N reduced. However, the tool must be improved: e.g. the two emission level symbols should be combined. We also suggest tests with farmers to adapt the tool to their needs before it will be implemented in practice.

Acknowledgements

This project was funded by the Swiss Federal Office of Agriculture and the Swiss Farmers' Union.

References

Hafner, S.D., et al. 2019. A flexible semi-empirical model for estimating ammonia volatilization from field-applied slurry. Atmos Environ 199, 474-484.

60. The influence of changes in production technique on modelled ammonia emissions in Switzerland

Kupper, T. [a*], Valach, A.C. [a], Zaucker, F. [b] & Haeni, C. [a]

Bern University of Applied Sciences School of Agricultural, Forest and Food Sciences, Zollikofen, Switzerland[a]; Oetiker+Partner AG, Olten, Switzerland[b]; *T. Kupper, email: thomas.kupper@bfh.ch

Introduction

In Switzerland, the inventory for ammonia (NH_3) emissions from agriculture is regularly updated since 1990, based on survey data on the agricultural production techniques. The inventory is used to assess the achievement of targets related to NH_3 emissions.

Methodology

In the reference years 2002, 2007, 2010, 2015, 2019 and 2024, a representative survey on production techniques of Swiss farms was conducted. The sample of approx. 50'000 farms was stratified according to three altitude levels, three regions of the country, and five farm types. Emission calculations were conducted with the model Agrammon (Kupper et al., 2015). For 1990 and 1995 expert knowledge was used to obtain the model input data. Between reference years, emission data were interpolated.

Results and discussion

From 1990 to 2019 total NH_3 emissions from agriculture decreased by 22%, from livestock production and manure management by 21% and from crop production by 39%.

Besides the emission level, the contribution of sources changed considerably due to changes in production, especially due to the wide introduction of systems benefitting animal welfare, nutrient balance restrictions, and changes in animal numbers. The strong decrease of emissions from crop production was due to the introduction of nutrient balance regulations that led to a decrease of mineral N-fertilizer use by 40% N. The principal reason for the decrease of emission from livestock production and manure management was the reduction of cattle and pig numbers (cattle -18%, pigs -34%) whilst the amount of produced meat and milk remained almost unchanged. Emissions from cattle decreased by 15%. This was mainly due to the decrease of emissions from dairy production by 24% which was partly compensated by the strong increase of emissions from nursing cows by a factor of 11.5. Emissions from pig production decreased by 49%. For the remaining livestock categories emissions increased considerably, but by an insignificant level (poultry 23%, equids 43%, small ruminants 3%).

Due to incentives for animal friendly production systems introduced in 1994, the N excretions deposited onto pastures increased by 56% for cattle. Combined with the reduced cattle numbers, this led to a decrease of N excretion in the housing area by 37%. In spite of this decrease, emissions from cattle housing increased by 20% because of the shift from tied to loose housing systems and the introduction of exercise yards, introduced due to increased herd sizes per farm and for animal welfare reasons. Due to the decrease of N excretions and higher emissions in the housing area, the N flow to and thus NH_3 emission from manure storage decreased considerably. The same was true for pigs. Overall, the share of emissions from the housing area increased from 26% to 36% of total emissions from livestock production, while the share of emissions from manure application decreased from 58% to 44%. The decrease of emissions from manure application to 37% for slurry application also reflects the shift to low emission application systems.

We will present the latest data related to manure management and ammonia emissions from agriculture in 2024 and for the time-period between 1990-2024.

Acknowledgements

This project was funded by the Swiss Federal Office for the Environment.

References

Kupper, T., et al. 2015. Evolution of farm and manure management and their influence on ammonia emissions from agriculture in Switzerland between 1990 and 2010. Atmos. Environ. 103, 215-221.

61. Mitigating ammonia emissions from pig farms implementing source-oriented measures

Levrault, C.M.[a*], Seefedpari, P.[a], de Mol, R.M.[a], Hol, J.M.G.[a], Aarnink A.J.A.[a] & van der Fels, J.B.[a]

Wageningen Livestock Research, Wageningen University & Research, The Netherlands [a]; [*]Corresponding author, email: cecile.levrault@wur.nl

Introduction

In the past decades, the European pig sector has intensified to answer the growing food demand. For the animals, this intensification translates in an increase of chronic environmental stressors that have adverse effects on their health, welfare, and productivity (O'Connor et al., 2010). One of the consequences of the higher animal densities that are observed in these intensive production systems (Maes et al., 2020) is the emission of pollutants such as ammonia (NH_3) (Zhang et al., 2024). This has repercussions on both indoor and outdoor air quality, with armful impacts on pigs and workers health as well as on the environment (Donham, 2000; Webb et al., 2014; Philippe and Nicks, 2015). Mitigating its emission is therefore essential.

Methodology

The NH_3 emissions of four commercial pig barns in the Netherlands were monitored over a period of two years. These emissions were monitored using a combination of real-time measurements taken by commercial sensors and a reference method (wet-chemical analysis (Mosquera et al., 2019)). Source-oriented reduction strategies such as daily manure removal, reduction of emitting area and manure dilution were implemented in a number of rooms of the target pig farms. Their effect on the aforementioned emissions was compared to the levels observed in the conventional pen designs.

Results and discussion

This study highlighted once again the challenges of monitoring emissions under practical settings. Sampling location, the number of samples taken, the time interval between two observations, and technology used are some of the difficulties encountered in practice. Yet, preliminary results showed the positive effect of these reduction strategies on NH_3 emissions, leading to significantly lower emission factors. Simultaneously, the better indoor air quality observed in these low-emission pens seemed to have positive effects on pigs health (decrease in occurrence of respiratory diseases) as well as on productivity (shorter fattening phase).

Conclusion

Preliminary analysis show the potential of mitigation strategies on both emissions and animal health. Furthermore, real-time emission monitoring would help farmers track their emissions and enable immediate decision-making for better management. Further analysis will allow for more precise conclusions to be drawn.

Acknowledgements

The authors acknowledge De Hoeve Innovatie for their contribution as project partner and the ministries LVVN and I&W for funding this project. Also special thanks for the efforts of the four participating pig farmers.

References

Donham, K.J. 2000. The Concentration of Swine Production: Effects on Swine Health, Productivity, Human Health, and the Environment. Vet. Clin. North Am.: Food Anim. Pr. 16:559–597.

Maes, D.G.D., et al. 2020. A critical reflection on intensive pork production with an emphasis on animal health and welfare. J. Anim. Sci. 98:S15–S26.

Mosquera, J., et al. 2019. Determination of ammonia concentrations in air from livestock housing systems: Reference method using gas washing as applied by Wageningen Livestock Research. Wageningen Livestock Research.

O'Connor, E.A, et al. 2010. The impact of chronic environmental stressors on growing pigs, Sus scrofa (Part 1): stress physiology, production and play behaviour. Animal 4:1899–1909.

Philippe, F.-X. and B. Nicks, 2015. Review on greenhouse gas emissions from pig houses: Production of carbon dioxide, methane and nitrous oxide by animals and manure. Agric., Ecosyst. Environ. 199:10–25.

Webb, J., et al. 2014. Ammonia and odour emissions from UK pig farms and nitrogen leaching from outdoor pig production. A review. Sci. Total Environ. 470:865–875.

Zhang, L., et al. 2024. A systematic review of life-cycle GHG emissions from intensive pig farming: Accounting and mitigation. Sci. Total Environ. 907:168112.

62. Ammonia emissions from separated cattle slurry fractions following land application

Lloyd, I.L.[a*], Thorman, R.E. [a], Kingston, H. [a], Kendle, S. [a], Priest, H. [a], Chadwick, D.[b] & Sagoo, E.[a]

ADAS, UK [a]; Bangor University, UK [b]; *Corresponding author, email: isobel.lloyd@adas.co.uk

Introduction

Agriculture is responsible for *c.*87% of UK ammonia (NH_3) emissions[1] and 11% of UK greenhouse gas (GHG) emissions[2], including 71% of the country's nitrous oxide (N_2O) emissions[2]. A considerable proportion of these losses are attributed to the storage of livestock slurries and their application to land as organic fertilisers. The separation of livestock slurries into solid and liquid fractions is a practical method that can reduce slurry storage and transportation costs. The low dry matter (DM) content of the liquid fraction compared to the whole slurry can increase infiltration of the material into the soil, potentially reducing NH_3 emissions and increasing crop available nitrogen (N) supply. Conservation of the N in the soil, however, may increase N_2O emissions and nitrate leaching losses. If the UK is to meet its targets of net zero GHG emissions by 2050 and reduce NH_3 emissions by 16% by 2030, it will be important to understand the impacts of applying the separated fractions of cattle slurry on crop nutrient availability, gaseous losses to air and nutrient losses to water. This is the focus of a new three-year Defra-funded project in the UK.

The overall aims of this project are to: understand the impacts of cattle slurry separation on crop growth, and quantify the impact of slurry separation on losses of NH_3 and GHGs. This poster will focus on NH_3 emissions.

Methodology and results

Field experiments will be carried out at two arable sites (central England, loamy sand soil and southeast England, clay soil), with treatments applied to both sites in autumn 2024 (to bare soil following potato harvest at the central England site and to cereal stubble at the southeast England site) and also in spring 2025. In autumn 2024 the following treatments were applied: 1) whole reception pit slurry (bandspread), 2) whole reconstituted slurry (bandspread), 3) separated liquid slurry (bandspread), 4) separated solids (surface applied), and 5) separated solids (surface applied and incorporated). Both sites were sown with winter wheat following the autumn 2024 treatment applications, and the same treatments were applied to different plots in spring 2025 to the actively growing winter wheat crop, with the exception that treatment 5 was replaced with stored separated solid (surface applied). The reconstituted slurry was created to simulate slurry diluted with rainfall during storage in an open lagoon/tank. Whole slurry taken from the reception pit was diluted with water to reach a target DM content of 6%.

The experiments will use a randomised plot design (each plot measuring 5 m x 12 m long), with three replicates of each treatment. Treatments will be applied using the ADAS small plot applicator (liquid slurry treatments) or by hand (solid treatments) at a target application rate of 100-150 kg total N ha^{-1}. Ammonia emissions from each plot will be measured using the wind tunnel technique (1 tunnel/plot) with emissions measured for 7 days following application. The wind tunnels will be moved daily along 3 positions to ensure that the soil/crop has been exposed to the elements.

A range of statistical analysis techniques will be used to assess the effects of slurry separation on NH_3 emissions and the influence of application method (i.e., bandspreading (trailing hose) vs surface broadcast, incorporated vs surface applied) and application timing (i.e., autumn vs spring application). Cumulative NH_3 emissions from each treatment will be presented, alongside an indication of the NH_3 lost as a percentage of the N applied.

Acknowledgements

This research is supported by the Defra-funded project: Evaluating the agronomic and environmental impacts of slurry and digestate separation.

References

[1] Defra, 2024. https://www.gov.uk/government/statistics/emissions-of-air-pollutants/emissions-of-air-pollutants-in-the-uk-ammonia-nh3#major-emission-sources-for-ammonia-in-the-uk

[2] Defra, 2024. https://www.gov.uk/government/statistics/agri-climate-report-2023/agri-climate-report-2023

63. Estimating the efficacy of low emissions slurry spreading (LESS) methods and slurry acidification at ammonia (NH_3) reduction under temperate grassland conditions in Ireland

McIlroy, J.[a*], Morton, P.A.[a], Gleasure, G.[b], Higgins, S.[a], Kelleghan, D.[c], Lanigan, G.J.[b], Olave, R.[a], Owusu-Twum, M.Y.[b], Ramsey, R.[a], Richards, K.G.[b] & Krol, D.J.[b]

Agri-Food and Biosciences Institute (AFBI), Belfast, Northern Ireland [a]; Teagasc, Johnstown Castle, Co. Wexford, Ireland [b]; University College Dublin, Dublin, Ireland [c]; [*]Corresponding author, email: john.mcilroy@afbini.gov.uk

Introduction

Gaseous ammonia (NH_3) negatively impacts both human and environmental health (Wyer et al., 2022). Agriculture is responsible for about 90% of NH_3 emissions on the island of Ireland, with over a third arising from the landspreading of cattle slurry (Bourdin et al., 2014). Slurry is used as a source of fertiliser and is landspread, typically on grassland, which is the predominant form of agricultural land use in Ireland. The traditional spreading method across Ireland involves a splashplate attachment to broadcast slurry, which creates a large surface area of exposure to the atmosphere, encouraging NH_3 volatilisation. It has been shown in several countries that LESS technologies reduce the NH_3 emissions from slurry spreading by depositing slurry at ground level or below, reducing the surface area of spread slurry and minimising contact with the atmosphere (Nyameasem et al., 2022). However, the efficacy of different LESS technologies on NH_3 emission reduction is uncertain under Irish conditions. Therefore, the aim of this study was to investigate the ability of three different LESS techniques to reduce NH_3 emissions compared to splashplate under typical Irish grassland conditions.

Methodology

Six paddock-scale plots (50 m x 50 m) were spread with cattle slurry at two permanent grassland sites, Loughgall in Northern Ireland and Johnstown Castle in the Republic of Ireland (ROI). Loughgall has sandy clay loam soil and Johnstown Castle has loamy soil; the soils and climate at these sites are representative of that found across a large proportion of agricultural grassland across the island of Ireland. Two of the plots at each site were spread by splashplate and two by trailing shoe. The other two plots at Loughgall were spread by trailing hose (dribble-bar) and the other two at Johnstown Castle were spread by open-slot injection. Acidified cattle slurry (sulphuric acid to slurry pH 6) was spread on two plots at Loughgall only, using the trailing hose method. These trials were run for two years, with three slurry applications and measurement periods at each site per year. The NH_3 emissions were monitored using integrated horizontal flux (IHF) shuttles and Fourier-Transform Infrared (FTIR) spectroscopy for at five days following each spreading event. Emission factors were calculated as the background-corrected cumulative NH_3 emissions for each trial divided by the total ammoniacal nitrogen (TAN) applied in slurry to each plot at the beginning of a trial. Linear mixed effects models were used to test for differences in TAN loss between slurry spreading techniques and spreading seasons.

Results and discussion

NH_3 emissions tended to peak on the day of spreading, with an average of 64% of NH_3 loss measured within 6 hours of spreading. Emissions then decreased exponentially to background emissions within five days. Mostly, emissions were lower during spring (March/April) trials, when temperatures were cooler and plants were growing rapidly, and highest in late summer (August). Due to the variability in NH_3 emissions from spreading techniques and between years, the season slurry was spread did not significantly affect the NH_3 emissions ($p > 0.05$). At both sites, NH_3 emission factors were significantly higher from splashplate plots than from slurry spread by LESS techniques ($F_{2,28} = 7.87$; $p < 0.01$ for Johnstown Castle, $F_{2,24} = 20.4$; $p < 0.01$ for Loughgall; Despite reducing TAN loss by 37% on average compared to splashplate, there were no significant differences between the LESS techniques ($p > 0.05$). Acidified cattle slurry spread by trailing hose exhibited the greatest reductions in NH_3 with an emission factor of 10.2% TAN.

Conclusion

On average, the LESS techniques explored in this study lower NH_3 emissions relative to splashplate spreading following slurry landspreading under Irish grassland conditions. However, compared with established emission factors for specific LESS techniques, as used in the UK and ROI agricultural NH_3 inventories, this study found lower differences in ammonia emissions between LESS types. Acidifying slurry to pH 6 in combination with a LESS technique offers significant further reductions in NH_3 emissions, beyond those offered solely by the LESS techniques. The data generated in this study may be used to revise Northern Ireland / ROI ammonia inventory emission factors, and in practical terms suggests there should be a focus on encouraging farmers and contractors on the island of Ireland to use the most readily available and accessible LESS equipment, as this may increase uptake and achieve greater total reductions in NH_3 at national level.

Acknowledgements

This research was financially supported by the Irish Department of Agriculture, Food and Marine (grant number 2019R554) and the Northern Irish Department of Agriculture, Environment and Rural Affairs (grant number 19/4/16).

References

Bourdin, F., Sakrabani, R., Kibblewhite, M., & Lanigan, G. 2014. Agriculture, Ecosystems & Environment, 188, 122-133.

Nyameasem, J., Zutz, M., Kluβ, C., ten Huf, M., Essich, C., Buchen-Tschiskale, C., Ruser, R., Flessa, H., Olfs, H-W., Taube, F., & Reinsch, T. 2022. Environmental Pollution, 315, 120302.

Wyer, K., Kelleghan, D., Blanes-Vidal, V., Schauberger, G., & Curran, T. 2022. Journal of Environmental Management, 323, 116285.

64. Management of nitrogen in nutrition of Italian heavy pig to reduce excretion and emissions

Moscatelli, G.[a]*, Bertolini, A.[a] & Pacchioli M.T.[a]

Research Centre on Animal Production – CRPA scpa, Reggio Emilia, Italy [a]; * g.moscatelli@crpa.it

Introduction

Among the innovations to limit Nitrogen (N) excretion and emissions from pig farming, the BATs (best available techniques – Santonja et al. 2017) include reducing the crude protein (CP) content of the diet and the use of feed additives. The evaluation of the effects of the indicated techniques was carried out in a commercial pig farm to assess how these experimentally verified effects (Shurson, 2023) can be measured and demonstrated under field conditions.

Methodology

The use of standard (Sp, 13,5%) and low (Lp, 12,2%) CP diets were evaluated. Both diets, balanced for amino acid and net energy intake, were evaluated with or without the addition of a commercial prebiotics mix (0.1% to the feed as is) with organic acid and chelated trace elements (SpA and LpA) in the grow-finishing diets. Animal performance of 1,956 Italian heavy pigs (from 60 to 170 kg live weight) divided into 4 groups housed in 4 barns independent for ventilation and slurry collection were monitored. Excreted N[2] and N yield[3] were evaluated (Della Casa et al, 2012). The air flows extracted by the fans of each shed and the ammonia concentration in the extracted air were measured 24/24 - 7/7 for three sessions (1 week each) during the grow-finishing to compute ammonia emission factors. To assess the effect of the 4 diets on the slurry, amounts of slurry were sampled during this three sessions from each shed. NH_3, nitrous oxide (N_2O) and methane (CH_4) emissions were measured six times on pig slurry samples, using the Static Chamber Method (Brewer et al, 1999) and gas analyser (INNOVA 1412), during a 3 weeks storage period under controlled conditions (20°C).

Results and discussion

In vivo and slaughter performances of the pigs in the 4 groups did not differ Excreted N results of 18.1, 15.9, 14.6 and 15.0 kg/head/year in Sp, SpA, Lp and LpA respectively. The differences in NH_3 detected in the stables were 3.54, 2.84, 3.37 and 3.32 kg NH_3 /pig place/year in Sp, SpA, Lp and LpA respectively, following the different N excretions produced by the 4 diets. The N_2O and NH_3 emissions of the Lp diets were lower than those of the Sp diets. For CH_4, significant differences between all 4 dietary treatments were registered, with the lowest emission for the LpA diet and the highest for the Sp diet. CH_4 emission was also significantly different between the SpA and Sp diets (0.151 ± 0.031 vs. 0.235 ± 0.065).

Conclusion

The effectiveness of emission mitigation measures evaluated at the experimental level was also appreciable at the field level in a real pig farm. However, measuring emission dynamics is very difficult in commercial farm as well as appreciating statistically relevant differences due to the application of BATs.

Acknowledgements

Initiative within the SUS-STAINABILITY EIP-AGRI Operational Group SUS-tainability, co-financed by the FEASR - Operation 16.1.01 of the RDP 2014 – 2020 of the Lombardy Region.

References

Germán Giner Santonja, Konstantinos Georgitzikis, Bianca Maria Scalet, Paolo Montobbio, Serge Roudier, Luis Delgado Sancho; Best Available Techniques (BAT) Reference Document for the Intensive Rearing of Poultry or Pigs; EUR 28674 EN; doi:10.2760/020485.

Shurson GC and Kerr BJ (2023) Challenges and opportunities for improving nitrogen utilization efficiency for more sustainable pork production. Front. Anim. Sci. 4:1204863. doi: 10.3389/fanim.2023.1204863

Della Casa G., Pacchioli M.T. and Marchetti R. (2012) Nitrogen use efficiency improvement in heavy-pig production in Northern Italy. 17th International Nitrogen Workshop, Wexford, Ireland June 26 -29 2012.

Brewer S.K., Costello T.A., 1999. In situ measurement of ammonia volatilization from broiler litter using an enclosed air chamber. Transactions of the ASAE. 42 (5): 1415-1422

Web addresses: https://www.fondazionecrpa.it/prodotto/sus-tainability/

[2] (Ingested N – in fixed in tissue of incoming pigs) – (Estimated N fixed in tissue of died and ongoing pigs)

[3] (N fixed in tissue/Ingested N * 100)

65. Air fresher captures ammonia in pig farm and improves animal health

Moure Abelenda, A.[a*], Fernández, M.D.[b] & Rodríguez, M.R.[b]

Soil Quality Assessment Research Group, Department of Soil Science and Agricultural Chemistry, Universidade de Santiago de Compostela, Avenida de Vigo, s/n, 15782 Santiago de Compostela, Spain [a]; Department of Agroforestry Engineering, Higher Polytechnic Engineering School, Campus Terra, Universidade de Santiago de Compostela, 27002 Lugo, Spain [b]; *Corresponding author, email: alejandro.moure@usc.es

Introduction

Farming is responsible of the 30% of global anthropogenic emissions (Lal, 2021). There are many factors affecting animal wellbeing in the intensive pig production (Buller et al., 2018): light, temperature, composition of the atmosphere, rate of removal of the slurry under the grill, etc. The present study investigates a novel air fresher to capture bad odours and ammonia (Gu et al., 2021), to keep pigs calm and with a good rate of weight gain.

Methodology

This research was conducted for 4 weeks, to allow sufficient time for recording the air quality without the air fresher (first 2 weeks) and with the air fresher (last 2 weeks). In addition to the homogenous distribution of the air fresher thought out the whole stable of 300 pigs, the photoacoustic gas monitor of Innova 1512 with the multipoint sampler Innova 1409 were installed and connected to computer for continuous recording throughout the 4 weeks incubation. At the beginning of the study the Large White pigs weight around 50 kg.

Results and discussion

Pigs were found to be quieter and the levels of ammonia in the atmosphere decreased significantly with the use of the air fresher. The farmer also reports better smell and less problems with his breathing. However, concerns of the cost of the air fresher and the rate of consumption to ensure a pleasant atmosphere has been raised by the farmer.

Conclusion

The use of this type of air freshers are recommended to ensure a smooth operation in the pig farms, as pigs were found to be quieter and calmer. Long term studies are required to confirm the techno-economic viability of this air freshers measure.

References

Buller, H., Blokhuis, H., Jensen, P., & Keeling, L. (2018). Towards Farm Animal Welfare and Sustainability. Animals, 8(6), 81. https://doi.org/10.3390/ani8060081

Gu, B., Zhang, L., Van Dingenen, R., Vieno, M., Van Grinsven, H. J., Zhang, X., Zhang, S., Chen, Y., Wang, S., Ren, C., Rao, S., Holland, M., Winiwarter, W., Chen, D., Xu, J., & Sutton, M. A. (2021). Abating ammonia is more cost-effective than nitrogen oxides for mitigating PM 2.5 air pollution. Science, 374(6568), 758–762. https://doi.org/10.1126/science.abf8623

Lal, R. (2021). Climate change and agriculture. In T. M. Letcher (Ed.), Climate Change, Observed Impacts on Planet Earth (3rd ed., pp. 661–686). Elsevier B.V. https://doi.org/10.1016/b978-0-12-821575-3.00031-1

66. Effect of nitrification inhibitors mixed in field applied organic slurries on ammonia emissions under conditions of Central Europe

Pacholski, A.S.[a*] and Wonneberger, A.[a]

Thuenen-Institute of Climate Smart Agriculture, Germany [a*]Corresponding author, email: andreas.pacholski@thuenen.de

Introduction

Nitrous oxide (N_2O) is one of the most relevant greenhouse gases (GHG) emitted from agriculture, in particular from mineral and organic nitrogen fertilizers applied to soil. N_2O-emission mitigation practices in arable farming play therefore an important role in the overall reduction of this potent GHG. One of the most debated and strongly recommended measures for N_2O emission reduction is the use of nitrification inhibitors (NI) mixed into organic or coated on mineral nitrogen fertilizers. While the effect on the N_2O emission reduction is still discussed for annual emissions, it is not clear to which extent their use can affect ammonia (NH_3) emissions from nitrogen fertilizers, potentially diminishing the envisaged environmental benefits from NI use. NIs stabilize the ammonium form in fertilizers and this has also the potential to increase NH_3 emissions. There is some global evidence for an increase in NH_3 emissions after use of NI DCD in slurry and from NIs DCD and DMPP on urea from literature (Lam et al 2017, Wu et al. 2021), but it is still uncertain to which extent this is the case for particular climatic conditions and for specific inhibitor substances. This study provides insights on NH_3 emissions from field applied organic manures mixed with nitrification inhibitors under conditions of central Europe. The guiding hypothesis was that such ammonia emissions are not increased by use of nitrification inhibitors due to slow ammonium nitrification rates under typical cold temperature application conditions of central European and comparably fast NH_3 emissions dynamics.

Methodology

This study summarizes evidence from literature and from recent field studies in the context of the national joint project 'NitriKlim' on GHG emission, crop productivity and detrimental side effects of their use including NH_3 emissions. Measurements within the project were done in all study sites (6) in replicated plots (9 m x 9 m) with cattle slurry treated with the often-used NI DMPP applied by open slot injection into winter wheat canopy. Ammonia concentrations were determined by ALPHA passive samplers and NH_3 emissions calculated by means of inverse dispersion modelling for an emissions period of 1 week after slurry application. Emissions are statistically compared and evaluated with respect to location, inhibitor type and soil and weather conditions.

Results and discussion

First results obtained from literature (e.g. Huf et al. 2023,) give evidence that ammonia emissions were not increased by addition of the NI DMPP after injection of biogas digestates and cattle slurry on arable and grassland in Germany under spring conditions, with also no concomitant effect on N_2O emission reduction. The samples from NitriKlim project are still under processing but first results corroborate previous observations of no NH_3 emission increase by use of NI under the chosen condition. NitrKlim results will add a large amount of new evidence on the effects of NI use on NH_3 emissions from field applied slurries. The effects of weather, soil conditions and inhibitor type on NH_3 loss require more attention.

Conclusion

A first summary of NI effects on ammonia emissions from slurries supports the hypothesis that NH_3 emissions are unaffected by NI use under conditions of central Europe. A more detailed analysis will be presented on the conference.

Acknowledgements

This study is supported by the German Federal Agency on Agriculture and Food (BLE).

References

Huf M, Reinsch T, Zutz M, Essich C, Ruser R, Buchen-Tschiskale C, Flessa H, Olfs H-W, (2023) Effects of liquid manure application techniques on ammonia emission and winter wheat yield. Agronomy 13(2):472, DOI:10.3390/agronomy13020472

Lam, SK; Suter, H; Mosier, AR.; Chen, D (2017): Using nitrification inhibitors to mitigate agricultural N_2O emission: a double-edged sword? Glob Chang Biol 23 (2), 485–489. DOI: 10.1111/gcb.13338

Wu, D.; Zhang, Y.; Dong, G.; Du, Z.; Wu, W.; Chadwick, D.; Bol, R. (2021): The importance of ammonia volatilization in estimating the efficacy of nitrification inhibitors to reduce N2O emissions: A global meta-analysis, Environmental Pollution 271, 116365, DOI: 10.1016/j.envpol.2020.116365

67. Evaluation of application and treatment options for reducing ammonia emissions from field-applied slurry digestate

Pedersen, J.[a*], Romio, C.[a], Pacholski, A. S.[b] & Hafner, S. D.[a]

Dept. of Biological and Chemical Engineering, Aarhus University, Denmark [a]; Thünen Institute for Climate-Smart Agriculture, Braunschweig, Germany[b]; [*]Corresponding author, email: jp@bce.au.dk

Introduction

Biogas can be produced from digestion of animal slurry. In Denmark, recalcitrant biomasses are often added to the process, resulting in a high dry matter (DM) digestate with a high potential for ammonia (NH_3) emission after field application, posing a risk to the environment and loss of nitrogen for the farmer (Pedersen & Hafner 2023; Romio et al., 2024). The aim of this study was to investigate how different treatments and application techniques affect NH_3 emissions from field application of high DM digestates.

Methodology

A total of 12 field trials were conducted to quantify the effects of different digestate treatments and application techniques on NH_3 emissions after field application of digestates. Treatments were low-dose acidification (1 kg H_2SO_4 per ton digestate) and solid-liquid separation. Four different application techniques were compared: trailing hose, two different trailing shoe designs, a novel design combining trailing shoe with a harrowing tine, and open slot injection. Emissions were measured with a system of dynamic flux chambers (Pedersen et al., 2024) using cavity ring-down spectroscopy for NH_3 concentration measurements (Garcia et al. 2024), allowing for replicates and high-time resolution of the NH_3 flux measurements.

Results and discussion

Measured NH_3 emissions varied substantially among trials, and emission was clearly related to digestate source. Acidification with 1 kg H_2SO_4 per ton slurry effectively reduced emissions by up to 33% in some cases, but the effect was inconsistent and most likely related to DM concentration of the digestate. There was a significant lower cumulative emission from the liquid fractions after separation compared to the unseparated digestate in all cases, but the magnitude of the reduction varied from 33 to more than 80%. On average, application by trailing shoe yielded similar emissions as application by trailing hose, but in individual trials lowest emissions were observed from trailing shoe. Application by a new design, combining trailing shoes with a harrowing tine, consistently lowered NH_3 emissions in four separate trials, by more than 40% in some cases.

Conclusion

The presented field trials results assessing different low NH_3 emission digestate treatments and application techniques revealed a lack of consistency regarding mitigation effects. As it is therefore not possible to recommend one universal approach, the optimal application technique and possible digestate treatment should be assessed based on digestate properties and soil and crop conditions at the time of application. It is important to investigate the sources of variation in reduction efficiencies to understand when and why a certain measure is efficient at reducing the NH_3 emissions.

Acknowledgements

This work was funded by the Ministry of Food, Agriculture and Fisheries of Denmark (GUDP, journal nr.: 34009-21-1829)

References

García, P. et al., 2024. Investigation of non-target gas interferences on a multi-gas cavity ring-down spectrometer. Atmos. Environ. X. 22. 100258. doi: oi.org/10.1016/j.aeaoa.2024.100258

Pedersen, J. and Hafner, S. D. 2023. Ammonia emissions after field application of anaerobically digested animal slurry : Literature review and perspectives. Agric. Ecosyst. Environ. 357. 108697. doi: 10.1016/j.agee.2023.108697

Pedersen, J. et al. 2024. Evaluation of optimized flux chamber design for measurement of ammonia emission after field application of slurry with full-scale farm machinery. Atmos. Meas. Tech., 17, 4493-4505. doi: 10.5194/amt-17-4493-2024

Romio, C. et al., Characterization and valorization of biogas digetate and derived organic fertilizer products from separation processes. Front. Sustain. Food Syst. 8 :1415508. doi: 10.3389/fsufs.2024.1415508

68. NO_x and N_2O emissions following RENURE, organic and inorganic fertilizer application to clay soils

Van Waaij, J.J. [a*], Porre, R.J.[a], Van Groenigen, J.W.[b] & Velthof, G.L.[a]

Wageningen Environmental Research, Wageningen University & Research, The Netherlands [a]; Soil Biology Group, Wageningen University & Research, The Netherlands [b]; [*]Corresponding author, email: jurrian.vanwaaij@wur.nl

Introduction

Organic fertilizers are widely used within Dutch agriculture (Oenema and Oenema, 2021), but its use is becoming more restricted due to associated nitrogen losses – like NO_x and N_2O – to the environment. N_2O is a potent greenhouse gas and NO_x as an air pollutant is detrimental to both nature and animal and human health. Furthermore, the overproduction of manure poses an economical problem for farmers (Ryan and Hoes). Recovered nitrogen from manure (RENURE) has been introduced as a means to address economic and environmental issues linked to fertilization practices (Vingerhoets et al., 2025). Yet, it is unclear how RENURE usage affects N losses, such as N_2O and NO_x emissions from cropping systems. Especially NO_x emissions have received little attention, hampering both our understanding on and mitigation of these emissions. First incubation studies indicate that inorganic fertilizers induce considerably higher NO_x emissions than organic fertilizers, but it is not clear how these findings translate to cropping systems, especially given the wide variety in origin of RENUREs. To this end, the research question is posed:

"How do organic, inorganic and RENURE fertilizers affect NO_x emissions from grassland and maize cropping systems?"

Based on the first findings, the next hypothesis are posed:

- Maize cropping will emit more NO_x than grassland because applied mineral N is rapidly taken up by grassland, whereas soil mineral N contents are elevated for a longer period in arable systems after N application.
- Fertilizing with NO_3^- based fertilizers lowers NO_x emissions compared to fertilizing with NH_4^+ based fertilizers, and fertilizing with organic fertilizers lowers NO_x emissions compared to fertilizing inorganic fertilizers.
- Plots with a lower bulk density will emit more NO_x than soils with a higher bulk density as aeration levels for soils with a lower bulk density are more optimal for NO_x emissions.
- Plots with a higher C/N ratio will emit less NO_x compared to soils with a lower C/N ratio as fertilizer-N is immobilized in soils with a higher C/N ratio whereas soils with a lower C/N ratio deliver extra N through mineralization.

Methodology

A two-year field experiment will be conducted in which NO_x and N_2O emissions will be measured from grass and maize cropping systems on clay soils. Various inorganic, organic and RENURE fertilizers will be compared, as well as application of combined organic and inorganic fertilizers. Soil N contents and pH will be monitored over time by taking soil samples.

Results and discussion

Preliminary results will be available in October

References

Journal citation format:

Oenema, J., et al. 2021. Intensification of grassland-based dairy production and its impact on nitrogen and phosphorus use efficiencies. Frontiers of agricultural science and engineering. 8, 130-147.

Ryan, M., et al. 2024. Justice and Sustainability Tensions in Agriculture: Wicked Problems in the Case of Dutch Manure Policy. Ethics, Policy & Environment, 1-18.

Vingerhoets, R., et al. 2025. Economic potential for nutrient recovery from manure in the European union. Resources conservation and recycling. 215.

69. Development of microbial inoculant consortia for sustainable pig slurry treatment

López, M.J.[a*], Salinas, J.[a,b], Jurado, M.M.[a], López-González, J.[a], Estrella-González, M.J.[a], Segura-Pérez, M.L.[b], Contreras, J.I.[b], Carpena-Istán, V.[a], Segado, M.[a], & Suárez-Estrella, F.[a]

Department of Biology and Geology, CITE II-B, University of Almería, Agrifood Campus of International Excellence, ceiA3, CIAIMBITAL, 04120, Almería, Spain [a] ; Institute of Research and Training in Agriculture and Fishery (IFAPA), E04745, La Mojonera, Almería, Spain [b]; *Corresponding author, email: mllopez@ual.es

Introduction

Effective management of pig slurry is essential to mitigate environmental impacts, such as ammonia and greenhouse gases (GHG) emissions, odors, and the leaching of nitrates into soil and groundwater. To address these challenges, there is growing interest in developing sustainable biological treatments within the circular bioeconomy, which aim to reduce the environmental burden of pig slurry while promoting resource recovery (Wu et al., 2023). Microbial inoculants are specially selected microorganisms used to enhance biological processes, such as the treatment of pig slurry. The use of microbial consortia, which are tailored mixtures of microorganisms, enhances treatment efficiency and can be optimized for specific goals. This study aims to develop microbial inoculants and management strategies to reduce inputs, harmful emissions, and costs while maximizing nitrogen conservation in pig farm.

Methodology

Microorganisms were obtained through enrichment and isolation from pig slurry samples. The isolates were cultured using selective techniques and combined into consortia to achieve specific activities. The consortia were designed to stabilize nitrogen and reduce ammonia and GHG emissions. The effectiveness of the inocula was tested in laboratory experiments using 250 mL flasks, with the analysis of parameters such as pH, BOD, volatile solids, nitrogen species, and microbial communities composition. The members of the selected inocula were identified through sequencing, and their composition was adjusted based on their functionalities.

Semi-pilot-scale incubation experiments were performed in two bioreactors and a 2L tray to simulate farm conditions. Bioreactor 1 adapted the selected inoculum, Bioreactor 2 simulated a manure pit, and the tray replicated manure storage pond conditions. The effects of variables such as inoculant type, nutrients, chemical agents, inhibitors, and biochar on transformation efficiencies and emissions were evaluated.

Results and discussion

The isolates obtained from pig slurry included lactic acid bacteria such as *Lactobacillus*, heterotrophs with denitrifying activity like *Bacillus* and *Sporosarcina*, as well as *Brevundimonas* and *Dietzia*, which exhibit nitrifying activity. In parallel, a complex inoculum was obtained by adjusting pH, aeration, and adding nutrients to fresh pig slurry. The composition of this inoculum was analyzed, revealing a diverse microbial community, and its functionality was predicted. The isolates were combined into three different consortia based on their compatibility and nitrogen metabolism. Additionally, three complex inocula were obtained from different pig slurry samples. Lab-scale analysis revealed that three of the inocula caused a decrease in pH and maintained ammonium levels with low emissions. Semi-pilot-scale experiments are currently ongoing, and the results obtained at lab scale are being replicated, showing consistent outcomes.

Conclusion

This study will contribute to developing more sustainable livestock manure management practices, focusing on microbial inoculants to reduce environmental impact and operational costs. If successful, it will pave the way for implementing these innovative treatments in real-world farm settings.

Acknowledgements

This work was funded through the project PP.PEI.IDF2023030.001 - Development of Treatment Techniques and Agricultural Valorization of Intensive Pig Slurry in Eastern Andalusia (AgroPuriTech). Instituto Andaluz de Investigación y Formación Agraria, Pesquera, Alimentaria y de la Producción Ecológica (IFAPA). Consejería de Agricultura, Pesca, Agua y Desarrollo Rural. Junta de Andalucia (Spain).

References

Wu, H., et al. 2023. The potential and sustainable strategy for swine wastewater treatment: resource recovery. Chemosphere, 336, 139235.

70. Evaluating Four Configuration Systems for NH_3 Emission Reduction and Nitrogen Recovery as Fertilizer

Calvo de-Diego, P., García-González, M.C., Sánchez-Báscones, M. & Molinuevo-Salces, B.

Department of Agroforestry Sciences, ETSIIAA, Universidad de Valladolid, Avenida de Madrid 44, 34004 Palencia. Spain [a]
*Corresponding author, email: beatriz.molinuevo@uva.es

Introduction

Ammonia (NH_3) emissions from livestock farming represent a significant environmental challenge, contributing to air pollution, ecosystem disruption and indirect greenhouse gas emissions. Various technologies have been developed for NH_3 capture from livestock operations. These include acid scrubbers, biofilters and chemical additives. However, gas-permeable membrane (GPM) technology has emerged as a promising solution due to its efficiency and versatility (Vanotti and Szogi, 2010). The objective of this work is to study 4 different configuration systems using GPM to abate NH_3 emissions while recovering N as a valuable fertilizer.

Methodology

To carry out this study, 4 different systems were studied, namely T1, T2, T3 and T4. The 4 systems proposed were as follows: T1: GPM system with gas recirculation, where the gas is introduced through the inside of the membrane and recirculated from the outlet to the container where the emission of the gas is done, T2: GPM system with forced circulation of the gas through the GPM, where the end of the membrane is closed, T3: System with bubbling of the NH_3 in the water by means of diffusing stone, and a GPM system submerged in the water with circulation of acidic solution through the inside of the GPM and T4: System with direct bubbling of the gaseous NH_3 into the acidic solution. The emission of NH_3 was performed using an NH_3 solution subjected to agitation with a magnetic stirrer. The recovery of N was carried out using as trapping solution a solution of 1N sulfuric acid. The emission and recovery systems were connected. The experiments were performed in duplicates and the experimental time was 60 minutes for all the proposed systems. The initial volume of emitting solution and trapping solution was 150 mL and 250 mL, respectively. A sample was taken every 20 minutes from both the emitting and trapping solutions, from which total ammonia nitrogen (TAN) was measured. With the TAN emitted and recovered, the percentage of N recovered was calculated.

Results and discussion

Nitrogen recoveries of up to 48% were obtained with T1, where the NH_3 gas was circulated inside the GPM system. T1 provided better results than T2 under forced gas circulation conditions, achieving N recovery values of 47 ± 2%, while T2 reached N recovery values in the range of 14 ± 5%. On the other hand, T3, which utilized a water trap and bubbled the generated NH_3 into water using a diffusion stone, achieved N capture percentages between 20 ± 4%. These results were slightly lower than those obtained with T4, which employed direct bubbling of the NH_3into acid using a diffusion stone, achieving N capture percentages of 22 ± 3%. These results are in accordance with Riaño et al. (2022), who reported that the use of GPM selectively allows NH_3 to permeate through the membrane pores. Once traversed, the NH_3 is captured and concentrated in an acidic trapping solution, thus enhancing the overall recovery process, compared to the direct bubbling of NH_3 into the acidic solution using a diffusion stone.

Conclusion

Considering the results obtained in the 4 configuration systems, the best results were obtained in T1 with NH_3 recirculation inside the membrane. So that the use of the membrane to transfer the NH_3 to the sulfuric acidic solution and thus obtain ammonium sulfate is more effective with the use of the membrane than with direct bubbling (with fine bubbles) directly in the acidic solution.

Acknowledgements

This work has been funded by the European Union under the Project Life GREEN AMMONIA (LIFE20-ENV/ES/000858). B. Molinuevo-Salces thanks AEI for funding, through RYC-2020-029030-I/AEI/10.13039/501100011033.

References

Vanotti, M. B., and Szogi, A. A. 2010. Removal and recovery of ammonia from liquid manure using gas-permeable membranes. In *2010 Pittsburgh, Pennsylvania, June 20-June 23, 2010* (p. 1). American Society of Agricultural and Biological Engineers.

Riaño, B., Molinuevo-Salces, B., Vanotti, M. B. and García-González, M. C. 2022. Effect of Operational Conditions on Ammonia Recovery from Simulated Livestock Wastewater Using Gas-Permeable Membrane Technology. *Environments*, *9*(6), 70.

71. Effect of Biochar on Nitrogen Dynamic to Regulate Ammonia and Nitrous Oxide Emissions during Composting

Elviliana, Elviliana.[a*], Couvert, Annabelle.[b] Capson-Tojo, Gabriel.[c] Escudié, Renaud.[c] & Trémier, Anne.[a*]

INRAE, OPAALE, F-35044 Rennes, France[a]; Univ Rennes, Ecole Nationale Supérieure de Chimie de Rennes, CNRS, ISCR - UMR 6226, F-35000 Rennes, France[b]; INRAE, Univ Montpellier, LBE, 11100 Narbonne, France[c]; [*]Corresponding author, mail: elviliana.elviliana@inrae.fr

Abstract

The release of ammonia (NH_3) and nitrous oxide (N_2O) emissions during composting is inevitable, compromising nutrient recycling efficiency and contributing adversely to air quality. Previous researches have shown that incorporating biochar into composting leads to a reduction of nitrogen (N) losses, particularly NH_3, and N_2O emissions[1,2]. However, a recent statistical study has shown that the effectiveness of biochar still varies significantly across different treatments of composting and highly depend on its characteristics[3]. The goal of this study is to fully elucidate the mechanisms through which biochar regulates the N dynamics and ultimately decreases those gaseous emissions during composting. For this reason, composting trials at laboratory scale were performed in controlled conditions for four experimental groups, with two types of biochar (woody/WBC and algae-derived biochar/ABC), under different pyrolysis temperature (450℃ and 650℃). In addition, two types of raw waste to be composted, i.e., solid digestate (SD) and food waste (FW), were investigated to observe the connection of biochar capacity to retain N with the characteristics of the raw materials. Results showed that NH_3 emission occurred largely during the bio-oxidative phase of composting, while the N_2O emissions emerged mainly in cooling and maturation phase. Compared to WBC biochar, the treatment with addition of ABC biochar had a beneficial effect on the mitigation of N losses thanks to a higher reduction of NH_3 emission. Concerning N_2O emission, all the biochar treatments led to higher cumulative N_2O emission compared to the control treatments without biochar. This study highlights the mechanisms associated with biochar addition, providing valuable insights for controlling ammonia emissions and suggesting directions for the future development of functional biochar with specific characteristics aiming at limiting later emissions of N_2O.

References

1. Liu, J., *et al.* 2024. Insight into mitigation mechanisms of N2O emission by biochar during agricultural waste composting. *Bioresour. Technol.* 406, 130970.

2. Gu, X., *et al.* 2025. Magnesium modified biochar facilitates favorable nitrogen conversion to mitigate ammonia and nitrous oxide emissions during pig manure composting. *Chem. Eng. J.* **504**, 159073.

3. Vieira Firmino, M. & Trémier, A. 2023. Nitrogen Losses Mitigation by Supplementing Composting Mixture with Biochar: Research of the Ruling Parameters. *Waste Biomass Valorization*.

72. Nitrous oxide emission from fertilised temperate grassland: a comparison of cumulative emissions determined by automatic and static chamber methods.

Agyemang Duah, A.[a, b,d*], Murphy, P.N.C.[a,c] , Krol, D.J.[b,d] , Connolly, S[b].& Richards, K.[d]

School of Agriculture and Food Science, University College Dublin, Dublin, Ireland [a]; Environment, Soils and Land Use Department, Teagasc, Wexford, Ireland [b]; UCD Earth Institute, University College Dublin, Belfield, Dublin, Ireland [c]; Teagasc Climate Center, Wexford, Ireland [d]; [*]Corresponding author, email: angela.a.duah@teagasc.ie

Introduction

Agriculture soils account for 66% of global anthropogenic N_2O emissions emitted into the atmosphere due to N fertilisation (Davidson and Kanter, 2014). However, measuring soil N_2O using static chambers introduces significant uncertainties in estimating cumulative emissions and emission factors (EFs) (Hénault et al., 2012), as specific management events can significantly influence seasonal N_2O emissions. Therefore, intensive monitoring of N_2O is essential for improving the accuracy of annual cumulative N_2O and EFs estimates, assessing mitigation strategies, and refining national emission inventories. This study aimed to comparatively explore the differences in quantifying seasonal N_2O emissions from synthetic N fertilisers at different temporal scales using manual and automated chamber methods.

Methodology

The field study was conducted on a managed grassland from March to December 2023 at Teagasc, Wexford, Ireland. Experimental plots were arranged in a randomised block design, with four fertiliser treatments applied at a rate of 40 kg N ha^{-1} in five equal split applications. The treatments were: (1) calcium nitrate (CN); (2) NPK 27-2.5-5; (3) NPK 18-6-12 and; (4) ammonium sulphate (AS). To directly compare the two measurement methods, static and automatic chambers were set up side by side on the same plot. Static chamber sampling occurred daily between 10 am and 1 pm for the first two weeks, followed by twice-weekly sampling for subsequent weeks and weekly measurements until the next fertilisation event. In contrast, automatic chamber measurements were taken continuously throughout the fertilisation period, with each chamber sampling for five minutes per cycle.

Results and discussion

Soil N_2O fluxes were highly variable and fertilisation-dependent. Peak N_2O emissions recorded by automatic chambers were 1.4 to 3.2 times higher than the static chambers. Seasonal cumulative N_2O emissions from treatments ranged from 0.02 to 1.37 kg N ha^{-1} for static chambers and 0.07 to 2.09 kg N ha^{-1} for automatic chambers due to significant changes in soil moisture and temperature dynamics. Significant differences were observed between methods during the fertilisation periods. In early spring (first split application), automatic chamber measurements showed 65% higher cumulative N_2O emissions for AS plots ($P = 0.006$) than static chamber measurements. However, no significant differences were observed among the remaining treatments. In late spring (second split application), automatic chamber measurements recorded emissions 60 to 71% higher than static chamber measurements across all treatments ($P < 0.05$). No significant differences were observed between the two methods for the rest of the fertilisation period.

Conclusion

The automatic chamber measurements showed dynamics of N_2O changes throughout the season that were unobservable with static chamber measurements due to low temporal resolution. Seasonal cumulative N_2O emission was 24 to 69% higher with automatic chamber than static chamber measurements, highlighting the need for continuous sampling to provide more accurate data for greenhouse gas inventories and mitigation strategies.

Acknowledgements

This research was supported in part by a Grant from Science Foundation Ireland under Grant number (21/RI/9642) and the Department of Agriculture, Food and the Marine (2021R550).

References

Davidson, E.A. and Kanter, D. (2014) 'Inventories and scenarios of nitrous oxide emissions', *Environmental Research Letters*, 9(10), p. 105012.

Hénault, C. *et al.* (2012) 'Nitrous oxide emission by agricultural soils: a review of spatial and temporal variability for mitigation', *Pedosphere*, 22(4), pp. 426–433.

73. Can diet influence methane emissions from the manure of dairy cows?

Ambrose, H.W. [a*], Dalby, F.R.[a], Lashkari, S.[b], Børsting, C.F.[b]

Department of Biological and Chemical Engineering, Aarhus University, Denmark [a]; Department of Animal and Veterinary Sciences, Aarhus University, Denmark [b]; [*]Herald Wilson Ambrose, email: herald@bce.au.dk

Introduction

Diet plays a crucial role in rumen fermentation in cattle, directly influencing enteric methane (CH_4) emissions (Martins et al., 2024). CH_4 formation is tightly linked to the rumen's hydrogen (H_2) flux, as methanogens scavenge H_2, competing with alternative sinks like propionate, a vital volatile fatty acid (VFA), that reduces H_2 availability for methane synthesis (Wang et al., 2018). While diet composition and feed additives have been extensively studied for mitigating enteric CH_4 emissions, their impact on VFA production and CH_4 emissions from manure during storage in dairy barns remains largely unexplored. This study aimed to investigate the downstream influence of CH_4 mitigation strategies applied in cow's diet on CH_4 emissions from stored manure.

Methodology

Danish dairy cattle were fed twelve different diets, obtained from 3 different studies (4 treatments per study). Across all treatments, silage accounted for 54-58% of the total diet.

Study (1) investigated grass or maize silage-based diets supplemented with either saturated or unsaturated fat at level of 51 g fatty acids/kg of DM diet. Study (2) investigated grass or maize silage-based diet containing either barley or dried beet pulp at a level of 215 g/kg of DM diet. Study (3) investigated three CH_4 mitigation strategies (3-nitrooxy proponal (3-NOP), nitrate, and high fat) in a basal diet with 54:46 silage to concentrate ratio. The cows were fed these diets for a period of 63, 48, and 168 days in studies 1, 2, and 3, respectively, after which feces and urine were collected. The feces was mixed with urine and inoculum in a ratio of 1.85:1.0:0.86 and incubated at 18 ^{o}C for 42 days in a headspace emission setup. CH_4 and CO_2 emissions from the manure was monitored with cavity ring-down spectroscopy (G2201-i, Picarro, CA, USA). Biochemical characterization (pH, VFA, TAN) was conducted on samples collected at the beginning and end of the experiment.

Results and discussion

In study (1), manure from dairy cattle fed with saturated fat emitted about 12-18% less CH_4 compared to diets with unsaturated fat in both maize and grass silage combinations. Within silage combinations, manure from cattle fed with maize silage-based diet emitted 33-38% more CH_4 than grass silage-based diets. In study (2), manure from grass silage containing barley resulted in the least CH_4 emissions, followed by combination of grass silage with dried beet pulp. In this study, combinations with corn silages resulted in emissions similar to the control. In study (3), diets with additional fat, nitrate, or 3-NOP, resulted in slightly higher emissions than the control diet, but none of the emissions were statistically significant.

Over the storage period of 42 days of manure incubation, an increase in VFA production was observed in all the treatments. In all the treatments, the proportion of propionic acid in total VFA (PA/ tVFA) increased in the end compared to the beginning. The change of PA/tVFA from the beginning to end was higher in the manure derived from grass silage combined with barley, compared to treatments in study 2 and 3.

Conclusion

The effects of diet on CH_4 emissions from manure was more pronounced in feed composed of grass silage with barley compared to other diets investigated. Dietary supplementation with 3-NOP or nitrate did not influence CH_4 emissions from manure storage. This study highlights that VFA production from manure storage and CH_4 emissions are influenced by diets fed to dairy cows.

References

Martins, L.F., et al. 2024. Effects of dose, dietary nutrient composition, and supplementation period on the efficacy of methane mitigation strategies in dairy cows: A meta-analysis. J. Dairy Sci. 107, 9289–9308.

Wang, K., et al. 2018. Shifts of hydrogen metabolism from methanogenesis to propionate production in response to Replacement of forage fiber with non-forage fiber sources in diets in vitro. Front. Microbiol. 9, 1–12.

74. Quantification of enteric methane in cattle fed with high-grain, low-grain, and pure-grain diets

Timm, T.G. [a,b], Maranhão, T.D.[a,b], Ovani, V. [a,b], Amâncio, B. R.[a,*], Lopes, L.S.[c], Araújo, P.C.R.[d], Machado, R.S.[d], Abdalla, A.L.[a,b]

CENA- University of São Paulo, Brazil [a]; CCARBON - University of São Paulo, Brazil [b]; University of Lavras, Brazil [c]; Rações Futura Co., Brazil [d]; [*]Corresponding author, email: amanciobruna@usp.br

Introduction

Enteric methane (CH_4) emissions from ruminants contribute significantly to greenhouse gas (GHG) emissions, prompting the need for dietary interventions to mitigate their impact (Beauchemin, et al. 2022) This study aims to quantify the CH_4 emissions from cattle consuming high-grain, low-grain, and pure-grain diets, assessing their effects on rumen fermentation and feed efficiency.

Methodology

The study involved an *in vitro* gas production assay and *in silico* estimations. Experimental diets (pure-grain, high-grain, and low-grain) were prepared and analysed for nutritional composition. Rumen fluid was collected from 24 cattle (n=8 per diet) and incubated for 24 hours at 39°C under CO_2 infusion (Bueno, et al. 2005). Fermentation parameters, gas production, CH_4 yield, and short-chain fatty acids (SCFA) were measured (Bizzuti, et al. 2023). Additionally, CH_4 emissions were estimated using predictive models based on dry matter intake (DMI) and fibre content (Monteiro, et al. 2024).

Results and discussion

The pure-grain diet resulted in higher ruminal fermentation efficiency, producing more SCFAs and a lower acetate-to-propionate (A:P) ratio, favouring reduced hydrogen availability for methanogenesis. Although total CH_4 production per unit of degraded organic matter was highest for the pure-grain diet, CH_4 intensity per unit of weight gain was significantly lower than for the low-grain diet. The in-silico estimation confirmed these findings, showing a CH_4 reduction of approximately 20% for cattle on pure-grain diets. Furthermore, microbial analysis revealed a decline in methanogenic archaea and fibre-digesting bacteria in animals consuming high- and pure-grain diets, aligning with observed fermentation patterns.

Conclusion

High-grain and pure-grain diets improved feed efficiency and reduced CH_4 emissions per unit of weight gain, supporting their role in sustainable livestock production. These findings highlight the potential of diet formulation as a strategy for mitigating enteric CH_4 emissions while optimizing animal performance.

Acknowledgments

Acknowledgments to FAPESP fellowship grant (#2024_06301-7; #2024_07657-0), CNPq researcher fellowship (#306116_2023-5), and CAPES finance code 001 fellowship).

References

Beauchemin, K. A., et al. 2022. Invited review: Current enteric methane mitigation options. Journal of Dairy Science, 105, 9297-9326.

Bizzuti, B. E., et al. 2023. *In Vitro* Degradability and Methane Production from By-Products Fed to Ruminants. Agronomy-Basel, 13.

Bueno, I. C. S., et al. 2005. Influence of inoculum source in a gas production method. Animal Feed Science and Technology, 123, 95-105.

Monteiro, A., et al. 2024. Crop-livestock-forestry systems as a strategy for mitigating greenhouse gas emissions and enhancing the sustainability of forage-based livestock systems in the Amazon biome. Science of The Total Environment, 906, 167396.

75. Greenhouse Gas and Ammonia Emissions from Manure Storage: Impact of Slurry Separation and Treatment Strategies

Brassard, P.[a*], Mila Saavedra, L.[a], Palacios, J.[a] & Godbout, S.[a]

[a] Research and Development Institute for the Agri-environment (IRDA), 2700 Einstein Street, Quebec, Canada, G1P 3W8 *Corresponding author, email: patrick.brassard@irda.qc.ca

Introduction

Agriculture is a significant source of greenhouse gases (GHGs), primarily due to methane (CH_4) and nitrous oxide (N_2O) emissions (Hansen et al., 2006). In Quebec (Canada), the agricultural sector accounts for 10% of total GHG emissions, with manure management contributing 27.9% (MELCCFP, 2024). Additionally, ammonia (NH_3) emissions from manure storage contribute to indirect N_2O emissions, exacerbating environmental impacts. Separating pig slurry into solid and liquid fractions directly within the facility is a promising strategy to mitigate these emissions while improving nutrient management. The solid fraction (SF) retains most of the phosphorus, whereas the liquid fraction (LF) is richer ammonium-nitrogen and potassium (Hansen et al., 2006). However, SF storage poses challenges, as rapid degradation can lead to significant CH_4 and N_2O emissions. This study evaluates GHG and NH_3 emissions from the storage of treated and untreated pig slurry fractions compared to raw slurry (RS) using a pilot scale approach. Treatments include dry anaerobic digestion of the SF for biogas production and nutrient stabilization, and aerobic treatment of the LF. The findings will guide strategies to reduce the environmental footprint of manure management.

Methodology

The experiment is divided into two parts. At first, 6 kg of each fraction (RS, untreated LF and SF) were stored in 20-L buckets kept uncovered in a controlled environment (~20°C). Gas concentrations were measured periodically at nine time points over a 30-day period, with the buckets covered and a controlled airflow of 2 L/min applied to the surface to ensure precise emission quantification. Each fraction was tested in triplicate. For the second part, the liquid fraction was aerated at an air flow rate of 25 L/min/m³ for 8 days, while the solid fraction underwent anaerobic digestion under mesophilic conditions at 35°C for 28 days. Following these treatments, the storage experiment was replicated similarly using 7.5-liter buckets containing 3 kg of each fraction (RS, untreated and treated fractions) and stored for two months in five replicates. Gas emissions were monitored at nine time points throughout the experiment.

Results and discussion

In the first part, CH_4 emissions generated by the SF storage were 87.5% lower than those from the RS, while LF emissions were 25% lower than RS (mass basis). Regarding ammonia (NH_3), SF storage resulted in 77% lower emissions compared to RS, while the LF generated twice the emissions. Nitrous oxide (N_2O) emissions were slightly higher for both fractions (LF and SF) compared to RS. Globally, in-barn slurry separation into liquid (67.8%) and solid (32.2%) fractions (mass basis) reduced total greenhouse gas (GHG) emissions from storage by 18.4% compared to a non-separation scenario. This reduction accounts for indirect N_2O emissions from ammonia losses. The second part of the study is in progress and the results will be presented at the conference.

Conclusion

During the storage of untreated liquid and solid fractions, GHG emissions were reduced by 18.4% compared to raw manure; however, ammonia emissions were higher. Implementing additional treatments for these fractions could further mitigate both ammonia and greenhouse gas emissions while producing valuable by-products such as biogas and digestate. The observed reduction in emissions due to in-barn separation highlights the potential for complementary strategies to enhance environmental benefits, optimizing nutrient management and improving the overall sustainability of manure handling practices.

Acknowledgements

This project was carried out with financial support from the Quebec Ministry of Agriculture, Fisheries and Food (MAPAQ).

References

Hansen, M.N., Henriksen, K., Sommer, S.G. 2006. Observations of production and emission of greenhouse gases and ammonia during storage of solids separated from pig slurry: Effects of covering. Atmospheric Environment. 40, 4172–4181.

Ministère de l'Environnement, de la lutte contre les changements climatiques, de la Faune et de Parcs (MELCCFP). 2024. Inventaire québécois des émissions de gaz à effet de serre en 2022 et leur évolution depuis 1990. https://www.environnement.gouv.qc.ca/changements/ges/index.htm.

76. Modelled effect of storage tank size on methane emission and temperature dynamics in manure

Dalby, F.R., Hafner, S.D., Kamp, J., Feilberg, A.

Department of Biological and Chemical Engineering, Aarhus University, Denmark

*Frederik Rask Dalby, email: fd@bce.au.dk

Introduction

Measuring methane emission from stored manure in full scale storage tanks is challenging. Smaller pilot-scale manure storages facilitate management comparisons and replication and can more easily accommodate measurement systems. However, manure temperature dynamics depend on tank size and management (including timing of slurry addition and removal), with the potential to substantially affect methane emission. Therefore, measurements from pilot-scale or smaller tanks may not in fact provide quantitative estimate or even useful insights for full-scale systems. To explore this problem, here we modelled the effect of tank size and sampling strategy on methane emission to develop recommendations for measurements.

Methodology

The STM model (Hafner & Mjöfors, 2023) was extended to two dimensions (2D) to predict temperature dynamics at different positions in a manure tank. The new "STM2D" implements simple laws of heat transfer with inputs being tank dimensions, air temperature, and solar radiation. STM2D was fitted to dynamic and spatial temperature measurements in manure storage tanks. Temperature predictions were linked to a new 1D (vertical) version of the ABM methane emission model (Dalby et al., 2021). The new "ABM1D" incorporates sedimentation of manure particles and predicts methane emission as a function of methanogenic activity. The model was roughly calibrated to measured manure organic matter content in different hights of a manure storage tank.

Results and discussion

The models predicted that full-scale storage tanks emit more methane per volume on an annual basis than pilot-scale tanks under Danish weather and manure management. This is due to reduced heat loss from full-scale tank and resulting warmer slurry temperature during the cooling season, where the tank is near full capacity. The effect of size on temperature is largest at the bottom, which has a higher organic matter concentration due to particle settling. During the warm season emission and temperature would be higher from smaller tanks, but with relatively small amounts of manure stored in the tanks, effects on emission are small. There was not much difference in temperature along the horizontal dimension of the tank for distances more than 1 m from the tank edge. Hence, manure samples and temperature measurements should be conducted at least 1 m from the edge. Due to settling dynamics of manure a full profile sample should be acquired, and significant effort should be made to include bottom sediment in the sample as it represents a large fraction of the bulk organic matter of the tank.

Conclusion

Measuring campaigns should be conducted on full-scale storage tanks if the aim is to estimate absolute emission levels. However, pilot-scale storages may be sufficient for assessing relative effects of manure treatment on methane emission. Attention should be paid to manure and temperature sampling as methane is not uniformly produced in slurry storage tanks.

References

Dalby, F. R., et al. (2021). A mechanistic model of methane emission from animal slurry with a focus on microbial groups. PLoS ONE, 16(6), e0252881-e0252881. https://doi.org/10.1371/journal.pone.0252881

Hafner, S. D., & Mjöfors, K. (2023). STM: A software tool for predicting daily temperature in stored animal slurry. SoftwareX, 22. https://doi.org/10.1016/j.softx.2023.101354

77. Organic matter degradation dynamics in cattle manure: Effect of diet and storage temperature

Dalby, F.R.[a*], Ambrose, H.W. [a], Lashkari, S.[b], Børsting, C.F.[b]

Department of Biological and Chemical Engineering, Aarhus University, Denmark [a]; Department of Animal and Veterinary Sciences, Aarhus University, Denmark [b]; [*]Frederik Rask Dalby, email: fd@bce.au.dk

Introduction

Methane emission from cattle manure depends on cattle diet and temperature in the manure storage. A farm-scale model should aim to capture these effects, but in order to do so, a deeper understanding of degradation dynamics of the manure is needed.

Methodology

Danish dairy cows were fed three different diets: These were on a dry matter 1) 48% maize silage, 12% grass silage and 40% concentrates (**SMAI**), 2) 48% grass silage, 12% maize silage, and 40% concentrates (SGRA), and 3) 77% fresh barn fed clover grass, and 23% concentrates (CLO). These diets represent both common and extreme diet compositions encountered in Danish dairy industry. Feces and urine were collected from the dairy cows, and inoculum manure was collected from a pre storage tank and sieved to remove large particles. Urea in urine was enzymatically hydrolysed to ammonia by adding urease enzyme 24 h before experiment start. The feces, urine, and inoculum manure were mixed in a wet mass ratio of 1.85:1:0.94 and incubated in 500 mL closed bottles in water baths at 5, 10, 15 and 20 ℃ (triplicate manure bottles for each diet, temperature and sampling day). At days 0,2,4,7,21,42, and 90 after incubation manure bottles were taken out for analysis of chemical composition. The manure was analyzed for total ammonia nitrogen (TAN), nitrogen (crude protein, CP = 6.25 × (N-TAN)), dry matter (DM), volatile solids (VS), neutral detergent fiber (NDF), indigestible NDF, total lipids (TL), and different non-cellulose polysaccharides (NCP). The first order rate constant, and equations for estimating its' dependency on temperature was estimated for the different components and in the different diets based on the analysis results.

Results and discussion

The DM of the feces from the SMAI, SGRA, and CLO diets were 14.1, 13.8, and 11.1%, respectively. Despite differences in initial DM content, the rate of degradation of VS and DM was overall very similar for manure from cows fed the three diets. After 90 days, 17.3, 20.0, and 17.4% of the inoculum corrected DM was degraded at 20 ℃, whereas it was 6.9, 6.4, and 3.1% at 5 ℃ for the SMAI, SGRA and CLO diets, respectively. CP (excluding TAN) was degraded very quickly during the initial days of incubation at all temperatures, but then decreased to a very low degradation rate after approximately 7-21 days. The total VFA concentration also increased rapidly during the initial 7-21 days, which was mostly attributed to increases in acetic acid, and with higher concentrations at higher temperatures. This indicated that methanogenic activity was insufficient to consume the produced VFA, which originated from combined hydrolysis and fermentation.

A principal component analysis revealed that particularly manure from the CLO diet differed in composition compared to the SMAI and SGRA diets. It contained less fibre and lignin, but higher xylose content. Approximately 20% of the total lipids in the CLO diet disappeared after 90 days at 20 ℃, whereas it did virtually not disappear in the SMAI and SGRA diets. This difference could be due to higher amounts of waxes and non-polar compounds in the CLO diet, which was based on fresh clover grass. These compounds may still be present in the fresh manure, but then break down to more water soluble compounds during the incubation. In the SMAI and SGRA diets, non-polar compounds such as waxes may already be hydrolysed during ensilage.

Conclusion

The interaction between diet and storage temperature of liquid manure on methane emission and organic matter degradation is complex. This study indicates that some organic components, independent of diet, contribute less to methane emission than others. Despite differences in chemical composition, the overall level of organic matter degradation can be assumed to be relatively similar in manure from cows fed different diets.

78. Can diet influence methane emission from manure from dairy cows?

Ambrose, H.W. [a*], Dalby, F.R.[a*], Lashkari, S.[b], Børsting, C.F.[b]

Department of Biological and Chemical Engineering, Aarhus University, Denmark [a]; Department of Animal and Veterinary Sciences, Aarhus University, Denmark [b]; [*]Herald Wilson Ambrose, email: herald@bce.au.dk

Introduction

Diet plays a crucial role in rumen fermentation in cattle, directly influencing enteric methane (CH_4) emissions. CH_4 formation is tightly linked to the rumen's hydrogen (H_2) flux, as methanogens scavenge H_2, competing with alternative sinks like propionate, a vital volatile fatty acid (VFA), that reduces H_2 availability for methane synthesis While diet composition and feed additives have been extensively studied for mitigating enteric CH_4 emissions, their impact on VFA production and CH_4 emissions from manure during storage in dairy barns remains largely unexplored. This study aimed to investigate the downstream influence of CH_4 mitigation strategies applied in cow's diet on CH_4 emissions from stored manure.

Methodology

Danish dairy cattle were fed twelve different diets, obtained from 3 different studies (4 treatments per study). Across all treatments, silage accounted for 54-58% of the total diet.

Study (1) investigated grass or maize silage-based diets supplemented with either saturated or unsaturated fat at level of 51 g fatty acids/kg of DM diet. Study (2) investigated grass or maize silage-based diet containing either barley or dried beet pulp at a level of 215 g/kg of DM diet. Study (3) investigated three CH_4 mitigation strategies (3-nitrooxy proponal (3-NOP), nitrate, and high fat) in a basal diet with 54:46 silage to concentrate ratio The cows were fed these diets for a period of 63, 48, and 168 days in studies 1, 2, and 3, respectively, after which feces and urine were collected. The feces was mixed with urine and inoculum in a ratio of 1.85:1.0:0.86 and incubated at 18 ^oC for 42 days in a headspace emission setup. CH_4 and CO_2 emissions from the manure was monitored with cavity ring-down spectroscopy (G2201-i, Picarro, CA, USA). Biochemical characterization (pH, VFA, TAN) was conducted on samples collected at the beginning and end of the experiment.

Results and discussion

In study (1), manure from dairy cattle fed with saturated fat emitted about 12-18% less CH_4 compared to diets with unsaturated fat in both maize and grass silage combinations. Within silage combinations, manure from cattle fed with maize silage-based diet emitted 33-38% more CH_4 than grass silage-based diets. In study (2), manure from grass silage containing barley resulted in the least CH_4 emissions, followed by combination of grass silage with containing dried beet pulp. In this study, combinations with corn silages resulted in emissions similar to the control. In study (3), diets with additional fat, nitrate, or 3-NOP, resulted in slightly higher emissions than the control diet, but none of the emissions were statistically significant.

Over the storage period of 42 days of manure incubation, an increase in VFA production was observed in all the treatments. In all the treatments, the proportion of propionic acid in total VFA (PA/ tVFA) increased in the end compared to the beginning. The change of PA/tVFA from the beginning to end was higher in the manure derived from grass silage combined with barley, compared to treatments in study 2 and 3.

Conclusion

The effects of diet on CH_4 emissions from manure was more pronounced in feed composed of grass silage with barley compared to other diets investigated. Dietary supplementation with 3-NOP or nitrate did not influence CH_4 emissions from manure storage. This study highlights that VFA production from manure storage and CH_4 emissions are influenced by diets fed to dairy cows.

79. Methane emission from digestate storage as impacted by temperature and acidification

Dold, C.[a*] & Sørensen, P.[a]

Department of Agroecology, Aarhus University, Blichers Alle 20, 8830 Tjele, Denmark[a]; [*]Corresponding author, email: c.dold@agro.au.dk

Introduction

Danish biogas plants use approximately 35% of all produced manures for biogas production. The resulting digestates can be separated by centrifugation (decanter) and sedicanter processing into solid and liquid fractions, and liquid fractions are beneficial for use as fertilisers by surface application in growing crops due to lower ammonia losses. Methane emissions can occur during storage of liquid fractions in tanks with fluctuating temperatures further affecting methane production. It has previously been shown that acidification of slurries using sulphuric acid to below pH 5.5 inhibits microbial activity including methane formation. However, little is known on how acidification may influence methane emissions from the liquid fraction of digestates, and how this interacts with temperature. The aim of this study was to quantify the methane emissions from liquid fractions of digestates as impacted by acidification and temperature. In addition, effects of an extra digestion step on methane emission were quantified.

Methodology

We quantified methane emissions from differently treated liquid digestates in an incubation study. There were four treatments: untreated liquid digestate (pH 7.9), liquid digestate acidified to pH 6.8 and pH 4.7, respectively, using sulphuric acid, and post-digested sedicanter liquid (pH 8.5), which were incubated at three temperature levels (10, 15, and 20 °C, respectively). The experiment started about two weeks after sampling at a commercial biogas plant following the methodology in Petersen et al. (2024). Approximately 3 mL of each material was sieved and filled into 27-mL test tubes in batches of six tubes per treatment. The test tubes were immediately closed with butyl rubber stoppers and flushed with N_2 gas to ensure anaerobic conditions. Thereafter, four of six test tubes were pre-incubated for approximately 24 hours to activate methanogenesis. The remaining two test tubes were sampled immediately to determine dissolved methane in the sample at the start of the experiment. For sampling, 3mL gas from the test tube headspace was transferred to exetainers. All samples were analysed for CH_4 concentration with gas chromatography (7890, Agilent, Nærum, Denmark), and related to volatile solids contents.

Results and discussion

The liquid fractions with pH 7.9 and 6.8 showed substantial effects of temperatures on CH_4 production from close to 0 at 10 °C to 64 and 126 mg CH_4 kg VS^{-1} d^{-1} at 20 °C. The liquid fraction with pH 4.7 showed negligible methane production at all temperatures. The post-digested sedicanter liquid also showed low CH_4 production with a maximum of 8 ± 0.8 mg CH_4 kg VS^{-1} d^{-1} at 10 °C. We could show that the methane production of strongly acidified liquid digestate was much lower than untreated or slightly acidified material, especially at the highest temperature. This confirmed previous studies showing that methanogenesis is interrupted by strong acidification. Interestingly, post-digested sedicanter liquid also showed a low methane production, likely due to the reduced content of decomposable organic solids. In a next step, we will further analyse the temperature response on methane production from liquid fractions of digestates.

Acknowledgements

The work was financially supported by the LOWHIGH project funded by *AgriFoodTure*, *Innovation Fund Denmark*, and *The European Union NextGenerationEU*.

References

Petersen, S.O., et al. 2017. In-vitro method and model to estimate methane emissions from liquid manure management on pig and dairy farms in four countries. J. Envir. Man. 353, 120233.

80. Low dose acidification of full-scale slurry storage tanks mitigating methane emissions

García, P.[a*], Feilberg, A.[a], Petersen, S.O.[b] & Kamp, J.K.[a]

Department of Biological and Chemical Engineering, Aarhus University, Denmark[a]; Department of Agroecology, Aarhus University, Denmark[b]; [*]Corresponding author, email: pg@bce.au.dk

Introduction

Outdoor storage slurry tanks are a source of methane (CH_4) emissions. As CH_4 is a potent greenhouse gas contributing significantly to global warming, the development of mitigation strategies is needed. Acidification is a promising strategy to mitigate the CH_4 emissions from outside storage slurry tanks. The addition of sulphuric acid lowers the pH of the slurry, inhibiting the activity of methanogenic archaea which may involve toxic effects from H_2S and acetic acid, and competition between sulphate reducing bacteria and methanogens (Petersen et al. 2012). The amount of acid is critical both in relation to cost and sulphur loading to fields, and a pilot-scale study has indicated that significant methane mitigation is possible at 2 kg sulfuric acid per m^3 slurry (Ma et al., 2021). In this study, low dose acidification early in the storage period is used to evaluate if a reduced amount of acid can significantly reduce CH_4 emissions from full-scale slurry storage tanks. Therefore, the goal of the study is to evaluate the impact that early acidification targeting this lower dose has on CH_4 emissions from covered slurry tanks with pig and cattle slurry in Denmark during both cold and warm periods.

Methodology

The air exchange in the tent covered slurry tanks is needed to calculate CH_4 emissions. This was determined using a tracer decay method. For this study, N_2O was used as tracer gas, and the decay rate is assumed to be proportional to the air exchange rate. The CH_4 and N_2O concentrations were quantified using cavity ring down spectroscopy (CRDS) (model G2509, Picarro Inc. Santa Clara, California, USA). PTFE tubes were used to measure the gas concentrations at two different positions under the tent cover. A dilution system with pumps and mass flow controllers was used and a rotary valve switched between positions, measuring 12.5 minutes at each position inside the tank and then for 5 minutes the background air used for dilution. N_2O was injected into the tank at one position for 1-2 hours to yield sufficiently high N_2O concentration. A total of 8 tanks were investigated including 4 control tanks without acidification (2 pig and 2 cattle) and 4 acidified tanks (2 pig and 2 cattle). The N_2O decay was fitted to exponential functions or consecutive differences to determine the average air exchange rate for the individual time intervals, which was combined with head space volume and CH_4 concentration to obtain emissions. Slurry samples were collected at different depths and analysed in the laboratory.

Results and discussion

The preliminary results show reductions in emissions from the acidified slurry tanks for both cattle and pig slurry, but also variation between farms. On average, the emissions from the control tanks are higher than the baseline from Kupper et al. (2020). The average measured CH_4 emission from October to February is 1.5 g m^{-3} h^{-1}, including pig and cattle slurry, whereas the average reported value for uncovered tanks is below 0.7 g m^{-3} h^{-1} for both pig and cattle slurry. However, indicated by these preliminary results, the emission reduction in acidified tanks is comparable with approximately 65% less emissions from acidified tanks on average. Nonetheless, the preliminary results also show that one of the acidified tanks with cattle slurry presented emissions on the same level as the control tanks. Acid was added once to the slurry tank early in the storage period, but fresh slurry is added regularly. Slurry analyses indicate that this could be due to incomplete mixing of fresh slurry from the barn, rather than a general loss of inhibition over time. Low dose in-line acidification treating all slurry with sulphuric acid will be tested with preliminary results expected to be presented with positive results.

Acknowledgements

This work was funded by the Danish Ministry of Environment (journal nr.: 2021-26127).

References

Kupper, T., et al. 2020. Ammonia and greenhouse gas emissions from slurry storage - A review. Agriculture, Ecosystems and Environment, 300, 106963. https://doi.org/10.1016/j.agee.2020.106963

Ma, C., Dalby, F.R., Feilberg, A., Jacobsen, B., Petersen, S.O., 2022. Low-dose acidification as a methane mitigation strategy for manure management. Agricultural Science and Technology 2, 437-442. https://doi.org/10.1021/acsagscitech.2c00034

Petersen S. O. et al., 2012. Effects of Cattle Slurry Acidification on Ammonia and Methane Evolution during Storage. Journal of Environmental Quality, 41, 1, 88-94. https://doi.org/10.2134/jeq2011.0184

81. Effects of charcoal powder addition on temperature and greenhouse gas emission during high-moisture cow manure composting

Hanajima, D.[a*], Yasuda, T.[b], Usui N.[a] & Yamane T.[c]

[a]Division of Dairy Production Research, Hokkaido Agricultural Research Center, NARO, Sapporo, Hokkaido, Japan; [b]Division of Advanced Feeding Technology Research, Institute of Livestock and Grassland Science, NARO, Tsukuba, Ibaraki, Japan; [c]Division of Large-Scale Upland Farming Research, Hokkaido Agricultural Research Center, NARO, Sapporo, Hokkaido, Japan; [*]Corresponding author, email: hanadi@affrc.go.jp

Introduction

Biochar, a carbon-rich material obtained by biomass pyrolysis, is known to have a large surface area, porosity, cation-exchange capacity, and water-holding capacity (Sanchez-Monedero et al., 2018). However, there is limited information on the effects of biochar when used as an additive in organic waste composting, especially for high-moisture manure composting. Cow manure is a high-moisture organic waste that causes poor air permeability in compost piles. The large surface area and porosity of biochar are expected to improve the environmental conditions in the compost pile. In this study, we investigated the effects of charcoal powder addition on heat generation and GHG emissions during cow manure composting process under high-moisture conditions.

Methodology

The charcoal powder was manufactured from wood, and the particle size was less than 5 mm. Fresh cow feces and shredded wheat straw were mixed in a dry ratio of 3.2:4.1, and this mixture was used as the non-addition (control) composting material. Fifteen percent of the total dry matter of this mixture was substituted with charcoal powder (CP15%) by reducing the amount of shredded wheat straw. The moisture content of each mixture was 75%. Thirty kilograms of wet volume of each material were placed into a cylindrical PVC pipe (40 cm diameter) with glass-wool insulation. The compost mass was manually turned for each treatment after 23 and 57 days, and the composting trials were terminated on day 73. The composting experiments were performed in triplicate. Methane (CH_4) and nitrous oxide (N_2O) concentrations were determined daily using a cylindrical plastic chamber. The gas samples were withdrawn from the chamber headspace using a polypropylene syringe and stored in a gas-tight evacuated glass vial.

Results and discussion

The compost temperature increased, and maximum temperatures were recorded between days four to six. After the turning on day 57, no further temperature increase was observed, and the composting trials were terminated on day 73. The average maximum temperatures were similar between control and CP15% (64.3 and 62.9 °C, respectively), however, the values of average duration of the temperatures above 55C°decreased by addition of charcoal powder (118.7 and 80.5 h, respectively). These data imply that charcoal powder is a more recalcitrant material than cow manure or wheat straw and has negative effects on heat generation required for the elimination of weed seeds and/or pathogens. CH_4 emissions increased in initial and middle phase of composting. Contrarily, N_2O concentration increased in the latter phase of composting. The CH_4 emissions of control and CP15% during composting process were 12.0 and 17.5 g C/m^2, and the N_2O emissions were 10.5 and 6.8 g N/m^2, respectively. Liu et al. (2021) reported the different effects of biochar addition on CH_4 emissions might be moisture-dependent and enhanced emission occurred under high-moisture conditions, but decreased emission occurred under low-moisture conditions. Initial moisture content of 75% in our study might have negative effect on CH_4 emissions.

Conclusion

The addition of charcoal powder to the high-moisture cow manure did not increase the heat generation required for the elimination of weed seeds and/or pathogens. The use of charcoal powder as a compost additive slightly reduced N_2O emissions but increased CH_4 emissions.

Acknowledgements

This study was supported by the Ministry of Agriculture, Forestry and Fisheries of Japan, via the commissioned project studies on “Development of GHG Mitigation Technology in the Livestock Sector (Grant Number JPJ011299)”.

References

Liu, M. et al., 2021. Impact of biochar application on gas emissions from liquid pig manure storage. Sci. Total Environ. 771, 145454.

Sanchez-Monedero, M. A. et al., 2018. Role of biochar as an additive in organic waste composting. Bioresour. Technol. 247, 1155-1164.

82. Measuring ammonia and greenhouse gas emissions from pilot-scale slurry storage tanks

Kamp, J. N.[a]* & Feilberg, A.[a]

Department of Biological and Chemical Engineering, Aarhus University, Denmark[a], *Corresponding author, email: jk@bce.au.dk

Introduction

Storage of liquid animal manure (slurry) is a significant source of methane (CH_4) and ammonia (NH_3) emissions, with nitrous oxide (N_2O) emissions being relatively minor (Kupper et al., 2020). Accurate quantification of these emissions is crucial due to their environmental and climatic impacts. NH_3 emissions contribute to air and water pollution, affecting ecosystems, biodiversity, and human health, while CH_4 and N_2O are potent greenhouse gases contributing to climate change.

Measuring emissions from full-scale slurry storage tanks under controlled conditions is highly challenging due to the complexity of real-world conditions. These tanks experience variations in temperature, wind speed, and other environmental factors that significantly influence emission rates. In addition, achieving replications in representative production scale require infrastructure that is rarely available. To address these challenges, this study investigates emissions from pilot-scale slurry tanks (5m3) to gain insight into emission dynamics under more controlled conditions. However, downscaling introduces its own set of challenges, potentially altering conditions such as temperature, airflow, and microbial activity, affecting the representativeness of results when extrapolated to full-scale conditions.

Methodology

Pilot-scale slurry tanks (5m3) were set up to measure emissions from slurry storage from three different dairy farms. The backward Lagrangian stochastic (bLS) method was applied to quantify NH_3, CH_4, and N_2O emissions over the storage period. The slurry tanks were filled in May corresponding to filling after field application to grass land following the first cut of grass. In July and October, tanks were emptied leaving 1/3 of the slurry before filling with fresh slurry from the same three dairy farms. This corresponds to field application after second and fourth cut of grass and subsequent filling with fresh slurry. Slurry samples were analysed for chemical composition for each of the batches and slurry temperature was measured throughout the storage period. The storage period lasted from May 2024 to March 2025 to measure from a full storage cycle.

Results and discussion

Measuring emissions from slurry storages remains challenging due to the complexity of these sources. Natural variations in emissions were observed across slurry from the three farms but also difference in slurry properties between farms were observed. CH_4 and NH_3 emissions aligned with previous findings by Kupper et al. (2020). N_2O emissions were below detectable levels, indicating minimal contributions from slurry storage. Downscaling to pilot-scale tanks altered conditions such as temperature, airflow, and microbial activity, making direct comparisons to full-scale tanks difficult. These changes impacted the accuracy of emission estimates, highlighting the challenges in translating small-scale measurements to real-world scenarios. Despite these limitations, pilot-scale experiments provide valuable insights into emission trends and influencing factors under more controlled conditions.

Conclusion

CH_4 and NH_3 emissions varied between farms and slurry properties, supporting previous research. N_2O emissions were negligible, reinforcing its minor role in slurry storage emissions. However, downscaling influenced results by altering key environmental conditions, making direct comparisons to full-scale tanks challenging. While pilot-scale experiments help in understanding emission processes, full-scale validation remains necessary for accurate quantification and mitigation strategy development.

Acknowledgements

This research was funded by the Danish Agricultural Agency (journal no.: 33010-NIFA-21-767).

References

Kupper, T., et al. 2020. Ammonia and greenhouse gas emissions from slurry storage - A review. Agriculture, Ecosystems and Environment, 300, 106963. https://doi.org/10.1016/j.agee.2020.106963

83. Gaseous Nitrogen losses from slurry application – effect of mitigation measures

Kühne, J.[a*], Potthoff, T.[a], Stenfert-Kroese, J.[b], Mielenze, H.[a], Greef, J.M.[a], Buchen-Tschiskale, C.[b] & Well, R.[b]

[1]*Julius Kühn Institute - Federal Research Centre for Cultivated Plants, Institute for Crop and Soil Science, Braunschweig, Germany*, Germany [a]; *Thünen Institute, Institute of Climate-Smart Agriculture, Braunschweig, Germany*, Germany [b]; [*]Corresponding author, email: Johannes.kuehne@julius-kuehn.de

Introduction

Gaseous Nitrogen (N) losses from agricultural soils are economically relevant for the farmer as well as they contribute to climate change. Against the background of quantifying N-losses from denitrification we measure nitrous oxide (N_2O) and ammonia (NH_3) emissions in a 3-year field trial (maize – wheat – maize rotation) testing different mitigation measures (acidification, drag hose application, slit injection and nitrification inhibition) on organic fertiliser (cattle slurry). Nitrogen use efficiency (NUE) and a total N-balance are employed to evaluate the effect of the tested mitigation measures. Furthermore the treatments are compared to a mineral fertiliser (CAN) in order to assess the substitutability of organic fertiliser for the standard mineral one.

Methodology

GHG: Closed chamber Method (Hutchinson & Mosier 1981)

NH_3: bLs method (Flesch et al. 1995), using ALPHA sampler (Tang et al. 2001) and WindTrax modelling (Ni et al. 2015, Götze et al. 2025 (submitted)).

Results and discussion

Results are pending. Emissions, yields, corresponding parameters, NUE and N-balance will be presented.

Conclusion

Results are pending and will be presented.

Acknowledgements

We acknowledge funding from the German Federal Ministry of Food and Agriculture (BMEL) through the Federal Office for Agriculture and Food (BLE), grant number 2822ABS029.

References

Flesch, T. K.; Wilson, J. D..; Yee, E. (1995): Backward-Time Lagrangian Stochastic Dispersion Models and Their Application to Estimate Gaseous Emissions. In: J. Appl. Meteor. 34 (6), p. 1320–1332. DOI: 10.1175/1520-0450(1995)034%3C1320:BTLSDM%3E2.0.CO;2.

Götze, H.; Brokötter, J.; Frößel, J.; Kelsch, A.; Kukowski, S.; Pacholski, A. (2025 submitted): Comparison and evaluation of different methods to determin NH_3 emission after urea fertilization in small field plot experiments.

Hutchinson, G. L.; Mosier, A. R. (1981): Improved Soil Cover Method for Field Measurement of Nitrous Oxide Fluxes. In : Soil Science Society of America Journal. 45 (2), p. 311-316. DOI: 10.2136/sssaj1981.03615995004500020017x.

Ni, K.; Köster, J. R.; Seidel, A.; Pacholski, A. (2015): Field measurement of ammonia emissions after nitrogen fertilization—A comparison between micrometeorological and chamber methods. In: European Journal of Agronomy 71, p. 115–122. DOI: 10.1016/j.eja.2015.09.004.

Nicholson, F.; Bhogal, A.; Cardenas, L.; Chadwick, D.; Misselbrook, T.; Rollett, A.; Taylor, M.; Thorman, R.; Williams, J. (2017): Nitrogen losses to the environment following food-based digestate and compost applications to agricultural land. Environ. Pollut. p. 228, 204–516.

Tang, Y. S.; Cape, J. N.; Sutton, M. A. (2001): Development and Types of Passive Samplers for Monitoring Atmospheric NO2 and NH3 Concentrations. In: The Scientific World JOURNAL 1, S. 513–529. DOI: 10.1100/tsw.2001.82.

WinTrax, 2021. http://www.thunderbeachscientific.com/

Evaluation of a Low-Cost Wireless Sensor Network for CO_2 Measurements in a Dairy Barn.

Macartan, B. P. [a,b], Connolly S.[a], Curran T. P.[b], Coorevits K.[e], Janke D.[c], Amon B.[cd], Dragoni F.[c], Sahu H.[c], Umar W.[c], Krol D. J.[a*]

[a]Teagasc, Environment, Soils and Land-Use Department, Teagasc, Johnstown Castle, Co., Wexford, Ireland; [b]UCD School of Biosystems and Food Engineering, University College Dublin, Belfield, Dublin 4, Ireland; [c]Leibniz Institute for Agricultural Engineering and Bioeconomy (ATB), Potsdam, Germany; [d]Faculty of Civil Engineering, Architecture and Environmental Engineering, University of Zielona Góra, Poland; [e]Technology and Food Science Unit, Flanders Research Institute for Agriculture, Fisheries and Food (ILVO), Belgium; *Corresponding author, email: Dominika.Krol@teagasc.ie

Introduction

Dairy production is a significant source of greenhouse gases (GHG) such as carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O) and air pollutants such as ammonia (NH_3). In dairy houses, animal respiration and anaerobic breakdown of manure are the major sources of CO_2. CO_2 is used as a natural tracer gas to estimate the gaseous emissions of other pollutants through indirect mass balance techniques. This makes the accurate measurements of CO_2 concentrations inside and outside the barn vital. Most dairy housing systems are naturally ventilated, posing a challenge for accurate estimation of CO_2 and other gases. As a result, measurements are frequently restricted to a small number of scientific-focused barns and are not appropriate for a wide range of applications. Recently, a low-cost online tool for monitoring barn climate and air pollutant emissions (OTICE) have been developed to provide real-time data on gaseous levels (Amon et al., 2022). Using a GASERA photoacoustic gas analyser as a reference, this study investigated the reliability of the OTICE Wireless Sensor Network (WSN) nodes for CO_2 measurements in a naturally ventilated barn in Ireland.

Methodology

5 OTICE-WSN nodes (i.e. sampling points) (3 inside and 2 outside) were mounted in a 14 m by 20 m naturally ventilated dairy shed in Teagasc, Johnstown Castle Research Centre, Co. Wexford, Ireland in Winter 2024. The 3 nodes inside the shed were about 3 m apart with heights ranging from 4.5 to 5.5 m and aligned diagonally in the barn. The outer nodes were placed at a height of approx. 6 m on either side of the shed. The GASERA was used together with a multipoint sampler with sampling tubes made of polytetrafluoroethylene (PTFE). Each GASERA sampling point was placed beside each OTICE node to ensure direct comparison. Concentration measurements of CO_2 from the OTICE nodes and GASERA tubes were allowed to run continuously. Scatter plot, time series plots and correlation was used to compare the results of each sampling point.

Results and discussion

This experiment is still ongoing, early results show that maximum relative deviations between the OTICE nodes and Gasera were 16% and 20% for indoor and outdoor CO_2 measurements respectively. Correlation of 0.99 and 0.66 was also observed for indoor and outdoor respectively. The results from this study are comparable to findings reported by (Janke et al., 2023) who evaluated the OTICE system in a dairy barn in Germany using a Fourier transform infrared (FTIR) gas analyser as the reference system. Their results showed relative deviations of less than 7%, maximum peak deviations of 32% and a strong correlation of 0.8 for CO_2 measurements (Janke et al., 2023).

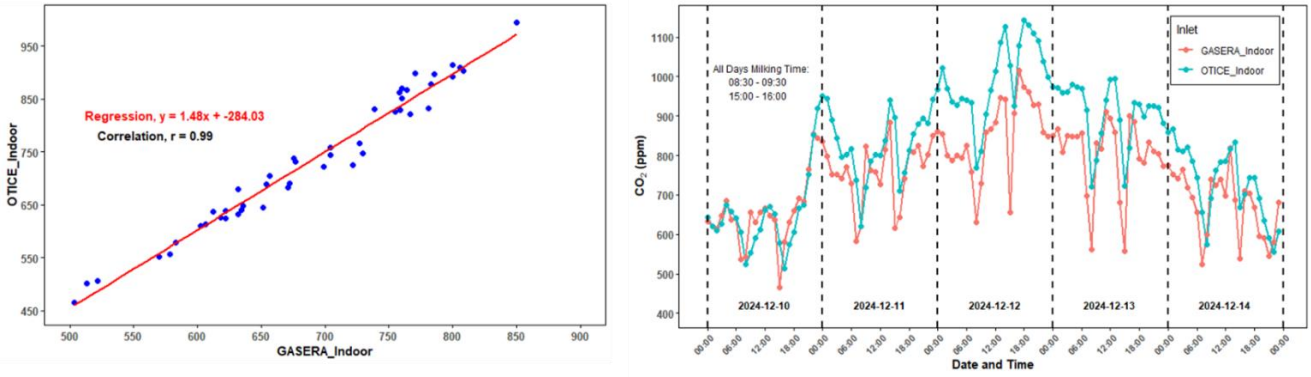


Figure 1: Scatter plot showing correlation (left) and time series (right) between OTICE and Gasera CO_2 measurements.

Acknowledgements

The authors acknowledge the financial support through the partners of the DairyMix project, funded under the Joint Call of the Cofund ERA-Nets SusCrop (Grant No. 771134), FACCE ERA-GAS (Grant No. 696356), ICT-AGRI-FOOD (Grant No. 862665), SusAn (Grant No. 696231). Irish partners were funded by the Department of Agriculture, Food and Marine (DAFM), Ireland (2021EN904) and the Teagasc Walsh scholarship scheme (2021212).

References

Amon, B., Díaz De Otálora, X., Janke, D., Winiwarter, W., Suchowska-Kisielewicz, M., Rychła, A., Frątczak-Müller, J., Bartzanas, T., Anestis, V., Coorevits, K., Balaine, L., Krol, D., Buckley, C., Wilfart, A., Mittenzwei, K., Jørgensen, G., Castellan, E., Breen, J., Dach, J., Dragoni, F., 2022. Milkey: Decision Support System for Sustainable Ghg and N Optimised Milk Production in Key European Areas, in: Proceedings of the XXI International Nitrogen Workshop: Halving Nitrogen Waste by 2030 24th – 28th October 2022. Presented at the N Workshop, Madrid, Spain, p. Page 136.

Janke, D., Bornwin, M., Coorevits, K., Hempel, S., Van Overbeke, P., Demeyer, P., Rawat, A., Declerck, A., Amon, T., Amon, B., 2023. A Low-Cost Wireless Sensor Network for Barn Climate and Emission Monitoring—Intermediate Results. Atmosphere 14, 1643. https://doi.org/10.3390/atmos14111643

85. N_2O and NO emissions from winter wheat crop under organic-mineral fertilization

Monistrol, A.[ab*], Guardia, G.[ab*], Iglesias-Díez, S.[ab], Salinas, J.[ab], Orellana,T.[a], Espín, G.[a], García, S.[ab], Vallejo, A.[ab]

Departamento de Química y Tecnología de Alimentos, Escuela Técnica Superior de Ingeniería Agronómica, Alimentaria y de Biosistemas, Universidad Politécnica de Madrid, Spain [a]; Centro de Estudios e Investigación para la Gestión de Riesgos Agrarios y Medioambientales (CEIGRAM), Universidad Politécnica de Madrid, Spain [b]; [*]Corresponding authors, email: a.marcas@upm.es, guillermo.guardia@upm.es

Introduction

The use of organic fertilizers in agriculture is a topic of increasing interest from agronomic, environmental and economic perspectives. Improving the way they are applied is a key factor in achieving a sustainable transition towards the use of these fertilizer sources.

Methodology

A two-year field experiment was conducted in central Spain to analyse the effect of combining organic and mineral fertilization in a winter wheat (*Triticum aestivum* L.) crop. Nitrous oxide (N_2O) and nitric oxide (NO) emissions, as well as crop yields and nitrogen (N) grain content were measured. Six different treatments were applied reaching a total rate of 120 kg N ha^{-1}: i) sheep manure dosed according to nitrogen (N) requirements (SM), ii) sheep manure dosed according to phosphorus (P) requirements and complemented with urea to supply N requirements (SM+U), iii) poultry manure dosed according to N requirements (PM), iv) pig slurry dosed according to P requirements and complemented with urea to supply N requirements (PS+U), v) 100% urea (U) and vi) control with no N fertilization (0N). In both years, fertilizers were split into a seeding (end of November) and a top-dressing fertilization events (mid-March).

Results and discussion

During first year, N_2O showed emission peaks after basal fertilization (in U and SM treatments), top-dressing fertilization (in PM and SM+U treatments), and after a soil rewetting event at postharvest (in SM+U plots). In the second year, the most significant N_2O peaks were reported after top-dressing fertilization in SM plots. Cumulative N_2O emissions presented significant differences only between 0N and the rest of the treatments in both years. Regarding NO emissions (measured only during the first year), the highest emission peaks were observed after top-dressing fertilization in PS+U, SM+U and U treatments. Cumulative NO emissions were largest in PS+U plots and were significantly higher than those in PM, SM and 0N plots. Harvest analyses from the first year revealed notable penalties associated with the application of SM dosed according to N and PM, both in grain yield (24% and 12%, respectively) and in the protein content of that grain (22% and 39%, respectively). In year 2, penalties in grain protein content were similar with the application of SM and PM (22% and 27%, respectively), but lower in grain yield for PS+U and U treatments (8% in both cases). Considering the overall experiment average, U, SM+U and PS+U plots produced higher yields than those treated with manure dosed according to N. Likewise, the percentage of N in grain was significantly higher in plots fertilized with U, SM+U and PS+U, with values ranging from 1.2% (SM) to 1.7% (U). Finally, topsoil analyses reported a significant increase of soil P content, as well as electrical conductivity, with the application of manure dosed according to N (SM).

Conclusion

The results so far indicate that, although U is the treatment with the highest N_2O emissions throughout the entire experiment, these emissions are not significantly greater than those from organic sources, especially when considering post-harvest emissions. Furthermore, plots treated or complemented with urea show higher yields and greater amounts of protein in the grain. Therefore, it will be necessary to consider the potential side effects of organic fertilization, such as possible excess of phosphates, as well as their advantages (upstream emissions, circular economy) in a comprehensive analysis of sustainability.

Acknowledgements

The authors are grateful to PID2021-125007OB-I00, grants: A. Monistrol (FPI, PRE2022-101276, MCIN/AEI/FSE+), and to the Comunidad de Madrid in the framework of the Agreement with Universidad Politécnica de Madrid for APOYO-JOVENES-21-V2UPP9-64-19ATU0 project.

86. Greenhouse gas balance of biochar mixed farmyard manure applied grassland in Nasu, Japan

Mori, A.*, Yamada, D. & Shibuya, T.

NARO, Japan; *Corresponding author, email: amori@affrc.go.jp

Introduction

The potential of biochar (BC) to enhance soil carbon (C) storage and herbage yield is a subject of considerable interest. The present study aims to clarify the greenhouse gas (GHG) balance and productivity of renovated grassland from the time of renovation in autumn until the fourth grass harvest in autumn of the following year. To this end, the present study measured the C balance, methane (CH_4) and nitrous oxide (N_2O) emissions, and grass yield on grassland where BC mixed farmyard manure (FYM) derived from cattle was applied during renovation.

Methodology

A field study was conducted in a mowed grassland located at the Institute of Livestock and Grassland Science, NARO in Nasu, Japan. The application of glyphosate was conducted on 5 September 2022, with the aim of killing deteriorated sward. The experimental plots were established in a randomised complete block design, with three replications for each treatment. The treatments included BC-mixed FYM plus synthetic fertilisers (BCMNPK), FYM plus synthetic fertilisers (MNPK), synthetic fertilisers only (NPK), and no N control (PK). On 26 September 2022, 5 Mg ha^{-1} of woody BC was applied to BCMNPK plots; 50 Mg ha^{-1} of FYM was applied to BCMNPK and MNPK plots; then all plots were ploughed to a depth of 30 cm. Calcium-magnesium carbonate was applied to all plots at a rate of 1000 kg ha^{-1}. Subsequent to this, all plots were rotovated to a depth of 15 cm. The newly prepared seedbeds were fertilised with synthetic fertiliser, containing 40 kg-N ha^{-1} y^{-1}, 200 kg-P_2O_5 ha^{-1} y^{-1}, and 80 kg-K_2O ha^{-1} y^{-1}. Cocksfoot (*Dactylis glomerata* L.) was sown at a rate of 30 kg ha^{-1}. The soil surface was then compacted. In the subsequent year, synthetic fertiliser was applied at the rates of 160 kg-N ha^{-1} y^{-1}, 150 kg-P_2O_5 ha^{-1} y^{-1}, and 300 kg-K_2O ha^{-1} y^{-1}, on 15 March, 17 May, 3 July, and 28 August. Herbage yield was measured on 16 May, 29 June, 24 August, and 26 October 2023. The fluxes of CH_4 and N_2O from the grassland plots were determined using the closed chamber method (Mori 2020). We used the root exclusion approach to estimate heterotrophic respiration (RH). A cylindrical chamber was placed on the bare subplot. The carbon dioxide (CO_2) flux from the bare subplots was determined by using a nondispersive infrared sensor (Mori 2020). The C balance (Mg-C ha^{-1} in 395 days) and the sum of GHG emissions (Mg-CO_2-eq ha^{-1} in 395 days) were calculated as follows:

$$\text{C balance} = \text{RH} + \text{CH}_4\text{-C}/1000 - \text{FYM} - \text{BC} - \text{Biomass}$$

$$\text{Sum of GHG emissions} = \text{C balance} \times 44/12 + \text{CH}_4\text{-C} \times 16/12 \times 0.028 + \text{N}_2\text{O-N} \times 44/28 \times 0.265$$

$$\text{GHGI} = \text{Sum of GHG emissions}/\text{Yield}$$

where RH is the amount of heterotrophic respiration (Mg-C ha^{-1} in 395 days), FYM is the C content in FYM (Mg-C ha^{-1}). Biomass is the C content of living roots and stubble immediately after the fourth grass harvest (Mg-C ha^{-1}), CH_4-C is the amount of CH_4 emissions (kg-C ha^{-1} in 395 days), and N_2O-N is the amount of N_2O emissions (kg-N ha^{-1} in 395 days). Yield is the cumulative TDN-based herbage yield in the year following grassland renovation (Mg-TDN ha^{-1}).

Results and discussion

The TDN yield exhibited a tendency to be greater in BCMNPK plots than in MNPK plots, while no significant differences were observed in root and stubble biomass among treatments. No significant difference was observed in RH, while N_2O production in BCMNPK plots exhibited a tendency to be smaller than that in MNPK plots. The GHG balances per area decreased in the following order: PK ≈ NPK > MNPK ≥ BCMNPK. Consequently, the GHGI decreased in the following order: PK > NPK ≥ MNPK ≥ BCNPK. The utilisation of BC-mixed FYM during the process of grassland renovation resulted in a net negative GHG emissions balance, with BC exhibiting a tendency to promote this GHG mitigation effect, concurrently a tendency augmenting pasture yields.

Acknowledgements

This work was supported by the MAFF Commissioned project study on “Development of Technologies to Reduce Greenhouse Gas Emissions in the Livestock Sector” (Grant Number JPJ011299).

References

Mori, A. 2020. Greenhouse gas emissions from cut grasslands renovated with full Inversion tillage, shallow tillage, and use of a tine drill in Nasu, Japan. Agriculture 10(2), 31

87. Greenhouse gas and ammonia emissions from fattening and sow pig houses in Spain

Perea-Cachero, A.[a*], Mateo-Marín, N.[a], Clavería, I.[a], Guillén, M.[a], Quílez, D.[a], Daudén, A.[b] & Herrero, E.[b]

Department of Environment, Agricultural and Forest Systems, Agrifood Research and Technology Centre of Aragon (CITA), Spain [a]; Project Office (CITA), Spain [b]; [*]Corresponding author, email: aperea@cita-aragon.es

Introduction

Livestock manure is a key source of greenhouse gas (GHG), mainly methane (CH_4) and nitrous oxide (N_2O), and ammonia (NH_3) emissions. Manure management accounts for 10.9, 9.9 and 69.1% of total CH_4, N_2O and NH_3 emissions in the EU-27 (Eurostat, 2022). Good management practices can reduce these emissions, thus preventing their negative environmental and health impacts, while increasing the fertilising value of the manures. The LIFE CLINMED-FARM project (www.lifeclinmed.eu) aims to cut down NH_3 and GHG emissions at every step of the manure management chain (i.e., manure production in animals' housing, external storage and landspreading) in Mediterranean pig and dairy cattle farms. The project monitors a reference scenario (R), with traditional manure management practices, and a demonstration scenario (D), where several best available techniques and good practices are implemented in existing and new facilities. In the animals' houses stage, the technique applied is frequent manure removal. In Spain (ES), the project studies a fattening (1) and a sow (2) pig farm. The removal systems used in R and D of the ES case are gathered in Table 1. This work presents the GHG and NH_3 fluxes emitted in the R scenario of (1) and (2) farms.

Table 1. Reference and demonstration scenarios in the animals' housing of the Spanish case.

Farm	Reference scenario (R)	Demonstration scenario (D)
(1) Fattening pig	All-in/all-out system	Autonomous vacuum robot
(2) Sow pig	All-in/all-out system	V-shaped pits

Methodology

Ventilation rates were calculated using the carbon dioxide (CO_2) mass balance method (Pedersen and Sällvik, 2002). The analyser ETG 7200 (with quartz-enhanced photoacoustic spectrometry technology, QEPAS) was employed to measure H_2O, CH_4, NH_3 and CO_2 concentrations inside and outside the farms by a multipoint system, and temperature and wind speed inside the buildings. The equipment SIMEDAM (*Sistema de Medición Ambiental*) combines low-cost sensors to determine CH_4, NH_3 and CO_2 concentrations, temperature and relative humidity and allows real-time online data tracking. Gas fluxes emitted from pits in both R scenarios were estimated using the calculated ventilation rates and measured concentrations. In (1), monitoring was carried out at the beginning (1st period) and end (2nd period) of a fattening cycle in summer. In (2), measurements were performed in a breeding and a farrowing room in the summer and winter seasons.

Results and discussion

In (1), the calculated emissions (1.1-1.8 kg CO_2 d^{-1} pig^{-1}; 5.1-7.3 g NH_3 d^{-1} pig^{-1}; 15.1-50.3 g CH_4 d^{-1} pig^{-1}; 2.4-9.1 kg H_2O d^{-1} pig^{-1}) are consistent with bibliography (Philippe et al., 2007), and higher emissions were observed in the 2nd period than in the 1st period as pigs were bigger. The comparison between QEPAS and SIMEDAM methodologies indicates that both gave similar data for all the parameters except for NH_3. In (2), higher CO_2 and H_2O concentrations were measured inside the breeding room because its ventilation system is less efficient. By contrast, NH_3 concentration in the farrowing room was slightly higher since the pits here were emptied less often, and measurements started with partially full pits.

Conclusion

The measuring equipment and CO_2 balance method showed consistent emissions fluxes in the two reference scenarios.

Acknowledgements

The LIFE CLINMED-FARM project is co-funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or CINEA. Neither the European Union nor the granting authority can be held responsible for them.

References

Eurostat, 2022. https://ec.europa.eu/eurostat/en/

Pedersen, S., Sällvik, K., 2002. 4th Report of Working Group on Climatization of Animal Houses: Heat and moisture production at animal and house levels. CIGR, Section II, 1–46.

Philippe, F.-X., et al. 2007. Gaseous emissions during the fattening of pigs kept either on fully slatted floors or on straw flow. Animal 1, 1515–1523.

88. Methodologies for measuring greenhouse gasses and ammonia emissions along the manure management chain

Mateo-Marín, N.[a*], Perea-Cachero, A.[a], Clavería, I.[a], Guillén, M.[a], Quílez, D.[a], Daudén, A.[b], & Herrero, E.[b]

Department of Environment, Agricultural and Forest Systems [a] & Project Office [b], Agrifood Research and Technology Centre of Aragon (CITA), Spain; [*]Corresponding author, email: nmateo@cita-aragon.es

Introduction

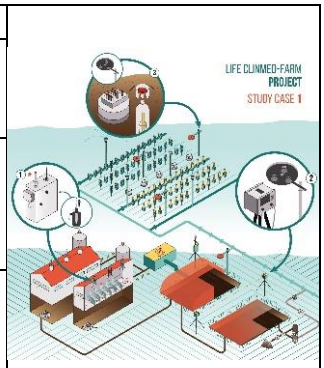
Agriculture is the second largest sector in terms of greenhouse gas (GHG) emissions and the first one emitting ammonia (NH_3) in the European Union. In the year 2022, methane (CH_4), nitrous oxide (N_2O), and carbon dioxide (CO_2) emissions from agriculture were 56.3 %, 71.9 %, and 0.4 % of total EU emissions, respectively (EEA, 2024a), and 93.4 % for total NH_3 volatilisation (EEA, 2024b). The wide agriculture extension and its complex links with nature make vital needs for more environmentally friendly farming practices. In this context, the LIFE CLINMED-FARM project (www.lifeclinmed.eu) aims to mitigate emissions (CH_4, N_2O, and NH_3) from pig and dairy cow slurry by implementing innovative and simple techniques at farm scale based on adapting existing facilities to the best available techniques and good practices.

Methodology

Different methodologies for emissions measurement are being tested in two study cases in a sow swine farm in Aragón (Spain) and a dairy cow farm in Piedmont (Italy) to fine-tune them and determine their strengths and weaknesses. For each study case, the emissions are monitored in a reference scenario, where traditional practices are applied, and in a demonstration farm, where the project implements techniques on all the manure management chain's key stages (i.e., animal housing, storage, and organic fertilisation) to reduce emissions.

Emissions monitoring methods used in the Spanish study case are featured in the following table:

Stage	Gas: monitoring method (calculation methodology)
1. Animals housing	NH_3, CH_4: QEPAS (Quartz-Enhanced PhotoAcoustic Spectroscopy) & SIMEDAM (SIstema de MEDición AMbiental, electrochemical sensors) by mass balance
2. Storage	NH_3: Passive sampler ALPHA® (Adapted Low-cost Passive High Absorption) & Laser analyser Boreal GasFinder3-OP CH_4: Laser analyser Boreal GasFinder2-OP by WindTrax (backward Lagrangian stochastic dispersion model)
3. Agricultural fertilisation	NH_3: Passive sampler ALPHA® & Laser analyser Boreal GasFinder3-OP CH_4: Laser analyser Boreal GasFinder2-OP by WindTrax (backward Lagrangian stochastic dispersion model) N_2O, CH_4: Closed static chambers and integration using linear regression



Results and discussion

The project is still in progress and data are being collected and processed. Thanks to the implemented technology, the emission is expected to be reduced by 1,200 t CO_2eq/yr. Methodologies will be a tool for data credibility since one of the foremost goals of the project is to develop robust gas emission measuring and monitoring methodologies. Besides evaluating the efficiency of innovative techniques, the tested methodologies will provide reliable, consistent, and comparable data on GHG and NH_3 fluxes. The project intends to contribute with these data to new versions of the BREF document, atmospheric emission inventories, and decision-making in environmental policy development.

Acknowledgements

The LIFE CLINMED-FARM project is co-funded by the European Union. However, the views and opinions expressed are those of the authors only and do not necessarily reflect those of the European Union or CINEA. Neither the European Union nor the granting authority can be held responsible for them.

References

European Environmental Agency (EEA), 2024a. Annual European Union greenhouse gas inventory 1990-2022 and inventory document 2024. First submission under the Enhanced Transparency Framework of the Paris Agreement. EEA/PUBL/2024/046

EEA, 2024b. Air pollution in Europe: 2024 reporting status under the National Emission reduction Commitments Directive. 07/2024. doi: 10.2800/019282 https://www.eea.europa.eu/publications/national-emission-reduction-commitments-directive-2024

89. Measuring the effect of feeding sainfoin (*Onobrychis viciifolia*) silage on methane emissions in a naturally ventilated dairy housing using a case-control approach

Schrade, S.[a*], Lazzari, G.[a], Steger, D.[b], Mohn, J.[b], Dohme-Meier, F.[a] & Zähner, M.[a]

[a] Ruminant Nutrition and Emissions, Agroscope, 8356 Ettenhausen and 1725 Posieux, Switzerland
[b] Empa, Laboratory for Air Pollution / Environmental Technology, 8600 Dübendorf, Switzerland
[*]Corresponding author, email: sabine.schrade@agroscope.admin.ch

Introduction

Feeding the tanniferous legume sainfoin (*Onobrychis viciifolia*) to dairy cows is a promising strategy to reduce both methane (CH_4) (Lazzari et al. 2023a) and ammonia (Lazzari et al. 2023b) emissions. The effect of the dietary inclusion of sainfoin on CH_4 emissions were mainly investigated at the individual animal level, e.g. in respiration chambers (Huyen et al. 2016) and with the GreenFeed system as well as by laboratory measurements of the manure (Lazzari et al. 2023a). However, for a realistic assessment of its CH_4 mitigation potential, measurements on a practical scale are necessary.

Methodology

Measurements were carried in a naturally ventilated dairy housing at Agroscope (Switzerland). To cover climatic conditions throughout the year the measurements were performed in summer, autumn and winter. Two separate compartments equipped with cubicles and solid floors, enabled comparative measurements in parallel, following a case-control approach. In one compartment, a group of 20 lactating cows was fed a sainfoin silage-based diet while a second group in the other compartment was offered a grass silage-based diet. Each measuring period lasted at least four days. The treatments were then switched in a cross-over design. CH_4 emissions were quantified using a dual tracer ratio method and cavity ring-down spectroscopy (Mohn et al. 2018). In addition to continuous recording of climatic data (e.g. temperature, wind speed) and daily feed intake per herd, each cow's milk yield was recorded once per period, with milk samples collected on the same day.

Results and discussion

Median CH_4 emissions ranged between 322 and 394 g per livestock unit per day for different measurement periods for both diets and were within the range of emissions reported for dairy loose housings with solid floors (Poteko et al. 2019). The reduction in CH_4 emissions from the sainfoin diet compared to the grass silage-based diet was around 10% across all three seasons. The statistical analysis using a linear mixed effect model showed that air temperature ($p < 0.001$) and diet ($p < 0.001$) were significant factors influencing CH_4 emissions. This is in agreement with a meta-analysis of emission data from different studies in dairy housings, which also found a significant positive effect of temperature on CH_4 emissions (Poteko et al. 2019).

Conclusion

These measurements on a practical scale show that feeding a sainfoin silage-based diet can reduce CH_4 emissions at the entire dairy housing level by about 10% compared to a grass silage-based diet. The presentation will provide more details on diets and their effects on animal performance and NH_3 emissions.

Acknowledgements

Thanks to numerous people from Agroscope and BBZ Arenenberg for technical assistance, chemical analyses, and cooperation (e.g. S. Ampuero-Kragten, A. Decker, S. Dönni, M. Hatt, M. Hausammann, M. Keller, and B. Kürsteiner).

References

Huyen, N. T., et al. 2016. Inclusion of sainfoin (*Onobrychis viciifolia*) silage in dairy cow rations affects nutrient digestibility, nitrogen utilization, energy balance, and methane emissions. J. Dairy Sci. 99(5):3566-3577.

Lazzari, G., et al. 2023a. Effects of *Acacia mearnsii* added to silages differing in nutrient composition and condensed tannins on ruminal and manure-derived methane emissions of dairy cows. J. Dairy Sci. 106(10): 6816-6833

Lazzari, G., et al. 2023b. Effects of tanniferous sainfoin and Acacia mearnsii extract on urinary N excretion and ammonia volatilization from the slurry of dairy cows. Anim. Feed Sci. Technol. 297:115577.

Mohn, J., et al. 2018. A dual tracer ratio method for comparative emission measurements in an experimental dairy housing. Atmos. Environ. 179:12-22.

Poteko, J., et al. 2019. Effects of housing system, floor type and temperature on ammonia and methane emissions from dairy farming: A meta-analysis. Biosys. Eng. 182:16-28.

90. Integrated emission mitigation solutions through innovative housing and manure management systems in pig farming

Sefeedpari P.[a*], Hertogh N. [a], van Rooijen J. C. [a], Aarnink A.J.A.[a]
Wageningen Livestock Research, the Netherlands [a]; *Corresponding author, email: paria.sefeedpari@wur.nl

Introduction

Pig farming in the Netherlands is dominated by large-scale, intensive production systems (Willems et al., 2016). Intensive farming practices provide affordable food but are often criticized for their impact on animal welfare, and environmental problems (Ambrosius, 2022). To mitigate these impacts, new techniques are needed to minimize the negative effects of pig farming as much as possible (Mol and Ogink, 2004; Sefeedpari et al., 2024). This study evaluated the impact of an innovative weaned piglet housing concept, integrating manure separation and daily removal and reduction of the emitting surface by reducing litter contamination and a relatively small excretion area at a rooting house concept, for its effectiveness in mitigating emissions of ammonia (NH_3), methane (CH_4), nitrous oxide (N_2O), odour, and particulate matter (PM). Furthermore, the inlet air was conditioned by air tubes in the ground underneath the barn and Ionization lamps have been installed inside the pig rooms for PM reduction.

Methodology

Field measurements were conducted six times over one year following a standardized protocol in a case-control setup, complemented by continuous sensor-based monitoring on a pilot pig farm. Ammonia (NH_3), methane (CH_4), and nitrous oxide (N_2O) concentrations were measured in both the case and control rooms, while particulate matter and odour were assessed only in the case room. Additionally, sensors continuously recorded NH_3, carbon dioxide (CO_2), temperature, and relative humidity. The ventilation rate was calculated using the CO_2 mass-balance method (CIGR, 2002).

Results and discussion

Preliminary results showed a reduction of 70% for NH_3 emission compared to a reference system with no manure separation and reduced emitting area. Methane emission showed a promising reduction of around 95%, attributed to the prevention of anaerobic decomposition through effective urine-feces separation and immediate manure removal. This approach also offers high potential for biogas production. Odour reduction was measured lower than anticipated, averaging below 40%, while PM emission increased due to dry bedding material, both compared with previous measured reference levels. Adjustments, such as using low-dust sawdust, may help mitigate this effect. The case room exhibited lower and more stable temperatures and humidity levels, suggesting an optimized indoor climate. Minimal floor contamination further improved air quality and reduced ammonia formation.

Conclusion

These findings underscore the effectiveness of source-based mitigation strategies in reducing emissions, enhancing air quality, and ultimately improving animal welfare in pig farming. The concept presents a promising alternative to traditional air scrubbers, contributing to sustainable livestock farming while aligning with regulatory and climate goals. Further analysis will enable more precise conclusions to be drawn. Future research will refine the system to optimize odour and PM reduction.

References

Ambrosius F.H.W. et al., 2022. Diffusion of organic farming among Dutch pig farmers: An agent-based model, Agricultural Systems, 197, 103336.

CIGR, 2002. 4th Report of Working Group on Climatization of animal houses. Heat and moisture production at animal and house levels (eds. Pedersen, S.; K. Sällvik).

Mol, G., & Ogink, N.W.M. 2004. The effect of two ammonia-emission-reducing pig housing systems on odour emission. Water Science and Technology, 50(4.), 335-340.

Sefeedpari, P., et al. 2024. Innovative pig house designs for minimal emissions: impact of manure management on methane and ammonia emissions. In D. Berckmans, P. Tassinari, & D. Torreggiani (Eds.), 11th European Conference on Precision Livestock Farming (pp. 206-213). European Association for Precision Livestock Farming.

Willems J., et al. 2016. Why Danish pig farms have far more land and pigs than Dutch farms? Implications for feed supply, manure recycling and production costs, Agricultural Systems, 144, 122-132.

91. Assessing the effect of long-term reduced tillage on N_2 and N_2O emissions – an incubation experiment

Stenfert Kroese, Jaqueline[a*] Prüßner, Annika[b] & Well, Reinhard[a]

Thünen Institut, Institute of climate-smart agriculture, Germany[a]; Technical University of Braunschweig, Germany[b]; [*]Corresponding author, email: Jaqueline.stenfertkroese@thuenen.de

Introduction

Gaseous emissions from denitrification, including nitrous oxide (N_2O) and molecular nitrogen (N_2), not only contribute to nitrogen losses that can impede crop yields but also play a significant role in climate change. The magnitude of these emissions is highly variable and influenced by factors such as climate, management practices, and soil properties. There is a lack of studies on effective measures to reduce denitrification losses through fertilization, soil cultivation, and crop rotation. This is primarily due to the difficulty in measuring N_2 losses at the field scale, owing to the atmospheric background concentration of N_2. As a result, agricultural practices that enhance nitrogen efficiency while minimizing nitrogen emissions have yet to be fully established. Soil cultivation through regular tillage or methods involving reduced or minimal tillage can lead to significant differences in the quantity and distribution of soil organic matter. Tillage can reduce emissions by loosening the soil, but it can also promote emissions by deeply incorporating crop residues. In contrast, increased N_2O emissions under minimal tillage are well-documented, due to soil compaction and higher concentration of organic matter at the soil surface.

Methodology

We conducted an incubation study using intact soil cores from a silt loam field in Lower Saxony. For the past 10 years, the field has been managed with three different practices: one section was managed conventionally using a mouldboard plough, while the other two sections employed reduced tillage practices with a chisel plough and a disc harrow. To further assess the impact of water content and the availability of labile carbon compounds under different management practices, treatments with a water-filled pore space (WFPS) of 55% and 57%, along with treatments with and without maize, were applied. The ^{15}N gas flux method in a N_2-reduced atmosphere was employed to quantify N_2 and N_2O fluxes.

Results and discussion

Preliminary findings indicate that maize treatments exhibited higher cumulative N_2 and N_2O emissions and the highest for conventional tillage. The product ratio of denitrification ($N_2O/(N_2+N_2O)$, referred to as N_2Oi was higher for the maize treatments compared to treatments without maize. In general, at higher WFPS, the N_2Oi was higher in the reduced till soil system compared to the conventionally tilled treatment. However, at slightly lower WFPS the N_2Oi was similar in all treatments.

92. Design and implementation of a modified semi-continuous simulation technique to assess enteric methane mitigation in ruminants

Timm, T.G.[a,b*], Bastidas Vasconez, J.J.[a,b], Ovani, V.[a,b] & Abdalla, A.L.[a,b]

Center for Nuclear Energy in Agriculture (CENA) of University of São Paulo (USP), Brazil [a]; Center for Carbon Research in Tropical Agriculture (CCARBON), Brazil [b]; *Corresponding author, email: ttimm@usp.br

Introduction

Livestock accounts for 14.5% of global GHG emissions, with enteric methane (CH_4) being a major contributor. Optimizing ruminant nutrition is crucial for reducing CH_4 while improving sustainability in meat production. *In vitro* rumen fermentation continuous techniques assess dietary strategies, but high costs limit their use. This study aims to develop an adapted semi-continuous *in vitro* rumen fermentation system for enteric CH_4 mitigation studies.

Methodology

The adapted semi-continuous system, named Rumiflow – *in vitro* rumen fermentation system (IVRFS), was developed and implemented at the Animal Nutrition Laboratory of the Center for Nuclear Energy in Agriculture, University of São Paulo (Piracicaba, São Paulo, Brazil). The system was established using solutions and reagents based on the original RUSITEC model, with adaptations using a shaker incubator with four fermentation vessels (1000 ml) equipped with a bottom buffer input and an overflow outlet for effluent and fermentation gases. Four *in vitro* experiments were conducted using a standardized diet: Tifton 85 hay (59.4%), concentrate (40%: 70% ground corn, 30% soybean meal), and mineral mix (0.6%). Ruminal content was collected from two canulated adult Santa Inês sheep [Protocol CEUA/CENA, nº 0004/2021] to prepare the inoculum. Each experimental period lasted five days (96 hours), divided into: a stabilization phase (days 1-3), for system stabilization; and a stable phase (days 4-5), the sampling period for total gas and CH_4 production, effluent volume, fermentation parameters, and organic matter degradability (OMD).

Results and discussion

OMD values showed no statistical differences between fermenters or experimental periods (48.9 ± 0.05%). Effluent and gas volumes were consistent across fermenters and periods, stabilizing after 72 hours for effluent (427 ± 29.7 ml/24h) and 48 hours for gas (1728 ± 247.5 ml/24h). Although CH_4 production varied in the first experimental period, later measurements showed no statistical differences among fermenters (6.4 ± 0.81 ml/g DM/24h).

Conclusion

The adapted system was effectively implemented and suitable for standardization. It offers an affordable alternative for CH_4 mitigation research, benefiting developing countries with growing beef production research. Improved gas quantification and nutrition technologies will enhance sustainability, animal welfare, and the circular bioeconomy, aligning with the SDGs.

Acknowledgments

The authors gratefully acknowledge the Center for Carbon Research in Tropical Agriculture (CCARBON). This study was financed, in part, by FAPESP - 2024/06301-7 and 2024/07657-0, CNPq 306116_2023-5, and CAPES finance code 001 fellowships.

References

Carlson, K. M., et al. 2017. Greenhouse gas emissions intensity of global croplands. Nat. Clim. Change. 7, 63–68.

Czerkawski, J. W., & Breckenridge, G. 1977. Design and development of a long-term rumen simulation technique (Rusitec). Br. J. Nutr. 38, 371-384.

Lima, P. M. T., et al. 2018. Nutritional evaluation of the legume *Macrotyloma axillare* using *in vitro* and *in vivo* bioassays in sheep. J. Anim. Physiol. Anim. Nutr., 102, p. e669–e676.

OECD, Fao. 2020. OECD-FAO Agricultural Outlook 2020–2029, OECD Publishing Paris,/Food and Agriculture Organization of. the United Nations, Rome.

Timm, T. G., et al. 2024. Peach palm shells (*Bactris gasipaes* Kunth) bioconversion by *Lentinula edodes*: Potential as new bioproducts for beef cattle feeding. Bioresour. Technol. 394, 130292.

Vargas, J. E., et al. Differential diet and ph effects on ruminal microbiota, fermentation pattern and fatty acid hydrogenation in RUSITEC continuous cultures. Ferment. 9, 320.

93. Agro-industrial by-products valorisation by *Lentinula edodes* bioconversion for ruminant feeding: *in vitro* effects on ruminal fermentation and greenhouse gases emissions

Timm, T.G. [a,g,*], da Rocha, B.M. [b], Savio, R.L. [b], Camargo, G.S. [b], Amâncio, B.R. [c], Loregian, K.E. [c], Cagliari, A.R. [b], Casagrande, A.C. [b], Magnani, E. [c], Helm, C.V. [d], de Lima, E.A. [d], Marcondes, M.I. [e,f], Branco, R.H. [c], de Paula, E.M. [c], Benedeti, P.D.B. [b], Tavares, L.B.B. [a]

Environmental Engineering Graduate Program of Regional University of Blumenau, Brazil [a]; Department of Animal Sciences of University of the State of Santa Catarina, Brazil [b]; Beef Cattle Research Center, Institute of Animal Science, Brazil [c]; Research Center of Forestry of Brazilian Agricultural Research Corporation, Brazil [d]; Department of Animal Sciences of Washington State University, United States of America [e]; William H. Miner Agricultural Research Institute, United States of America [f]; Current address: University of São Paulo (USP), Brazil [g]; *Corresponding author, email: ttimm@furb.br

Introduction

Methane (CH_4) is a major environmental pollutant from ruminants and contributes to approximately 2–12% of total dietary energy losses during enteric fermentation. Thus, mitigating CH_4 emissions through dietary improvements and adding functional substances is crucial for enhancing efficiency and promoting the sustainable development of the beef cattle industry. This study aimed to develop and evaluate the *in vitro* effects of novel high-value bioproducts derived from agro-industrial byproducts on ruminal fermentation and greenhouse gas emissions in beef cattle diets.

Methodology

The bioproducts were obtained through solid-state fermentation of king palm (SSF1) and peach palm (SSF2) shells by *Lentinula edodes*, followed by Shiitake mushroom cultivation in axenic blocks (SMS). Chemical analysis was conducted to determine the bioproducts' suitability as feedstuffs. Subsequently, *in vitro* experiments assessed gas production (GP), enteric methane (CH_4) and carbon dioxide (CO_2) emissions, short-chain fatty acids (SCFA), ammonia–nitrogen (NH_3-N), and *in vitro* organic matter digestibility (IVOMD) of both the ingredients (SSF1) and total formulated diets (SSF1, SSF2, and SMS), compared to conventional diets (corn silage, *Brachiaria* hay, sugarcane, and peach palm shells).

Results and discussion

The bioproducts exhibited high β-glucan (6.6-11.3%) and protein (7.4-10.0%) contents. SSF1 tested as an ingredient, showed significantly lower total GP at 24, 48, and 72 hours, IVOMD, CH_4 and CO_2 emissions, and total SCFA concentrations compared to conventional ingredients ($P < 0.01$). On the other hand, replacing corn silage with increasing levels of SSF1 (0%, 33%, 66%, and 100%) in total diets had no significant impact on total GP at 24 and 48 hours, IVOMD, CH_4 and CO_2 emissions, SCFA, or NH_3-N ($P > 0.05$). Additionally, SSF2 and SMS diets maintained IVOMD (>70%) comparable to conventional diets ($P > 0.05$). The SMS diet resulted in the lowest methane (19 mM/g OM) and carbon dioxide (84 mM/g OM) emissions, while the SSF2 diet exhibited lower CO_2 emissions (99 mM/g OM) than other diets, with no significant differences in CH_4 production.

Conclusion

These findings highlight the potential of these bioproducts as nutrient-rich feed and sources of bioactive compounds (β-glucans) for cattle diets, preserving nutritional quality while reducing greenhouse gas (GHG) emissions. Integrating agro-industry byproducts into livestock feeding systems through fungal bioconversion aligns with circular bioeconomy principles and the Sustainable Development Goals (SDGs), promoting sustainability and enhancing the nutritional quality, digestibility, and environmental impact of agro-industrial byproducts.

Acknowledgements

CAPES (#001; #88887.490173/2020-00), FAPESC (#027/2020; #2021TR937), Embrapa Florestas/CNPq (#20/2017), CNPq (#305880/2020-9; #02/2020), and FAPESP (#2017/50339-5; #2018/19743-7).

References

Gao, Q., et al. 2023. Recent advances in feed and nutrition of beef cattle in China — A review. Anim Biosci 36, 529–539.

Timm, T.G., et al. 2024a. Peach palm shells (*Bactris gasipaes* Kunth) bioconversion by *Lentinula edodes*: Potential as new bioproducts for beef cattle feeding. Bioresour. Technol. 394, 130292.

Timm, T.G. et al., 2024b. King Palm (*Archontophoenix alexandrae*) Byproduct Valorization by *Lentinula edodes* Colonization for Ruminant's Diet: *In Vitro* Effects on Ruminal Fermentation and Greenhouse Gases Emissions. Waste Biomass Valori. 1, 1-14.

94. Enhancing Methane Emission Estimates from Manure Management: A Comparative Analysis of IPCC Guidelines and Methodological Approaches

Triolo, J.M.[a,b*]Lee, S.H.[c], Shin, S.G.[a,b], Sommer, S.G.[d]

Gyeongsang National University, Department of Energy System Engineering, Republic of Korea[a]; Gyeongsang National University, Future Convergence Technology Research Institute, Republic of Korea[b]; Onespring Corporate Research Institute, Republic of Korea[c], Aarhus University, Department of Biological and Chemical Engineering, Denmark [d] *Corresponding author, email: jinmitriolo@gnu.ac.kr

Introduction

South Korea is transitioning from the 1996 to the 2006 IPCC guidelines to improve greenhouse gas (GHG) reporting accuracy. Its pig manure management system involves separating the liquid fraction for aerobic treatment while composting the solid fraction. Manure-based biogas production is still in its early stages, serving as an intermediate step before aerobic treatment, during which anaerobic digestate undergoes further purification. The complexity of manure management complicates methane emission estimation, further challenged by the lack of country-specific reference data and inconsistencies across IPCC guideline updates. This study aims to enhance methane emission accuracy in national GHG inventories, support standardized estimation methods, improve international comparability, and contribute to future refinements of IPCC guidelines and national reporting frameworks.

Methodology

First, a comprehensive review was conducted on methane(CH_4) emission factors from pig manure, key activity data, applied methodologies, reference data, and underlying assumptions across 36 of the 43 UNFCCC Parties. This review was based on the National Greenhouse Gas Inventory Reports(NIR) and Common Reporting Format (CRF) submissions reported in 2023. Additionally, an in-depth evaluation of activity data and parameters was performed, including an analysis of animal waste management systems and methodological approaches. Second, methane emissions from manure management in the context of South Korea were analysed and compared based on two key factors: (1) the impact of different IPCC guidelines, including the 1996 and 2006 guidelines as well as the 2019 refinements, and (2) the effect of different methodological approaches, such as the use of a single methane conversion factor (MCF) for representative manure management versus integrated MCFs applied to joint manure management systems through mass flow analysis.

Results and discussion

The average CH_4 emission factor across 36 investigated countries was 5.27 kg CH_4/head/year, ranging widely from 0.50 to 23.06 kg CH_4/head/year. Similarly, methane conversion factors (MCFs) derived from CRF-reported data varied significantly (1.8%–52.9%, averaging 15%), primarily due to manure management methods, such as the high use of anaerobic lagoons (e.g., Australia 66%, United States 44%–56%). While B_o and VS values remained relatively consistent, with most countries adopting the default B_o of 0.45 CH_4 m^3/kg VS. MCFs for solid systems were stable, whereas liquid systems exhibited greater variability influenced by climate, storage duration, and management practices. Fourteen countries reported biogas digesters in their CRF submissions, with MCF values varying nearly 100-fold, from 0.10% in Australia and 0.53% in Japan to ~10% in the Netherlands, Denmark, and Sweden (9.50%–10.91%), likely reflecting weighted averages of pre- and post-treatment manure management. Finally, the results were compared to methane emissions in South Korea. Consequently, methane emission estimates were more influenced by methodological approaches (e.g., simplified estimation vs. mass flow-based calculations) than by activity data differences.

Conclusion

The study highlights inconsistencies in methane emission estimation methodologies, particularly in the biogas digester treatment category, emphasizing the need for harmonized reporting guidelines to enhance comparability and accuracy in national greenhouse gas inventories. These discrepancies underscore the importance of a standardized framework that ensures methodological consistency while accommodating country-specific conditions, ultimately improving the reliability and comparability of national inventories.

Acknowledgement

This work was supported by the Livestock Environmental Management Institute (No. 20240706772-00 and R25TA00091586-00). This work was also supported by the Brain Pool program funded by the Ministry of Science and ICT through the National Research Foundation of Korea (RS-2024- 00410127).

95. Enhancing Energy Efficiency and Methane Emission Reduction in Pig Manure-Based Biogas Production

Park, S.B.[a,b], Bae, I.H.[b], Shin S.H.[c], Shin, S.G.[b,c] & Triolo, J.M.[b,c*]

Woncheon Energy Conversion Center, Sungwoo Pig Farm, 40-3 Hongnam-ro, Hongseong 32210, Republic of Korea[a]; Department of Energy System Engineering, Gyeongsang National University, 501 Jinjudae-ro, Jinju 52828, Republic of Korea[b]; Future Convergence Technology Research Institute, Gyeongsang National University, 501 Jinjudae-ro, Jinju 52828, Republic of Korea[c]; *Corresponding author, email: jinmitriolo@gnu.ac.kr

Introduction

In South Korea, pig manure-based biogas production has a relatively short history of about a decade and remain predominantly small-scale, indicating that anaerobic digestion is still in its early stages. The lack of national-level insights into energy production from manure-based biogas plants and their potential for greenhouse gas reduction underscores the urgent need for research. This study aims to address these gaps by exploring strategies to enhance productivity and stability while overcoming technological limitations and community resistance. Given their integral role in local communities, livestock farmers must actively support biogas initiatives alongside government policies. A comprehensive analysis of pig manure characteristics and methane yield is essential, along with predictive values for anaerobic digestion to improve biogas operations.

Methodology

Pig manure samples from 17 farms supplying a local biogas plant were categorized based on storage method (open, scraper, slurry) and pig type (fattening pigs, mixed sows, piglets, and fattening pigs). An analysis was conducted on the characteristics of manure collected from 17 pig farms. Following this, the methane potential of the manure was evaluated, and microbial community compositions were compared at the end of the biochemical methane potential test. Based on these analyses, methane production during anaerobic digestion was modelled under various scenarios, enabling the estimation of potential electricity generation and carbon dioxide reduction. Additionally, 16S rRNA gene sequencing was performed to examine microbial communities. The experimental results were further categorized based on manure management practices and the types of pigs raised.

Results and discussion

Total nitrogen (TN) and total ammonia nitrogen (TAN) concentrations in manure samples were significantly higher than expected, with overall ranges of 4.9–14.9 g/L and 3.5–12.3 g/L, respectively. Specifically, TAN concentrations were distributed as follows:5 farms in the 3–5 g/L range, 6 farms in the 5–7 g/L range, 5 farms in the 7–9 g/L range, and 1 farm exceeding 9 g/L. The biochemical methane potential test revealed methane yields between 282 and 491 mL CH_4/g VS, with the highest results observed in open-type storage manure. The scraper method exhibited the highest methane production. The microbial community analysis identified dominant bacterial families, including Clostridiaceae and Lachnospiraceae, while Methanoculleus and Methanothrix were the most prevalent archaeal genera, responsible for methane production. Modelling results indicated that co-digestion with food wastewater (Mixing ratio 70:30) enhanced methane production by approximately 1.4 times compared to mono-digestion. Estimated energy production from pig manure alone was 276 kWh/ton, while co-digestion increased this to 397 kWh/ton. Correspondingly, carbon dioxide reduction increased from 109 kg CO_2/ton in mono-digestion to 157 kg CO_2/ton in co-digestion.

Conclusion

The results demonstrated significant variation in methane yield based on manure management practices and pig types. Co-digestion with food wastewater proved more effective than mono-digestion, leading to higher methane production and energy recovery. The use of the predicting model facilitated accurate predictions of methane yield under various conditions. These findings underscore the importance of optimized anaerobic digestion conditions and improved manure management strategies for enhancing biogas production and contributing to sustainable energy generation and greenhouse gas reduction.

Acknowledgement

This work was supported by the Agricultural Policy Support Technology Development Project (RS-2022-RD010246) of the Korea Rural Development Administration. This research was also supported by Brain Pool program funded by the Ministry of Science and ICT through the National Research Foundation of Korea (RS-2024- 00410127).

96. Loss of biogas potential in the first three days after excretion of dairy cow and pig manure

Van Boxmeer, E.G.G.[*,a], Smit, H.J[a]

Wageningen Livestock Research [a], The Netherlands; [*]Corresponding author, email: emma.vanboxmeer@wur.nl

Introduction

During manure storage, organic matter degrades to volatile fatty acids (VFA) and methanogens use VFA to produce methane (CH_4). CH_4 emissions from dairy cow and pig houses can be reduced by minimizing manure storage time in the barn trough frequent removal of slurry (Dalby et al., 2021). Furthermore, anaerobic digestion of fresh manure can result in increased biogas production compared to previously stored manure (Hilgert et al., 2023). This leads to the question of how quick manure should be removed from the barn after excretion to reduce its environmental impact. For ammonia it is known that the peak of emission usually occurs within 2 hours after excretion (Elzing and Monteny, 1997). However, little is known about the breakdown of organic matter in the first hours after excretion. The aim of this research was to determine the breakdown of organic matter and emissions of CH_4 from dairy cow and pig slurry in the first hours after excretion.

Methodology

This study used three climate respiration cells (CRCs) to measure CH_4 emissions from slurry on a solid floor. Each chamber was divided into two airtight compartments (11.8 m^2, 35 m^3) and contained two manure pits with a square surface area of 1.3 m^2 and depth of 0.5 meters. During the experiment, only one manure pit per compartment was used and no animals were present in the CRCs. The manure pit was fouled with slurry that had previously been stored. Then, fresh slurry (< 1 hour old) was added to the pit. CH_4 concentrations from the inlet and exhaust air were measured in 3-minute intervals with a gas analyser for 72 hours for dairy cow slurry and 68 hours for pig slurry. CH_4 production was calculated from the difference between inlet and exhaust gas volumes. Manure volumes were based on the daily manure production of dairy cows and pigs, which is 16 and 11,5 L respectively. This resulted in manure heights in the pits ranging from 0,2 to 1,2 cm.

Dairy cow manure was collected from the experimental dairy farm of Carus research facility of Wageningen University and Research. Pig manure was collected from a commercial pig farm with both fattening pigs and gestating sows. Three treatments were studied: 1) dairy cow slurry with a temperature of 15°C (CS15), 2) dairy cow slurry with a temperature of 20°C (CS20) and 3) pig slurry with a temperature of 20°C (PS20). Manure samples were taken from the fresh slurry and the remaining slurry after 68 hours. From the fresh slurry, also the biochemical methane potential (BMP) was determined.

Results and discussion

The BMP of fresh dairy cow and pig slurry was 248 and 278 m^3 CH_4/ton OM respectively. The average CH_4 emissions from CS15 and CS20 were constant in the first three days. However, the emission rate of CS20 was consistently higher than that of CS15 (8.6 and 6.0 mg/h respectively). CH_4 emissions from PS20 showed a linear increase from 5 to 15 mg/h in the first 68 hours and thereby exceeded the emissions rates from slurry. Cumulative CH_4 emissions (after 68 hours) were highest for PS20 (0.4 m^3/ton OM), followed by CS20 (0.6 m^3/ton OM) and CS15 (0.8 m^3/ton OM). Compared to the BMP of fresh slurry, only 0.2% and 0.3% of the CH_4 potential is lost in the first three days after excretion. More results, e.g. manure characteristics, can be found in Van Boxmeer et al. (2024).

Conclusion

The breakdown of organic matter and emissions of CH_4 are low in the first three days after excretion, and the loss of biogas potential is limited. It should be emphasized that ammonia emissions can occur more quickly, which might require faster manure removal from the barn to reduce the total environmental impact of manure.

Acknowledgements

This research was funded by the Dutch Ministry of Agriculture as part of the programme “Integraal aanpakken”.

References

Elzing, A., G.J. Monteny. 1997. Ammonia emission in a scale model of a dairy cow house. Transactions of the ASAE. 40(3): 713-720

Dalby, F.R., et al. 2020. Understanding methane emission from stored animal manure. J. Environ. Qual. 50:817–835

Hilgert, J.E., et al. 2023. Assessment of the biochemical methane potential of in-house and outdoor stored pig and dairy cow manure by evaluating chemical composition and storage conditions. Waste Management 168: 14 – 24

Van Boxmeer, E. et al., 2024. Emissies uit verse drijfmest, urine en feces van rundvee, varkens en kalveren. WLR Report 1495

97. No reduction of annual N_2O emission by nitrification inhibitor DMPP added to Cattle Slurry and Ammonium Sulphate Nitrate - a multisite comparison

Wonneberger, Arnold [a*]; Pacholski, Andreas [a]; Binder, Ines [b]; Finck, Riecke [c]; Ohmann, Felix [d]; Schneider, Rosanna [e]

Thünen Institute of Climate-Smart Agriculture, Germany [a]; University of Hohenheim, Germany [b]; Kiel University, Germany [c]; University of Applied Sciences Osnabrück, Germany [d]; University of Göttingen, Germany [d]; *Corresponding author, email: arnold.wonneberger@thuenen.de

Introduction

The use of nitrification inhibitors (NI) is suggested and still discussed as an effective tool to reduce direct and indirect nitrous oxide emissions from nitrogen fertilization (e.g. Ruser & Schulz 2015). However, assessments of the effect of NI on N_2O emission reduction on an annual scale and for particular inhibitor compounds is still scarce (Shang et al. 2020). The NI 3,4-dimethylpyrazole phosphate (DMPP) is one of the globally and in Germany most used commercially available products, applied in liquid formulation for use in organic fertilizers or coated on mineral fertilizers. To date there exists only limited knowledge on efficacy of DMPP to reduce N_2O emissions on an annual level for both mineral and organic fertilizers under central European conditions. Within the German multi-site project NitriKlim, the efficacy of DMPP on N_2O emission reduction from mineral and organic fertilizers was compared.

Methodology

As part of the NitriKlim joint project, multisite experiments are being conducted at five winter wheat locations across Germany. The sites are localized in different agro-climates and soil conditions. The field experiment included the fertilizer treatments cattle slurry, cattle slurry+DMPP (addition of BASF, VIZURA®), Ammonium Sulphate Nitrate (ASN) and ASN+DMPP (former brand name Eurochem, ENTEC®26). The fertilizers are applied in two doses at the start of the growing season and at stem elongation (EC 32-35) at levels in accordance with the German Fertilizer Ordinance. The first slurry fertilization is a slot application and the second application is carried out using a trail hose. Nitrous oxide emissions are measured using the static chamber method with weekly sampling for the entire cropping year (1st fertilization of crop – 1st fertilization of subsequent crop).

Results and discussion

Emission data from the locations for the first two experimental years show, that within the vegetation period (March -harvest), the use of the nitrification inhibitor DMPP caused a significant reduction in nitrous oxide emissions for both cattle slurry and ASN compared to the fertilizers without DMPP addition. The liquid addition of DMPP to slurry showed a relatively greater reduction effect. With the onset of tillage after harvest, no reduction in nitrous oxide emissions were observed for either fertilizer treatment with DMPP in the remaining year. In sum, the annual cumulative N_2O emissions of nitrous oxide showed no significant reduction in both tested base fertilizers treated with DMPP, though there were tendencies towards a reduction at some sites. Based on the new data, the use of DMPP for reduction of annual N_2O emissions from the tested fertilizers is questionable under conditions of central Europe.

References

Ruser, R., et al. 2015. The effect of nitrification inhibitors on the nitrous oxide (N2O) release from agricultural soils—a review. J. Plant Nutr. Soil Sci. 178 (2), 171–188.

Shang, Z.Y.; et al. 2020. Measurement of N2O emissions over the whole year is necessary for estimating reliable emission factors. Environ. Pollut. 259, 113864

Evaluation of the dynamics of essential elements in soil by sludge incorporation under controlled conditions: Effect on greenhouse gas emissions and mineralisation

Martinez-Sabater, E.*, Orden, L., Sáez-Tovar, J.A., Pérez Murcia, M.D., Sánchez-Méndez, S., Bustamante, M.A. & Moral, R.

Centro de Investigación e Innovación Agroalimentaria y Agroambiental (CIAGRO-UMH), Universidad Miguel Hernández, Carretera de Beniel Km 3,2, Orihuela, Alicante 03312, España;
*Corresponding author, email: e.martinezs@umh.es

Poster or Oral (highlight the applicable)

Introduction

The application of sewage sludge as a fertiliser in agricultural soils facilitates the recycling of essential nutrients, in particular nitrogen and phosphorus, as well as the supply of organic matter. Furthermore, its use in agriculture is emerging as an efficient strategy for soil carbon sequestration, in line with the recommendations of the IPCC (2021), which recognises waste management as a key activity for climate change mitigation. In this study, the interaction between soil and sewage sludge was analysed in terms of mineralisation and dynamics of essential elements. For this purpose, greenhouse gas emissions were measured under controlled conditions (mesocosms), considering the type of sludge, the application dose and the characteristics of the type of soil or receptor medium as variables. Based on these data, behavioural models were developed to optimise the application rate and minimise the risk of excess nutrients in the ecosystem.

Methodology

Four integrated samples of sludge from 39 wastewater treatment plants in the Valencia region and a commercial sludge compost were used. The study was carried out by means of a mesocosm trial, considering the following experimental variables: i) type of sludge treatment: anaerobic digestion (AD) or forced aeration (FA); ii) soil type: classified according to its textural group (clayey and sandy); and iii) sludge application rate (25 t/ha and 50 t/ha, fresh matter basis). The sludge was applied to 200 g of soil in containers, and the experiment was conducted in an incubation chamber with controlled conditions of temperature (25 °C), day/night cycles and aerobic environment without leaching for 240 days. Throughout the test, the mixtures were maintained at 2/3 of their field capacity. Gas emissions were monitored using a static closed chamber system designed specifically for this study. Gas emissions were monitored using a static closed chamber system designed specifically for this study, connected to a multi-gas meter using photoacoustic infrared spectroscopy (Gasera One, Gasera Ltd.). Measurements were made at 14 points in time during the incubation period (0, 1, 3, 3, 7, 10, 22, 35, 49, 49, 70, 108, 148, 175 and 240 days). For each measurement, two replicates of the soil-sludge system were analysed. These values were modelled using the model used in Paredes et al (2000).

Results and discussion

The clay loam soil type allows or induces higher CO_2 emissions, as the microbiota conditions in the soil are favoured, allowing microbiological mineralisation processes. In clay soils total organic carbon (TOC) mineralisation rates are lower than in sandy soils. Mineralisation rates for FA sludge are higher than those found for DA sludge. Clay loam soils induce a higher N_2O emission flux, as the pore size is smaller, moisture retention is higher, nitrification - denitrification processes are favoured and N is lost as N_2O. The sandy soil type allows a higher NH_3 emission flux, as there are more N losses due to volatilisation.

Conclusion

The clay loam soil type allows or induces a higher CO_2 and N_2O emission flux and without significant differences between the treatment variable. TOC mineralisation rates depend on soil type, sludge type and application rate. As far as N losses are concerned, the main differences are observed by soil type.

Acknowledgements

This work is included in the framework of the OPTIFANGS research project, funded by the Valencian Innovation Agency (AVI) and the European Union within the framework of the European Regional Development Fund (ERDF) Comunitat Valenciana 2021-2027.

References

Paredes, C., Roig, A., Bernal, M.P., Sánchez-Monedero, M.A., Cegarra, J., 2000. Evolution of organic matter and nitrogen during co-composting of olive mill wastewater with solid organic wastes. Biol Fert Soils 32 (3), 222e.

98. FAMT, a Farm Ammonia Mitigation Tool to quantify farm specific mitigation options.

Dekker, C.* Verloop, K. & Oenema, J.

Wageningen Plant Research, The Netherlands [a]; *Corresponding author, email: colin.dekker@wur.nl

Introduction

The mitigation of on-farm NH_3 emissions requires farm specific understanding in the relation between farm management and NH_3emission. The Annual Nutrient Cycling Assessment (ANCA) tool (van Dijk et. al., 2022) is suitable for assessing the annual on-farm NH_3emissions but proves to be insufficient to explore the effect of multiple mitigation options. The goal of this study is to develop and evaluate a Farm Ammonia Mitigation Tool (FAMT) (Verloop & Oenema, in prep).

Methodology

The (FAMT) approach consists of three steps. A) Calculating baseline emissions by first estimating the Nitrogen (N) excretion based on the milk production per cow, youngstock-rate (#YS/ 10 cows) and the crude protein (CP) concentration (g/ kg DM) of the feed ration. And second the field emissions based on current nitrogen application and standard emission rates for manure and fertiliser, and current standard emission rates for grazing. B) Define a mitigation assignment (gap) based on the preferred reduction goal as a percentage of the farm specific benchmark based on the farm production intensity (kg milk/ ha). C) Choosing mitigation options.

Results and discussion

Experimental dairy farm De Marke was taken as a case-study. The baseline emission in 2023 was 34,2 kg NH_3/ ha. The benchmark emission of farms with the same intensity is 54,5 kg NH3/ ha. The emission goal for de Marke is 27,3 kg NH_3/ ha, 50% of the benchmark which is in line with national goals (LNV, 2022). The reduction assignment is 6,9 kg NH_3/ha (34,2 - 27,3 kg NH_3/ ha). Extending the grazing season with 1 month and increasing the grazing hours per day by 1 hour per day reduces the NH_3emissions by 2 kg NH_3/ ha. Reducing the young stock rate from 5,2 to 4,2 YS/ 10 cows reduces 0,9 kg NH_3/ ha. Reducing the CP content of the ration from 15,0% to 14,8% reduces 0,9 kg NH_3/ ha. And reducing the emission factor of the barn floor from 12,2% to 8,2% reduces 4,2 kg NH_3/ ha. All measures combined reduces the emission by 7,2 kg NH_3/ ha which is lower than the sum of the above due to interactions between individual measures. Important to notice is that FAMT only accounts for the on-farm effect and not externalisation of NH_3 emission by raising young stock in different sites.

Conclusion

FAMT can present the relative contribution of individual mitigation measures for NH_3emission on a specific dairy farm. FAMT proofed to be a useful tool in a pilot for Farm Specific Nutrient Budgeting to manage on-farm NH_3emissions (Verloop et.al, 2022).

References

Van Dijk, W., J.A. de Boer, M.H.A. de Haan, P. Mosterd, J. Oenema, J. Verloop, 2022. Calculation rules of the Annual Nutrient Cycling Assessment (ANCA) 2020, report 1023-UK, Wageningen.

Verloop, J. & J. Oenema, in prep. De Bedrijfs Ammoniak Mitigatietool Melkveehouderij; Instrument voor bedrijfsspecifieke verkenning van verlagen van de NH3 emissie.

Verloop, J., GJ Hilhorst, J. Oenema, C. Dekker, A. Hooijboer, W. van Dijk, 2022. Bedrijfsspecifieke mest- en kunstmestgiften op melkveebedrijven: Resultaten pilot Bedrijfs Eigen Stikstofbemesting (BES) 2015-2020. Koeien & Kansen, rapport 91, Rapport 1178.

LNV, 2022. Programma Stikstofreductie en Natuurverbetering 2022-2035, Ministerie van Landbouw, Natuur en Voedelkwaliteit, Den Haag.

99. Investing in mini-livestock production to enhance organic resource management, mitigate emissions, and secure food security in China

Zhaohai Bai*, Xuan Wang, Lin Ma

Center for Agricultural Resources Research, IGDB, The Chinese Academy of Sciences, China; *Corresponding author, email: baizh1986@126.com

Introduction

Agriculture faces dual challenges of ensuring food security and reducing greenhouse gas (GHG) emissions, with livestock production intensifying pressures on organic waste management and nitrogen (N) pollution [1-3]. This study evaluates how replacing conventional animal protein with mini-livestock protein (from insects and earthworms) can transform organic resource management in China. These nutrient-recycling species, reared on food waste and livestock manure, may reduce manure-related emissions while contributing to carbon neutrality, aligning with national priorities for sustainable organic resource and manure management.

Methods

We combined life cycle assessment (LCA) and scenario modeling to quantify the impacts of three substitution strategies: replacing imported products (SIP), domestic products (SDP), and both (SDIH). Using the NUFER-animal model and crop-land use data, we simulated changes in organic waste utilization, manure management, and GHG emissions under two land-use scenarios: afforestation and bioenergy with carbon capture and storage (BECCS). Key inputs included 102 Mt food waste and 1,661 Mt livestock manure in China (2018), converted into 4–7 Mt edible insect protein and 17–24 Mt feed protein via species-specific feed conversion ratios (e.g., black soldier flies, earthworms).

Results

Recycling food waste and manure into mini-livestock protein reduces reliance on synthetic N fertilizers and imported feed, redirecting 21 Mha cropland and 148 Mha grassland to carbon sinks or bioenergy. Manure-derived insect production (e.g., housefly larvae, earthworms) upgrades waste management: treating 1,661 Mt manure reduces methane emissions by 28 Tg CO_2 eq/year while producing frass—a nutrient-rich byproduct replacing 20% of conventional fertilizers. SDIH strategy (hybrid substitution) achieves the highest synergies: global GHG reductions of 2,350 Tg CO_2 eq/year (BECCS scenario), driven by reduced livestock feed demand, improved waste management, and land-use change. China's agricultural sector could achieve carbon neutrality by leveraging BECCS on recovered land, while reducing feed protein imports by 78% (SDP) to near zero (SDIH).

Conclusion

By centering on organic resource recycling—transforming food waste and manure into high-value protein—mini-livestock systems offer a dual solution for RAMIRAN-aligned objectives: improving manure management, reducing reactive N losses (by 50% in SDIH), and delivering climate mitigation. The success hinges on policy support for waste collection infrastructure, land-use flexibility for carbon sinks, and consumer acceptance. This study highlights how circular organic resource management via insect-based production can reshape agricultural sustainability at national and global scales.

Acknowledgements

This study was financially supported by Strategic Priority Research Program of the Chinese Academy of Sciences (CAS) (XDA28030302); National Natural Science Foundation of China (T2222016; 42001254; 41925004; 42175169).

References

1. Crippa, M., et al. 2021. Food systems are responsible for a third of global anthropogenic GHG emissions. Nat. Food, 2, 198-209.
2. Schulte-Uebbing, L. F., et al. 2022. From planetary to regional boundaries for agricultural nitrogen pollution. Nature, 610, 507-512.
3. Springmann, M. et al. 2018. Options for keeping the food system within environmental limits. Nature, 562, 519–525.

100. Bio-methanization Digestate as Animal Bedding: A New Strategy Towards a Circular Canadian Agriculture

Palacios, J. H.[a-b], Yukari Nakanishi, E.[a], Amri, N.[c-d], M'Hamdi, N.[d] & Godbout, S.[a*]

IRDA (Research and Development Institute for the Agri-environment), Canada [a]; Soil and Agri-Food Engineering Department, Faculty of Agricultural and Food Sciences, Université Laval, Canada[b]; École Supérieure des Industries Alimentaires de Tunis, Tunisia [c]; National Agronomic Institute of Tunisia, Tunisia [d]; *Corresponding author, email: stephane.godbout@irda.qc.ca

Introduction

In 2022, a bio-energy cooperative was stablished in Warwick, QC (Canada), based on a 3,000 m³ mesophilic anaerobic reactor. Typical digestate management includes direct use as fertilizer, as it retains a significant portion of the nutrients from the original feedstock. However, alternative processing methods can enhance its value and expand its applications. One such method is phase separation, which divides the digestate into two fractions: a liquid fraction (LF) and a solid fraction (SF). The LF, rich in soluble nutrients like nitrogen and potassium, can serve as a biofertilizer. Meanwhile, in the present case, due to economic and biosecurity considerations, the cooperative faced a problem in disposing of the SF. Therefore, to address this issue, an integral analysis was needed to identify a new market for this FS. Since SF contains more organic matter and fibrous material, the cooperative wanted to explore the use of this fraction as livestock bedding. Utilizing SF in this way could create a circular approach to waste management in dairy farming by reducing dependence on conventional bedding materials and enhancing the sustainability of manure recycling within agricultural systems. This study aimed to assess the feasibility of SF as a safe and viable bedding material for dairy farms before its adoption evaluating its physicochemical properties, microbiological safety, and potential impacts on air quality.

Methodology

The project was divided into two phases. **Phase 1:** SF Characterization. This phase aimed to evaluate bedding potential of SF and its stability over time. For this, SF was sampled bi-monthly over six months, followed by physicochemical analyses (pH, dry matter, density, water absorption and particle size) and microbiological assessments to determine sanitary safety (total coliforms, *Escherichia coli*, *Staphylococcus spp.*, *Salmonella*, *Klebsiella spp.* and *Clostridium spp*). **Phase 2:** Air quality and Emission Assessment. Pilot-scale spreading trials were conducted in 12 independent controlled chambers to compare the impact of SF, two recycled litters from commercial farms within the cooperative, and straw (control) on air quality (NH_3, PM2.5, PM10, total PM) and gas emissions (NH_3, CO_2, CH_4, N_2O) before, during, and after 20-minute spreading events. Each litter type was tested in three chambers, with trials repeated four times over one month using freshly sampled material for each trial.

Results and discussion

Phase 1. Physicochemical analyses indicated that FS has an adequate pH (8.5) and a favourable particle size distribution (>4 mm: 43%, 1-4 mm: 51%, <1 mm: 4%). However, SF exhibited low dry matter content (29.4%) and limited absorption capacity (108 g_water/100 g_material), suggesting the need for conditioning before use (the minimum recommended dry matter for recycled bedding is 34%, Godbout et al., 2019). Microbiological analysis revealed high levels of coliforms and *Staphylococcus spp.*, with *Salmonella* detected inconsistently over time. **Phase 2.** Before trials, SF was dried to 35% dry matter. During spreading, SF produced lower PM levels (PM2.5: 0.06 mg/m³, PM10: 0.08 mg/m³, total PM: 0.16 mg/m³) and higher NH_3 and CO_2 concentrations compared to other materials, but staying below regulatory thresholds and suggesting minimal respiratory risks for livestock and farm workers. Processing of gas emission results is underway.

Conclusion

Solid digestate from bio-methanization presents a promising alternative to traditional bedding. However, adjustments are necessary to meet biosecurity standards. Its low dry matter content and absorption capacity may pose challenges, requiring conditioning before use. Special attention should be given to microbial contamination, particularly *Salmonella* presence. Despite these challenges, SF spreading trials suggest minimal respiratory risks for animals and workers.

Acknowledgements

This work was supported by financial assistance from the Innov'Action Program, established under the Canada-Quebec Agreement for the implementation of the Canadian Agricultural Partnership, in collaboration with the Ministry of Agriculture, Fisheries and Food and Agriculture and Agri-Food Canada. The authors extend their gratitude to our partners at Coop Agri-Énergie Warwick and Coop Carbone (Nicolas Paris-LaFrance and Josée Chicoine), as well as the participating farms (Ferme Érilis and Ferme Rochebelle). Special thanks to the team at IRDA, as well as colleagues from Université de Montréal, IUCPQ, and Université Laval.

References

Godbout et al., 2019. Recycled Bedding in Dairy Production: Current State of Knowledge and Guidelines. CRSAD-IRDA, 51 p.

101. Agronomic benefits and challenges of using anaerobically treated pig slurry on agricultural soils in Córdoba, Argentina

Pegoraro, V.[a*], Sosa, N.[a], Mathier, D.[a], Bragachini, M.[a], Vélez, G.[a], Lorenzon, C.[a], Conde M.B.[a], Mazzini, P.[a], Miralles, S.[b], Crema, N.[b], Poliotti, V.[b], Gonzales, E.[b], Rocha, L.[b], Cuello, P.[b], Inga, M.[b], Avendaño, M.[b], Merino, B.[b], Del Bo, C.[b], Gómez, S.[b], Chagra, Y.[b], Pacharoni, F.[b], Ferrari, J.[d], Castro, P.[e], Lenarduzzi, V.[d], López, E.[d], Archilla, M.V.[c], Merlo, C.[c] & Vázquez, C.[c]

INTA, Argentina [a]; CEPROCOR, Argentina [b]; UNC, FCA, Argentina [c]; Secretaría de Ambiente, Córdoba, Argentina [d]; Secretaría de Ganadería, Córdoba, Argentina[e]; *Corresponding author, email: pegoraro.vanesa@inta.gob.ar

Introduction

Even though animal manures are used globally as fertilizers in agricultural soils, in Latin America this practice is relatively recent (Herrero et al., 2018). In Argentina, Córdoba province was the first to regulate the agronomic use of animal manure (both slurry and solid) through Resolution No. 29/2017, "Agronomic Management and Application of Livestock Waste." In line with this initiative, the state through the MINCyT financed the National Project "IMPACTAR No. 119," that evaluates the effects of stabilized in anaerobic lagoons pig slurry applications on soil properties.

Methodology

In 12 pig farms located in Córdoba province, samples of raw pig slurry and anaerobic lagoons were collected to determine physical, chemical, and microbiological variables (Lipps, 2020). Additionally, soil samples with and without pig slurry applications were collected at different depths (0-10 cm; 0-20 cm; 20-60 cm). Microbiological variables were determined for the 0-10 cm depth, while chemical variables related to soil fertility were determined for the 0-20 cm and 20-60 cm depths. Data analyses were performed using Infostat Professional statistical software.

Results and discussions

Anaerobic lagoons reduced total solids, volatiles, and chemical oxygen demand, and, to a lesser extent, nitrogen and phosphorus. In contrast, sodium, potassium, copper, pH, and alkalinity increased significantly ($p<0.05$). Regarding microorganisms, reductions were observed in thermotolerant coliforms (31%), E. coli (29%), *Salmonella* spp. (58%), and fecal streptococcus (24%). When evaluating the quality of agricultural soils with pig slurry, increases in organic nitrogen, mineral nitrogen, extractable phosphorus, potassium, zinc, and copper were observed—essential nutrients for crop growth. However, electrical conductivity and sodium increase were detected, which could be attributed to the salt content in the pigs' diet and/or the presence of salts in the groundwater used to wash the confinement facilities (Pegoraro et al., 2020, 2023). Regarding microbiological parameters, *Escherichia coli* and *Salmonella* spp. were not detected. However, a 27% and 37% increase in total coliforms and fecal streptococcus, respectively, was observed in soils with pig slurry applications compared to control soils.

Conclusion

Animal slurry is a valuable source of inorganic and organic matter as nutrients for agricultural soils, however, it may also contain microorganisms that can be pathogenic to humans and/or animals and accumulate potentially toxic metals. Therefore, it is crucial to stabilize it before use and manage it properly to minimize food chain and environmental impact.

Acknowledgements

Funded by Project IMPACTAR No. 119 (period 2022-2025), Ministry of Innovation, Science and Technology of the Nation (MINCyT-Argentina).

References

Pegoraro, V., et al. 2020. Impacts of different pig slurry application methods on soil quality indicators in a maize-soybean cropping sequence in the sub-humid pampas of Argentina. Islamic Azad University–Isfahan Branch. 9, 259-272.

Pegoraro, V., et al. 2023. Cambios en los atributos del suelo por aplicación continua de efluente porcino. *Ciencia del suelo*, *41*(2), 261-272.

Lipps, WC. 2020. Standard methods for the examination of water and wastewater. 24th ed. American Public Health Association. Washington, DC.

102. Addressing Pathogen Impact in Life Cycle Assessment: Nationwide spatially explicit characterization factor for organic fertilization

Piveteau P.*, Oliva A., Thiriet P., Aissani L.

*Corresponding author, email: pascal.piveteau@inrae.fr

Introduction

Life Cycle Assessment (LCA) is a useful method to assess environmental impacts of manure management and biogas production (Hijazi et al., 2016). However, there are several shortcomings in LCA applied to waste and biomass valorisation (Ekvall et al., 2007). One of these difficulties lies in the lack of important impact categories. The impact category "microbial pathogenic potential" has been disregarded so far. Here we present a proof of concept for the development of a new characterization factor using the pathogen Listeria monocytogenes and its implementation for spatialized LCA applied to organic fertilisers.

Methodology

The characterisation factor (CF) was constructed based on UseTox approach and expressed in equation 1: CF=FF.XF.EF where FF is the fate factor, XF is the exposure factor and EF is the effect factor. We examined the causal chain linking the land application of organic fertilizers to cheese production through the forage-fed dairy farming scenario.

Relevant information was retrieved from the literature to identify more than 20 environmental factors affecting the fate of L. monocytogenes in soils. Special attention has been paid to soil microbial diversity because it is a major provider of the service of regulation of pathogens. This required setting up a dedicated methodology. The available geospatial datasets describing these factors over Metropolitan France were retrieved and fed into the model.

CART modelling was implemented to reduce the number of variables in the final model. Based on Fuzzy logic, two distinct models were elaborated to take into account the edaphic conditions (FFb), and the physical characteristics of the fields (FFp). The spatially explicit FF was calculated as described in equation 2 : FF= FFb . FFp

Exposure factor was calculated based on surveys on food consumption and eating habits of the French population (ANSES, 2017). EF was based on epidemiological data (Pouillot et al., 2024). EF integrated the probability of developing listeriosis and the severity factor Disability-Adjusted Life Years (DALYs).

Results and discussion

Regression CART model identified soil pH and soil microbial diversity (N1) as good proxies of the fate of L. monocytogenes. Temperature (T°) was added as climate variable. pH, N1 and T° were included in FFb. The RUSLE factor and soil permeability were included into FFp to estimate the proportion of L. monocytogenes removed through runoff and/or underground percolation. FF is spatially explicit and was integrated at the scale of agricultural plots. XF and EF were considered uniform throughout France. One challenge of the methodology to calculate CF was the availability and the resolution of geospatial data. Further challenges will have to be addressed to integrate pathogens in LCA. One will have to calculate CF anew for every pathogen of interest because FF, XF and EF are specific to each pathogen.

Conclusion

This work describes the methodology to calculate characterisation factors for the new impact category "microbial pathogenic potential". This proof of concept confirms that this new impact category can be included in LCA applied to organic fertilisers. It opens new avenues of developments to integrate major microbial hazards in environmental assessment. Such an approach has the potential to make a major contribution to the long-term sustainability of new circular bioeconomy systems.

Acknowledgements

This work received the financial support of the French Agency for Ecological Transition ADEME

103. Towards climate-neutral agriculture: Integrating site-specific nitrogen fertilization recommendations and soil organic carbon dynamics – A case study for Swiss organic mountain farms

Tanner, E. [a*], Liebisch, F. [a], Keel, S. G. [b], Zosso, C. [b] & Bretscher, D. [b]

Agroscope (Water Protection and Substance Flows), Switzerland [a]; Agroscope (Climate and Agriculture), Switzerland [b]; *Corresponding author, email: elisabeth.tanner@agroscope.admin.ch

Introduction

Switzerland aims to reduce nitrogen (N) losses by 15 % by 2030 (compared to 2014-2016 average) and achieve net-zero greenhouse gas (GHG) emissions by 2050, necessitating targeted mitigation in agriculture. Optimizing N fertilization plays a pivotal role in reducing N surpluses and associated nitrous oxide (N_2O) emissions from soils. The Swiss corrected norms (corrNorm) method provides site-specific N fertilization recommendations by adjusting crop-specific norms to local soil, climate and cultivation conditions (Jordan-Meille et al., 2023). While small-scale trials have demonstrated its potential to reduce N inputs without yield losses (Grossrieder et al., 2022), its adoption among Swiss farmers remains limited, partly due to its exclusive focus on N, neglecting other nutrients and soil organic carbon (SOC). This study aims to integrate N fertilization recommendations with SOC dynamics modelling under different organic fertilizer strategies in organically-managed case study farms in the Swiss mountainous region of Grisons. The goal is to assess the applicability of the corrNorm in reducing N surpluses and fertilization-related GHG emissions while maintaining or increasing SOC stocks.

Methodology

Thirteen case study farms in the Grisons region, primarily managing permanent grasslands, were analysed using cultivation data (2020–2023), complemented by soil and organic fertilizer laboratory analyses. N reduction potential was quantified by comparing actual fertilizer applications with corrNorm recommendations, and subsequently, the potential for reducing fertilization-related GHG emissions was estimated using the IPCC emission factor approach (Hergoualc'h et al., 2019). SOC dynamics will be modelled with RothC (Coleman et al., 1997; Jenkinson, 1990) to depict C turnover under current practices and corrNorm recommendations, and to assess the effects of different organic fertilizers on SOC stocks.

Results and discussion

Preliminary results from the case study farms indicate that farmers often apply less N than recommended by the corrNorm, yet N allocation could be optimized at the plot level. Soil analyses showed SOC levels of 47 ± 22 g C kg^{-1}, aligning with previous findings on high SOC levels in Swiss grasslands, underscoring the importance of preserving SOC stocks for long-term soil health and climate benefits (Keel et al., 2024). Ongoing modelling will assess whether current fertilization practices suffice to maintain SOC, and whether adopting the corrNorm could increase local SOC stocks. This approach of integrating C and N will provide insights into organic fertilizer strategies for resource-efficient agricultural production, long-term soil health and climate change mitigation.

Acknowledgements

This work is part of the project *Climate-Neutral Agriculture Grisons*, funded by the Canton of Grisons.

References

Coleman, K., et al. 1997. Simulating trends in soil organic carbon in long-term experiments using RothC-26.3. *Geoderma*, *81*(1), 29–44. https://doi.org/10.1016/S0016-7061(97)00079-7

Grossrieder, J., et al. 2022. Standortangepasste Stickstoffdüngung: Aktuelle Methoden und Erfahrungen. *Agrarforschung Schweiz*, *13*, 103–113. https://doi.org/10.34776/AFS13-103G

Hergoualc'h, K., Akiyama, H., Bernoux, M., Chirinda, N., del Prado, A., Kasimir, Å., MacDonald, J. D., Ogle, S. M., Regina, K., & van der Weerden, T. J. (Eds.), 2019. N_2O emissions from managed soils, and CO_2 emissions from lime and urea application. In *Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories* (Vol. 4). Intergovernmental Panel on Climate Change (IPCC).

Jenkinson, D. S. 1990. The turnover of organic carbon and nitrogen in the soil. *Philosophical Transactions of the Royal Society B-Biological Sciences*, *329*(1255), Article 1255. https://doi.org/10.1098/rstb.1990.0177

Jordan-Meille, L., et al. 2023. Comparison of nitrogen fertilisation recommendations of West European Countries. *European Journal of Soil Science*, *74*(6), e13436. https://doi.org/10.1111/ejss.13436

Keel, S. G., et al. 2024. Dauergrünlandböden der Schweiz: Quelle oder Senke von Kohlendioxid? *Agroscope Science*, *189*, 1–21. https://doi.org/10.34776/AS189G

104. Integrated monitoring of manure management to implement best practices in Italian dairy cow farms

Provolo, G.[a], Finzi, A.[a*], Beretta, E.[a], Iavazzo, P.[b], Alberti, P.[b], Pacati, A.[b] & Motta, S.[b]

University of Milan - Department of Agricultural and Environmental Sciences, Italy [a]; Ente Regionale per i Servizi all'Agricoltura e alle Foreste della Lombardia, Italy [b]; *Corresponding author, email: alberto.finzi@unimi.it

Introduction

Best practices for manure management are widely studied to optimize their effectiveness and applicability in agriculture. Several techniques are widely applied among livestock farms, but there are limited examples of a systematic and integrated monitoring of the manure management chain (Petersen et al., 2007). The objective of this 3-years-long study is to apply the state-of-the-art monitoring technologies in three dairy cow farms, to assess their sustainability and to account for nutrient use efficiency, soil quality, gaseous emissions and nutrient leaching.

Methodology

The three monitored farms have these characteristics: farm A 300 heads, 160 of which milking cows with 3 automatic milking systems (AMS); farm B 215 heads, 100 of which milking cows with 2 AMS and external paddock; farm C 420 heads, 180 of which milking cows with a milking parlor and external paddock. The monitoring scheme is a combined approach including: IoT technologies for recording environmental variables inside and outside the barn (e.g. temperature, humidity, CO_2 and NH_3 concentrations), manure production and physic-chemical characteristics, water consumption; data obtained from livestock recordkeeping (number and category of animals, feed characteristics and delivered quantity); recordings of manure field application (manual and/or automatic); field operations data; crops yields; soil and crop harvested analyses. The collected information is then used to obtain an integrated nutrient balance estimating the losses of NH_3 from barn and storage, nutrient efficiency and leaching considering different manure management options.

Results and discussion

The first findings of the implemented monitoring system allowed us to identify some important aspects to consider in the whole management chain. It has been found that, in the barn, in hot period, the combined effect of cow showers and ventilation lower the concentration of NH_3 in the air (-41%); in addition, different management systems can affect significantly the addition of water in the slurry and the nutrient concentrations in the manure. The additional water from the cleaning of the milking systems resulted 21.3, 59, 68 L $head^{-1}day^{-1}$ while the average nitrogen content in the manure storage (before spreading) was 4.10, 2.44, 2.39 g kg^{-1} respectively for farm A, B and C. The adoption of slurry injection techniques as base dressing, followed by a mineral fertilizer applied by fertigation as top dressing, achieved a nitrogen use efficiency up to 75%. The use of a slurry broadcast application as base dressing, and a surface-applied mineral fertilizer as top dressing achieves a nitrogen use efficiency of 48%. This means that slurry injection combined with fertigation reduces nitrogen losses. Overall, the farm nitrogen balance can be improved only by properly managing manure in all the phases from the barn to the field as underlined by other authors (Hou et al., 2015; Sommer et al., 2013).

Conclusion

The results highlight the need for a whole farm perspective to ensure that the practices adopted can properly valorise livestock manure, also providing a useful guidance in directing regional policy towards sustainable livestock manure management systems.

Acknowledgements

This research is carried out within the scientific collaboration agreement between University of Milan - Department of Agricultural and Environmental Sciences and Ente Regionale per i Servizi all'Agricoltura e alle Foreste della Lombardia, funded by Lombardy Region, Italy.

References

Petersen, S.O., Sommer, S.G., Béline, F., Burton, C., Dach, J., et al. 2007. Recycling of livestock manure in a whole-farm perspective. Livest. Sci. 112, 180-191.

Hou, Y., Velthof G.L., Oenema O. 2015. Mitigation of ammonia, nitrous oxide and methane emissions from manure management chains: A meta-analysis and integrated assessment. Glob. Chang. Biol. 21, 1293-1312.

Sommer S.G., Jensen L.S., Christensen M.L., Schmidt T, 2013. Animal manure: recycling, treatment, and management. John Wiley & Sons Ltd.

105. APIVALE, a scientific consortium for an integrated approach of organic effluent recycling and valorisation

De Quelen, F.

106. Limit DGGAS project: Livestock manure digestate treatments to reduce GHG and NH3 emissions and meet crop nutrients requirement

Apostolico, A.[a], Scotto di Perta, E.[a*], Cervelli, E.[a], Dinuccio, E. [b], Fiorentino, N. [a], Grieco, R. [c], Verde, A. [a], Romano, D. [b], Escalante J.H.[b], Zavattaro, L. [d] & Pindozzi, S. [a]

Department of Agricultural Sciences University of Naples Federico II Portici (NA), Italy [a]; Department of Agricultural, Forest and Food Sciences, University of Torino, Italy [b]; Department of Agricultural and Food Sciences, University of Bologna, Italy [c]; Department of Veterinary Sciences University of Torino, Italy [d]; [*]Corresponding author, email: ester.scottodiperta@unina.it

Introduction

The European Green Deal underscores the importance of climate-neutral agricultural practices, where anaerobic digestion (AD) plays a key role in renewable energy production and sustainable fertilization. However, raw digestate presents challenges such as ammonia volatilization and nutrient imbalances, necessitating innovative treatment strategies to enhance its agronomic efficiency. This study evaluates nutrient recovery technologies implemented in two distinct biogas plants in Italy, aiming to optimize digestate management and mitigate environmental impacts.

Methodology

Two existing manure treatment plants are investigated: (i) a plant in Campania Region integrating anaerobic digestion, ammonia stripping and vermicomposting; and (ii) a facility in Piedmont Region employing mechanical separation and microfiltration. Each system is monitored for treatment efficiency through sampling and evaluation of parameters such as pH, total solids (TS), volatile solids (VS), total nitrogen (TN), total ammonia nitrogen (TAN), total phosphorus (TP) and potassium (TK). Furthermore, mesocosm experiments are conducted using Italian ryegrass (*Lolium multiflorum*) to compare the nutrient use efficiency (NUE) of the treated digestate versus mineral fertilizers. Ammonia (NH_3) and greenhouse gas (GHG) emissions are monitored under controlled storage conditions using dynamic/static chamber techniques to assess the environmental impact of the processes involved.

Results and discussion

The expected outcomes of the project are: (i) optimization of nutrient recovery processes from digestate, identifying key improvements to enhance efficiency in treatment plants; (ii) assessment of the agronomic performance of processed digestate as a valuable organic fertilizer; (iii) quantification of NH_3 volatilisation and GHG emissions associated with storage conditions; (iv) comprehensive techno-economic evaluation and spatial analysis of the adopted treatment approaches; (v) development of territorial-scale strategies to enhance mitigation measures and improve environmental sustainability.

Conclusion

This study highlights the importance of innovative digestate treatment strategies to enhance nutrient recovery, improve fertilization efficiency, and mitigate environmental impacts. The integration of ammonia stripping, composting, and filtration demonstrates promising potential in transforming digestate into high-value fertilizers while reducing emissions. Future efforts will focus on refining treatment processes, expanding field trials, and validating long-term sustainability to ensure the widespread adoption of improved digestate management practices

Acknowledgements

This study was carried out within the Next Generation EU Contributo alla spesa a valere sulla Missione 4 – Componente 2. Dalla Ricerca all'Impresa - Investimento 1.1 Fondo per il Programma Nazionale della Ricerca (PNR) e Progetti di Ricerca di Rilevante Interesse Nazionale (PRIN): "Limit DGGas" funded by Italian Miur, CUP E53D23010780006 and Agritech National Research Center and received funding from the European Union Next-Generation EU (PIANO NAZIONALE DI RIPRESA E RESILIENZA (PNRR) — MISSIONE 4 COMPONENTE 2, INVESTIMENTO 1.4—D.D. 1032 17/06/2022, CN00000022). This manuscript reflects only the authors' views and opinions, neither the European Union nor the European Commission can be considered responsible for them.

References

Guan, D., Zhao, J., Wang, Y., Fu, Z., Zhang, D., Zhang, H., ... & Wang, D. (2024). A critical review on sustainable management and resource utilization of digestate. Process Safety and Environmental Protection.

Vaneeckhaute, C., et al. 2017. Nutrient Recovery from Digestate: Systematic Technology Review and Product Classification. Waste Biomass Valorization. 8(1), 21–40.

107. EULED: an Investigation in sharing Emission Data across partners

Peeters, Q.[a*], Declerck, A.[a], Coorevits, K.[a], Brusselman, E.[a], Amon, B.[b,d], Janke, D.[b], Dragoni, F.[b] & Mosquera, J.[c]

Flanders Research Institute for Agriculture, Fisheries and Food (ILVO), Technology and Food Science Unit, Burgemeester Van Gansberghelaan 115, 9820 Merelbeke-Melle, Belgium [a]; Leibniz Institute for Agricultural Engineering and Bioeconomy (ATB), Max-Eyth-Allee 100, 14469 Potsdam, Germany [b]; Wageningen Livestock Research (WLR), Zodiac, De Elst 1, 6708 WD Wageningen, The Netherlands[c]; University of Zielona Góra, Faculty of Civil Engineering, Architecture and Environmental Engeneering, Zielona Góra, Poland;*Corresponding author, email: quinten.peeters@ilvo.vlaanderen.be

Introduction

The European Union aims to reduce the emissions from ammonia and greenhouse gases within its Member States through legislation such as the National Emissions Ceilings (NEC) directive (2016/2284/EU). In order to attain these goals, a lot of research has happened the past years across Europe towards reducing emissions and the quantification of livestock barn emissions. Measuring campaigns are, however, very labour intensive and expensive. This is why three research institutes (ATB, WLR and ILVO) want to start sharing data, in order to enable and encourage larger meta studies on data gathered by the different institutes, as well as to omit unnecessary measuring campaigns. The database that is in development to attain these goals is named the European Level Emission Database (EULED). In this poster presentation the process of setting up this database is discussed.

Methodology

In a first phase towards setting up the EULED, the needs and rights concerning the shared data of the different partners within the project (ATB, WLR and ILVO) were discussed. Key topics included the definition of what the shared data is, how the data is delivered and who owns the rights to the results from the meta-analysis. The creation of a data sharing agreement (DSA) should make the conclusions from these discussions precise and binding.

In a second phase, the database itself was structured. The information contained in the DSA and the discussions were used as a basis for the initial draft of the database. This initial database model was further developed using different dummy datasets from the research institutes. All this leads to a database that can store all the necessary variables recorded by all three institutions.

In a third phase, coinciding towards the finalization of the database model, definitions were created for all variables included in the database. This should enable all current and future partners to assign data to the correct variable.

Results and discussion

The most significant results of this project include the legal document containing a basis to safely and correctly share emission data between different partners and a detailed model for a database to store all this data. Apart from this, the value of this project comes from the conceptual discussions and alignment of the views of partners from different international institutes.

These discussions highlighted that, even though all involved research institutes perform measurements on dairy barns, the collected data and the underlying definitions differ significantly. In addition, all research groups use different measurement methods. This emphasizes the complexity of setting up a database between different research groups. The dummy datasets provided more insight in the data collection process of each partner and allowed for the construction of a database for storing all the necessary data from the different partners.

Conclusion

During this research, it became clear that sharing data between different research institutes is far from trivial. Legal documents (DSA) should be drafted and a clear and complete database model must be constructed.

On this poster the most important discussion points will be given, and the structure of the database will be discussed.

Acknowledgements

The authors acknowledge the financial support through the partners of the DairyMix project, funded under the Joint Call of the Cofund ERA-Nets SusCrop (Grant N° 771134), FACCE ERA-GAS (Grant No. 696356), ICT-AGRI-FOOD (Grant No. 862665), SusAn (Grant No. 696231). We would also like to thank the Dutch Ministry of Agriculture, Fisheries, Food Security and Nature for funding this research.

108. Enhancing compost quantity and quality by improved kitchen waste collection: Results from multi-storey buildings in two Residential Areas in the City of Lübeck

Raisfirooz, L.[1], Walk, S.[2], Lüchtenberg, A.[3], Körner, I.[1]

1 Hamburg University of Technology (TUHH), Germany; Leander Raisfirooz, email: leander.raisfirooz@tuhh.de; 2 Biocycle Consulting Steffen Walk (BC), Germany | 3 Entsorgungsbetriebe Lübeck (EBL), Germany

Introduction

Residential kitchen waste is an underutilized bioresource. This study aims to enhance its source-separated quantity and also its quality in order to receive more and better compost. In urban areas, especially multi-storey buildings, improper sorting by residents often leads to low quality of the biowaste due to impurities and with-it the compost is poor. Furthermore, huge quantities of kitchen waste are currently disposed with the residual waste and are therefore lost for compost production. To improve the situation, a project is conducted in residential neighbourhoods with multi-storey buildings in Lübeck, Germany, to implement an improved sorting behaviour by various improvements such as provision of sorting aids, better waste place design, increase collection frequency and communication. Previous investigations have demonstrated that such approach can significantly improve the quantity and quality of source-separated kitchen waste (Walk & Körner, 2022; Angouria-Tsorochidou et al. 2023).

Methodology

The study area includes test (T1, T2) and reference areas (R1, R2) with multi-storey buildings managed by housing cooperatives (TRAVE, LBV). In the reference areas no intervention takes place, but wasting behaviour is monitored. In the test areas with 467 household's interventions take place. The residents are provided with two 6-L-vessels, well-designed for a convenient and bag-free collection of kitchen waste at home. In the first project phase, the status-quo of sorting behaviour was determined for all areas: a) the contents from the biobins and the residual waste bins were weighted for 10 consecutive weeks; b) a waste sorting analysis was performed for both waste types with the waste generated over 2 weeks. The sorting considered 15 fractions including packaged and unpacked food waste as well as green waste from inside and outside the house. In the second phase, residents of the test areas will receive the vessels. They will deposit their contents into biobins at the waste deposition areas. In the third phase, the contents of the vessels are directly captured via an e-cargo bike. Also in these phases, mass determinations and sorting analysis will be conducted.

Results and discussion

The results of the analysis of the status quo revealed for all areas, that most of the contents were in accordance with the official sorting guidelines of Lübeck as well as with the German Biowaste Ordinance. However, some impurities were present. These included plastic bags, hard plastic, glass, and metal. Conventional plastic bags, used for waste collection by the residents, were the largest fraction of impurities in all areas. The total kitchen waste generation in the test areas, cumulative for the contents of the biobin and the residual waste bin, was between 0.7 and 1.0 kg per week and resident. However, only about 30-35% of the total kitchen waste was correctly sorted into the biobin. In the residual waste bin, also many other recyclables, such as paper, plastics and metals, were found. The results of the second weighing and sorting campaign are expected to be ready in spring and from the third in autumn.

Conclusion

The results of the status-quo analysis showed that there is a large potential for improved kitchen waste sorting by the citizens resulting in an increased potential for compost. The study of Angouria-Tsorochidou et al. (2023) revealed, that at least 65% of kitchen waste can be sorted correctly, if vessels for at-home sorting are provided. With the improved concept investigated in this study, we expect an even higher efficacy of the residents' sorting efforts.

Acknowledgements

The research is conducted within the projects KUKOM and CLOSECYCLE, funded by DBU and by EU INTERREG North Sea Programme. The authors thank the housing cooperatives TRAVE and LBV in Lübeck for their cooperation.

References

Angouria-Tsorochidou, E., Walk.S., Körner. I., Thomsen, M. (2023): Environmental and economic assessment of household food waste source-separation efficiency in a German case study, Cleaner Waste Systems, Volume 5, August 2023,

Walk, S., Körner, I. (2022): Report on collection set-up performance. Deliverable D6.6, DECISIVE-Project. https://doi.org/10.15480/882.4104

109. Policy changes in the EU and the Netherlands enable the sustainable use of acidification technology in the Netherlands. Dutch acidic soil types, in combination with acidification, offer near-zero ammonia emissions from slurry application

Toft M.

CEO BioCover A/S, Denmark Veerst Skovvej 6, 6600 Vejen, mt@biocover.dk

Introduction

Recent policy changes in the EU and the Netherlands have enabled a new perspective on the use of acidification technology in the Netherlands. A German three-year study conducted in 2022, comparing acidification with a boom to sod injection, found that ammonia emissions were twice as high with sod injection compared to acidification. Previously, sulfate levels made this technology unsustainable for use in the Netherlands. However, recent policy adjustments have reduced the allowable slurry application per hectare per year to between 24 m^3 and 48 m^3 per hectare. The corresponding sulfate level is 40 kg SO_3 per hectare, making this approach sustainable. With this volume of sulfuric acid per cubic meter, ammonia emissions on Dutch acidic soils (pH < 6) will be near zero. There is a disproportionately high number of Natura 2000 buffer zones with low soil pH levels. The combination of low soil pH and low slurry pH will eliminate ammonia emissions from slurry applications and significantly contribute to meeting the requirements for ammonia reduction - especially where critical levels of ammonia emission originate directly from slurry applied in Natura 2000 buffer zones. Near-zero ammonia emissions are achievable on Dutch acidic soil types through sustainable use of in-field acidification combined with a boom application system.

Methodology

This study examines:

- Policy changes in the EU (Nitrate Directive)
- The Dutch strategy to reduce dairy cow populations
- Peer-reviewed research on the effects and applications of acidification
- Dutch soil pH maps

Results and discussion

The mandatory use of sod injection excludes the use of acidification technology in the Netherlands. The potential of leveraging the naturally low soil pH in combination with in-field acidification is not being utilized, leaving a total of 10% potential ammonia emission reduction unexploited. This omission is causing significant harm to the Dutch dairy industry by unnecessarily increasing ammonia emissions.

Conclusion

The Dutch policy mandating sod injection is outdated and is increasing the pressure to reduce the dairy cow population due to excessive ammonia emissions during slurry application. A policy shift towards acidification technology would enhance sustainability, reduce emissions, and support the dairy industry.

Acknowledgements

J.F.M Huijsmans, W. Bussink

References

Caroline Buchen-Tschiskale, et al. 2022. G¨ulleBest : Mit welcher Technik lassen sich Gülle und Gärreste emissionsarm ausbringen ?

J.F.M Huijsmans1, et al Application of acidified manure with a trailing shoe machine on grassland. Plant research inernational. Buisness

Unit Agro Systems Engineering April 2015

GülleBest publications

ResearchGate: Numerical abundance and biodiversity of belowground taxocenes along a pH gradient across the Netherlands

110. Extraction of ammonium bicarbonate from raw cattle slurry *via* distillation

Moure Abelenda, A.[a*] & Baltrusaitis, J.[b]

Soil Quality Assessment Research Group, Department of Soil Science and Agricultural Chemistry, Universidade de Santiago de Compostela, Avenida de Vigo, s/n, 15782 Santiago de Compostela, Spain [a]; Department of Chemical and Biomolecular Engineering, Lehigh University, B336 Iacocca Hall, 111 Research Drive, Bethlehem, PA 18015, USA [b]; *Corresponding author, email: alejandro.moure@usc.es

Introduction

The RENURE (recovered nitrogen from manure) approach aims to enhance circularity, reduce dependence on fertilizer imports from Russia (which is sanctioned due to the Ukraine war), and make more bearable the restrictions of the application of N fertilizers given by the Nitrates directive (Herrera et al., 2023; Huygens et al., 2020). Currently, across the European Union, each farm has a limit 170 kg organic source N/ha (unless derogation exemptions were applied) and a limit for the chemical inorganic N fertilizers, which depends on the crop type and the units of livestock (European Commission, 2020). It is proposed that a farm with a stocking rate greater than 170 kg (organic) N/ha needs to export the excess of manure/slurry above that limit to an anaerobic digestion plant (Teagasc, 2024) or other type of manure processing plant (Huygens et al., 2020), and the farm will be able to import an additional 100 kg inorganic N (RENURE) fertilizer, which is extracted from the livestock manure. This improvement in the management of N is meant to reward farmers for their sustainability, but such RENURE fertilizer must meet the criteria described in the draft amendment (European Commission, 2024) to confirm that it behaves like a chemically manufactured N fertilizer that reduces the risk of nitrate leaching compared to the equivalent amount of N applied as raw slurry. In agreement with the set rules, the ammonium bicarbonate (NH_4HCO_3) is "*an ammonium salt (scrubbing salt), stemming from a gas purification or emission control process designed to remove ammonia from off-gases*" and "*have a ratio of mineral nitrogen to total nitrogen of at least 90% or a ratio of organically bound carbon to total nitrogen of no more than 3*". There are multiple options of extracting the excess of NH_4HCO_3 in the anaerobic digestion plants (Moure Abelenda, 2024; Moure Abelenda & Baltrusaitis, 2024; Moure Abelenda & Dolny, 2024), because the content of ammoniacal form of this element (NH_4^+-N) increases due to the mineralization process (Moure Abelenda et al., 2023). The present study investigated whether the extraction of NH_4HCO_3 would be possible from raw cattle slurry, which generally presents even less N than dairy slurry, without previously undergoing anaerobic fermentation to obtain biogas. Furthermore, the optimization of the extent of this distillation process with the addition of a basic titrant was evaluated.

Methodology

The liquid fraction of raw cattle slurry was subjected to distillation following the procedure described in previous studies (Moure Abelenda, 2024; Moure Abelenda & Baltrusaitis, 2024). Four replicates (n=4) of the distillation of the raw cattle slurry were carried out and the titration curves of the spent liquors and distillates were compared to that of raw cattle slurry and standard NH_4HCO_3 aqueous solutions of 2.5 and 10 g/L. The analysis of the comparison of the titration curves was performed by visual inspection and descriptive statistics, to identify the relative content of NH_4HCO_3, as this compound is the main responsible of the buffer capacity of slurries (raw and depleted) and distillate aqueous solutions. Subsequently, doses of NaOH (-0.013, -0.026, -0.037, and -0.127 equivalents of HCl/L raw cattle slurry) were employed to optimize the distillation process and enhance the extraction of NH_4HCO_3 out of raw cattle slurry.

Results and discussion

The raw cattle slurry behaved as it had a significant content of NH_4HCO_3 (*i.e.*, around 7 g/L raw liquor), despite the feeding of cattle relied on fresh pasture without any concentrated animal feed, which is often provided for faster fattening and gain of weight. The peak of M-alkalinity of raw cattle slurry showed that the content of inorganic carbon was much greater than that of NH_4^+-N (peak of P-alkalinity), implying that the stability of ammonium in this aqueous media was very high, due to the sequestration by acid-base neutralization. The distillation process was forced at boiling temperature over 1 hour, and mass losses did not exceed 30 %. However, the buffer capacity (*i.e.*, proxy parameter of NH_4HCO_3 content) of the distillate was not greater than that of the raw cattle slurry. Promoting volatilization of ammonia by adding alkali to the raw liquor, to enhance the distillation, showed that the efficiency of NH_4HCO_3 extraction had a peak at -0.026 equivalents of HCl/L raw cattle slurry. The use of this optimum dose of titrant also resulted in having a distillate with a greater buffer capacity than that of the raw cattle slurry, as could be seen in the less steep titration curve of the distillate (compared to that of the raw cattle slurry) to reach the endpoint of pH > 11.

Conclusion

Although the content of NH_4HCO_3 in the raw cattle slurry was significant, its high stability due to the large amount of inorganic carbon presented in the aqueous solution, would make necessary for the cattle slurry to undergo further fermentation to

increase the amount of NH_4^+-N and its extractability, as a way to deal with an accumulation of nitrates in the water bodies (*i.e.*, surface, ground and estuarine waters).

It needs to bear in mind that, as the draft is currently written (European Commission, 2024), the RENURE fertilizer could be discounted in the future from the chemical N allowance of the farm (*e.g.*, 225 kg chemical N/ha for a grassland stocking rate over 250 kg N/ha/y), as this is supposed to be a replacement of the chemical N fertilizers. Therefore, the economic viability of this valorisation process needs to be assessed once the farmers are not awarded with the additional RENURE fertilizer over the top of the chemical N allowance.

References

European Commission. (2020). The Nitrates Directive. Environment. https://ec.europa.eu/environment/water/water-nitrates/index_en.html

European Commission. (2024). COMMISSION DIRECTIVE (EU) .../… amending Council Directive 91/676/EEC as regards the use of certain fertilising materials from livestock manure. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=intcom:Ares(2024)2885619

Herrera, A., D'Imporzano, G., Clagnan, E., Pigoli, A., Bonadei, E., Meers, E., & Adani, F. (2023). Pig Slurry Management Producing N Mineral Concentrates: A Full-Scale Case Study. ACS Sustainable Chemistry & Engineering, 11(19), 7309–7322. https://doi.org/10.1021/acssuschemeng.2c07016

Huygens, D., Orveillon, G., Lugato, E., Tavazzi, S., Comero, S., Jones, A., Gawlik, B., & Saveyn, H. (2020). Technical proposals for the safe use of processed manure above the threshold established for Nitrate Vulnerable Zones by the Nitrates Directive (91/676/EEC). https://doi.org/10.2760/373351

Moure Abelenda, A. (2024). Isolation of ammonium bicarbonate by reactive distillation of food waste digestate liquor. Bioresource Technology, 399, 130592. https://doi.org/10.1016/j.biortech.2024.130592

Moure Abelenda, A., Aggidis, G., & Aiouache, F. (2023). Modelling of Amino Acid Fermentations and Stabilization of Anaerobic Digestates by Extracting Ammonium Bicarbonate. Fermentation, 9(8), 750. https://doi.org/10.3390/fermentation9080750

Moure Abelenda, A., & Baltrusaitis, J. (2024). Classical Batch Distillation of Anaerobic Digestate to Isolate Ammonium Bicarbonate: Membrane Not Necessary! Bioengineering, 11(11), 1152. https://doi.org/10.3390/bioengineering11111152

Moure Abelenda, A., & Dolny, P. (2024). Production of ammonium bicarbonate from the condensate of the upgrading biogas-pipelines. Journal of Cleaner Production, 449, 141787. https://doi.org/10.1016/j.jclepro.2024.141787

Teagasc. (2024, August 21). Nitrates and anaerobic digestion. Signpost Series. https://www.youtube.com/watch?v=0Xjbun84_zA

111. Sustainable optimization of nutrient budgets and co-benefits for other pollutants to ensure clean water

Ellerkamp, C.[a*], Meers, E.[b], Sigurnjak, I.[b], Wang, M.[a], & Strokal, M.[a]

Wageningen University & Research, The Netherlands a; Ghent University, Belgium b; *Corresponding author, email: carolin.ellerkamp@wur.nl

Introduction

The European Union "GREENHOOD" project (Horizon-CL6-2024-Zeropollution-01-1) has started at the beginning of 2025. The main goal is to demonstrate how regions can operate within safe ecological and regional nutrient budgets. We will integrate the insights from four demonstration sites (Spain, Belgium, Norway, Finland and the Netherlands) into integrative modelling approaches to simulate nutrient budgets at the regional / basin scales in Europe. The demonstration sites are operated to measure the effects of investigated measures for optimizing nutrient budgets such as the use of bio-based fertilizers to replace synthetic chemical fertilizers, and nature-based solutions to improve surface water quality in agricultural areas. The measured effects from the demonstration sites will be upscaled to the basins and Europe to identify their effects on nutrient reductions in rivers and coastal waters. In this abstract, we would like to present examples of the solutions and models that will form the basis for simulating nutrient budgets in Europe.

Methodology

We will develop a multi-pollutant model to simulate co-benefits between sustainably optimizing the budgets of nutrients and other pollutants, to ensure clean water. The MARINA-Nutrients (Ural-Janssen, Kroeze et al. 2024) and MARINA-Antibiotics models (Zhang, Li et al. 2025) will be integrated for specific basins in Europe and will be used to develop basin-specific scenarios. The demonstration site in Norway for example experiences nutrient pollution associated with fish sludge and manure, whereas the demonstration site in Spain (Ebro basin) has overfertilization issues. Basin-specific baselines are lacking. We will integrate the two models by taking their strengths and updating them in terms of basin-specific data, supported by the GREENHOOD project insights, and information from the demonstration sites. The new scenarios will incorporate the effects of measured solutions (e.g., bio-based fertilizers, nature-based solutions such as ponds, and wetlands) to better understand the effectiveness of measures on pollution reductions (e.g., nitrogen, phosphorus, antibiotics), considering global change drivers. This will support policy recommendations for sustainably optimizing nutrients budgets at the basin scale in Europe with co-benefits for other pollutants such as antibiotics.

Results and discussion

The project has just started. In the poster, we will show examples of expected results using other regions for which our models simulate water pollution levels. We will show lessons that we can learn from other regions and apply to European basins in our integrated modelling. One of them is China for which we show that manure is a source of multiple pollutants in rivers including nutrients (Li, Wang et al. 2022) and antibiotics (Zhang, Li et al. 2025). Manure is also a recognized issue in several demonstration sites in the GREENHOOD project. We expect manure to play an important role in the sustainable optimization of nutrient budgets, which may be also co-beneficial to reduce other pollutants such as antibiotics. Another insight is that manure recycling on land contributed to less river pollution but more groundwater pollution in China (Zhang, Li et al. 2025). This is one of the lessons to consider when modelling the effects of solutions to reduce nutrient and antibiotic pollution in waters from manure. Another lesson is related to the fact that fluoroquinolones were the dominant contributors to antibiotic pollution in China, which may differ in Europe because of different antibiotic usage. Synergies and trade-offs in pollution control between nutrients and other pollutants are important for sustainable practices.

Acknowledgements

European Union HORIZON-CL6-2024-Zeropollution-01-1 Grant Agreement Number 101181712 (GREENHOOD)

References

Li, Y., et al. 2022. Multi-pollutant assessment of river pollution from livestock production worldwide. Water research 209: 117906.

Ural-Janssen, A., et al. 2024. Large reductions in nutrient losses needed to avoid future coastal eutrophication across Europe. Marine environmental research 197: 106446.

Zhang, Q., et al. 2025. "More inputs of antibiotics into groundwater but less into rivers as a result of manure management in China." Environmental Science and Ecotechnology 23: 100513.

112. A potential future slurry management approach for Northern Ireland

Johnston, C. R.[a]*, Lyons, G.A.[a], Cathcart, A. M[a], Smyth, B.M.[b] & Bolaji, I.O.[b]

[a]Agri-Environment Branch, The Agri-Food & Biosciences Institute for Northern Ireland, Large Park, Hillsborough Co. Down, BT26 6DR
[b]School of Mechanical and Aerospace Engineering, Queen's University Belfast, Ashby Building, Belfast BT9 5AH, UK
*Chris Johnston, email:chris.johnston@afbini.gov.uk

Introduction

Northern Ireland (NI) has an important and intensive agricultural livestock sector which operates on a phosphorus (P) surplus i.e. above agronomic need. It is estimated that >60% of P water pollution is derived from agricultural sources (Rothwell et al., 2020). More sustainable solutions of managing agricultural wastes are therefore required. This study explores the potential of slurry separation and anaerobic digestion (AD) for nutrient redistribution and low-carbon energy production. Slurry separation can concentrate P in solid fractions for export, while retaining nitrogen (N) for on-farm use. AD offers substantial potential for biomethane generation, with estimates indicating that co-digestion of slurry with grass silage could displace >80% of NI's gas grid use (Mehta et al 2023). However, AD can also lead to ammonia emissions, necessitating additional treatment processes such as ammonia stripping and digestate stabilisation.

Methodology

AFBI, in conjunction with DAERA and QUB, have been working on potential options to manage farm slurries to facilitate phosphorus removal and reduce farm P balance. The recent launch of the Small Business Research Initiative (SBRI) is exploring whether "end-of-pipe" slurry interventions are indeed possible, practical and economically feasible (DAERA 2024). Commercial collaborations are investigating practical models, using mobile separation and anaerobic digestion, to partition nutrients in order to develop P export opportunities for the benefit of NI's environment. Several valorisation and value chains for the final digestate products are also being developed in these projects. In collaboration with the NI Centre for Advanced Sustainable Energy (CASE), on-going activity also incorporates farm-level engagement to understand the views and thoughts of farmers and end-to-end life cycle analysis (LCA) of such interventions.

Results and discussion

Although at an early stage, ongoing farm-level engagement and LCA is assessing the technical and economic feasibility of these interventions. Farmer engagement has revealed an understanding and a growing acceptance of slurry separation. The benefits include P surplus reduction, increased slurry storage capacity and improved slurry handleability using low emission spreading. Project findings have fed into regulatory discussions concerning several hurdles. These include how to promote the removal of slurry solids off farm and the acceptance of these "high P" feedstocks into AD, to enable recycling of digestate components while avoiding pollution swapping of ammonia or greenhouse gas (GHG) emissions. Preliminary results for a 5 MW case study plant show GHG savings of ~6,000 tCO_2e/yr from displacement of natural gas and synthetic fertilisers, and a breakeven biomethane price of approximately 12 p/kWh.

Conclusion

The integration of centralised biorefinery facilities could enhance NI's circular bioeconomy, reduce reliance on fossil fuels and imported fertilisers and contribute to achieving NetZero targets by 2050. Ultimately, if this strategy is well implemented and can be economically viable, allowing it to work at scale, it will lead to a flow of P off farms and a reduction in P loadings to land along with ammonia emissions reductions, GHG reductions and energy decarbonisation. Key challenges that currently exist to realise this impact include financing, legislation and regulation change and adoption, market development, and societal acceptance and buy-in from a range of stakeholders.

Acknowledgements

We acknowledge cooperation from the Department of Agriculture, Environment and Rural Affairs and project funding from the Centre for Advanced Sustainable Energy, Department for Economy N. Ireland.

References

Rothwell, S.A., et al. 2020. Phosphorus stocks and flows in an intensive livestock dominated food system, Resources, Conservation and Recycling, Volume 163, 105065

DAREA 2024. https://www.daera-ni.gov.uk/news/daera-awards-ps4m-first-successful-sustainable-utilisation-livestock-slurry-sbri-phase-2-company

Mehta., N, et al (2023. Evaluating the opportunity for utilising anaerobic digestion and pyrolysis of livestock manure and grass silage to decarbonise gas infrastructure: A Northern Ireland case study, Renewable Energy, 196, 343-357

113. Ammonium Dominated Liquid Fertilizer Injection (CULTAN) Contributes to Lower N Leaching While Maintaining Yield

Liebisch, F.[a*], Bernert, G.[a] & Spiess, E.[a]

[a] Agroscope, Group of Water Protection and Substance Flows, Zürich, Switzerland; *Corresponding author, email: add email address

Introduction

Organic and recycling fertilizers are often ammonium dominated and soil injection or fertilizer placement is often related to higher uptake efficiency (Nkebiwe et al. 2016). The controlled uptake long-term ammonium nutrition (CULTAN) fertilization technique consists of injecting a concentrated ammonium solution into the soil and aims to positively impact crop physiology and N use efficiency, thus often reducing losses to the groundwater. Aims: This study assesses whether CULTAN can contribute to lower N leaching while maintaining yields in temperate regions with an annual precipitation of around 1000 mm or higher.

Methodology

We analysed a 12-year lysimeter study with two consecutive 6-year crop rotations and a 3-year field study with winter wheat and maize in Switzerland. CULTAN was compared to a conventional surface application of ammonium nitrate fertilizer (ConvF). To evaluate the effects of CULTAN compared to ConvF across both experiments, yield and N leaching or soil mineral N were measured and N use efficiency was calculated. More details can be found in Bernert et al. (2024).

Results and discussion

CULTAN achieved at least similar yields compared to ConvF in both studies and had a 38% lower yield-scaled N leaching in the lysimeters. In both studies, CULTAN displayed higher nitrogen recovery efficiency (NRE) compared to ConvF, with an increase ranging from 8% to 17% depending on crop type, although a statistical significance was only found for winter wheat in the field study. NRE and N leaching were only weakly correlated, indicating that other N pathways are affected in the CULTAN fertilization system (Bernert et al 2024). Finally, we suggest that the timing and placement of the CULTAN injection need to be better adapted to the plant physiology and pedoclimatic conditions for optimal nutrient use and crop yields. A brief conclusion is that in areas of high nitrate concentration in the groundwater, CULTAN can be an effective fertilization strategy complementing loss reduction measures.

Acknowledgements

The authors would like to thank C. Humphrys and V. Prasuhn for conducting the experiment and helping with the data collection and discussion, R. Flisch for the field experiment data and helpful comments, M. Häberli, G. Steger, and P. Briner AG for practical discussions and helpful comments. This study was financed by the Swiss Federal Office for the Environment (Grant number: BAFU-D-7C3D3401/785) and by Agroscope Core Funding.

References

Bernert, G., et al. 2024. CULTAN fertilization contributes to lower N leaching while maintaining yield. J. Plant Nutr. Soil Sci. 188, 118-128. https://doi.org/10.1002/jpln.202300396

Nkebiwe, P., et al. 2016. “Fertilizer Placement to Improve Crop Nutrient Acquisition and Yield: A Review and Meta-Analysis.” Field Crops Research 196: 389–401. https://doi.org/10.1016/j.fcr.2016.07.018.

114. Lessons-learned from long-term phosphorus experiments on permanent grassland

Regelink,I.C.[a*], Van Middelkoop, J.C.[b]

Wageningen Environmental Research, The Netherlands[a,] Wageningen Livestock Research, The Netherlands[b]; [*]Corresponding author, email: inge.regelink@wur.nl

Introduction

Phosphorus fertilization rates should be optimized to minimize P losses while maintaining a sufficient soil P status and to produce grass containing sufficient P for dairy cattle. In The Netherlands, balanced P fertilization forms the basis for the P application standards. In 1997, a field trial started on four grassland sites (loam, clay and two on sand) to monitor the long-term effects of balanced P fertilization on soil P indicators, P in porewater and grassland yield.

Methodology

The P treatments include balanced P fertilisation (P input equal to average P uptake) and a yearly surplus of 9 kg P/ha and 18 kg P/ha. Each field receives 40-50 m^3/ha cattle slurry which corresponds to P requirement needed for balanced P fertilisation. The P surpluses are given as triple-super-phosphate. Field management reflects practices that are typical for Dutch dairy farmers and fields are grazed in summer. Grass yield and soil P indicators have been measured yearly since 1997. The field trials on sand ended after 16 yrs whereas the field trials on clay and peat are still in use.

Results and discussion

Soil P indicators respond only slowly to differences in P management. Despite the long monitoring period, effects of P treatment on soil P indicators remained rather small and were masked by high temporal variations in the measurements, in particular on clay and peat. The sites were managed as permanent grassland i.e. no grassland renewal. As a result, P accumulated in the top layer of the soil leading to high P-$CaCl_2$ concentration in the top 0-5 cm of the soil. These steep P profiles were most distinct on the peat and clay soil and suggests that subsurface runoff can be a potential emission route on these soils. On the sandy soils however, P was more homogeneously distributed in the 0-30 cm soil layer probably due to ploughing in the period before the start of the trial.

Soil porewater measurements showed that the level of P fertilisation had no clear effect on average P-PO_4 concentrations in the top soil of the grassland fields. Highest P-PO_4 concentrations were measured in the 0-5 cm soil layer, varying between 0.2-1.8 mg P/L. However, total P concentrations in porewater were far higher than P-PO_4 pointing to the presence of colloidal P (<0.45 um) in porewater samples which were collected by centrifugation. Colloidal P was associated with Fe pointing to the role of mineral colloids in the mobility of P.

Grass yield remained high on soils with balanced P fertilisation. Average P uptake rates varied between 34 and 38 kg P/ha on the four grassland sites. Cattle slurry is yet the dominant P fertiliser on grassland in The Netherlands. The upcoming tightening of the application standard for N from livestock manure to 170 kg N/ha means that P applications rates will decrease to about 22 kg P/ha when using cattle slurry. This implies that additional synthetic P fertiliser is required to maintain a balanced P fertilisation on grassland as soon as the stricter N application standards have come into force.

Conclusion

Soil P indicators and P concentrations in porewater respond poorly and slowly to differences in level of P fertilization. The role of subsurface transport and colloidal P should receive more attention when assessing transport of P to surface waters.

References

van Middelkoop, J. C., and I. Regelink. "Balanced phosphorus fertilization in a mixed grazing and mowing system on grassland; results after 26 years." *30th General Meeting of the European Grassland Federation (EGF2024): Why grasslands?*. Brill, 2024.

115. New integrative approaches for sufficient clean water in the Mediterranean Agro-Hydro-System

Renovell, J.[a*], Wang, M.[a], Paparrizos, S.[a], & Strokal, M.[a]

Wageningen University & Research, The Netherlands [a]; [*]Corresponding author, email: javier.renovellsala@wur.nl

Introduction

Clean water availability is already a challenge for many sectors in the Mediterranean region. Climate change is expected to influence the availability of clean water in the future because of droughts and floods. Additionally, socioeconomic activities may add more pollution. These two challenges will pose threats to food security in the region. As a result, farmers may become even more vulnerable because of more pollution and less water for irrigation purposes. Innovative pathways are needed that address food and water security challenges and inform farmers about relevant information. Within the European Union HORIZON-MISS-2023-OCEAN-SOIL-01 project, called Path4Med (https://www.path4med.eu/), we aim to integrate new information across scales and agricultural and water systems for sufficient clean water in the future. Path4Med is a multi-disciplinary project that started in 2024 and will last for four years. The overall focus of Path4Med is on new innovative pathways for water pollution that account for social, economic, and environmental aspects. One of the work packages (WP) focuses on systems integration and policy mainstreaming (WP6). Here, we aim to develop new integrative approaches to quantify water pollution today and in the future across scales in the Mediterranean region and provide water quality services for users (e.g., farmers) that can support policy recommendations for ensuring sufficient clean water.

Methodology

We develop a new model by integrating approaches for nutrients and agrochemicals (e.g., glyphosate). We start with an existing model for European basins that has been developed for nutrients: MARINA-Nutrients (Ural-Janssen, Kroeze et al. 2024). The model accounts for point (e.g., sewage systems) and diffuse (e.g., agricultural runoff) sources of nutrients in rivers and runs for the recent past (2010) and future (up to 2100). The model simulates annual river exports of nutrients by source to coastal waters. Our aim is to add more pollutants (e.g., pesticides) or plastic mulching (Li et al., 2023) to identify the effects of solutions to reduce nutrient pollution and co-benefits for other pollutants. First, we develop the model for a case study to validate it. After that, we upscale it to the European basins for rivers and coastal waters for today. Finally, we will develop future pathways with new information on the effects of the Green Deal Targets on river and coastal water pollution reductions. Scenarios will be developed by integrating the insights from the other work packages. This new information will be translated into the water quality services for users. For this, we aim to use the concept of climate information services (Paparrizos, Baggen et al. 2023) as inspiration.

Results and discussion

Results of existing MARINA models will be presented as the starting point. We will add steps to develop a new model for future pathways to reduce water pollution and ensure sufficient clean water for users in the Mediterranean region. We will also show examples of climate services that will be our inspiration to develop water quality services to support policy recommendations. Examples of results include sources of water pollution. In Europe, agriculture (i.e., manure, chemical fertilizers) contributes to over half of nitrogen and phosphorus in rivers, and over one-fifth of river exports of nitrogen end up in the Atlantic Ocean and phosphorus in the Mediterranean Sea according to the MARINA-Nutrients model. Europe is also reported to be a hotspot of glyphosate pollution (Zhang, Li et al. 2024). These are starting points to zoom in into specific basins in Europe to understand pollution sources and then develop future pathways.

Acknowledgements

European Union HORIZON-MISS-2023-OCEAN-SOIL-01 Grant Agreement No. 101156867 (Path4Med)

References

Li, Y., et al. 2023. The Plastic Age: River Pollution in China from Crop Production and Urbanization. Environ. Sci. Technol. 2023, 57, 12019−12032.

Paparrizos, S., et al. 2023. Commercialization pathways for climate services for small holder farmers in the global South. Climate Services 30: 100354.

Ural-Janssen, A., et al. 2024. "Large reductions in nutrient losses needed to avoid future coastal eutrophication across Europe. Marine environmental research 197: 106446.

Zhang, Q., et al. 2024. A global assessment of glyphosate and AMPA inputs into rivers: over half of the pollutants are from corn and soybean production. Water research: 121986.

116. Modeling agricultural plastic mulching: lessons from rivers in Europe and China

Klarhorst, L.[a*], Micella I.[a*], Li, Y.[b], Bak, M.P.[a], Ural-Janssen A. [a], & Strokal, M.[a]

Wageningen University & Research, The Netherlands [a]; China Agricultural University, China [b]; [*]Corresponding author, email: lars.klarhorst@wur.nl and ilaria.micella@wur.nl

Introduction

Mulching is a practice used in agriculture in which soil is covered to retain moisture, control weeds and improve soil health. While natural materials such as straw or wood chips were initially used for mulching, plastics have proven to be more efficient in terms of consistency and labour intensity and are nowadays the most commonly used material (Kasirajan & Ngouajio, 2012). Plastics used to cover crops on land or to grow crops in greenhouses, may end up in rivers, potentially causing pollution. Yet, this is hardly studied on a large scale. Additionally, information on the contribution of agricultural sources to the total plastic pollution in rivers (agricultural and urban sources) is scarce. In this study, we model inputs of macro- and microplastics from agricultural activities (mulching and greenhouses) to rivers and compare their contribution to other sources. We take Europe and China as case studies because of their differences in agricultural practices and socioeconomic developments. We summarize lessons for large-scale modeling of plastics from agriculture.

Methodology

We developed the first version of the MARINA-Plastics model for agriculture in China (Li et al., 2023). In this version, we considered plastics from agricultural (mulching and greenhouses) and urban (mismanaged solid waste and sewage systems) sources. We currently develop the second version for Europe with a focus on agricultural plastics from mulching (Klarhorst, in prep). The two model versions simulate annual inputs of macro- and microplastics into rivers at the sub-basin scale (around 400 Chinese sub-basins and 430 European sub-basins).

Results and discussion

In China (Li et al., 2023), around 20% of the plastics in rivers were from agricultural plastic films (mulching + greenhouses). Mismanaged solid waste dominated macroplastic pollution in rivers whereas sewage systems dominated microplastic pollution in rivers for China as a whole. Plastic pollution hotspots were in the areas with intensive crop production and urbanization. Preliminary results for Europe show that most pollution hotspots for rivers (kg/km^2) are located in Italy, the Netherlands, and Eastern Europe. While Italy and Spain have the highest plastic applications on crops, the main driver for the high loads in Eastern European countries are low collection rates. Data availability and approaches are key in large-scale modelling of plastic pollution from agriculture. Expert knowledge is essential in guiding the modeling choices for the scales and model parametrization as well as for verification of uncertain model inputs for which data is lacking.

Conclusion

Our models could serve as tools to explore effective solutions to reduce the impact of agriculture on river pollution with plastics. In large-scale water pollution modeling, agriculture is often overlooked as a source of plastics, especially for mulching. An important reason is data availability to build models and validate them. Thus, we argue the importance of expert knowledge to upscale expertise and guide choices when developing models.

Acknowledgements

The Wageningen Institute for Environment and Climate Research (WIMEK) [scholarship Project 5160958452]; The European Union's Horizon 2020 research and innovation programme under the Marie Sklodowska-Curie grant agreement 956623MSCA-ITN-ETN – European Training Network: inventWater (Inventive forecasting tools for adapting water quality management to a new climate) Project; the Major Science and Technology Project of Yunnan Province (202202AE090034), China Scholarship Council (No. 201913043) and Hainan University; The European Union HORIZON-MISS-2023-OCEAN-SOIL-01 Grant Agreement No. 101156867 (Path4Med); the Veni-grant of Maryna Strokal (0.16. Veni. 198.001).

References

Kasirajan, S., & Ngouajio, M. 2012. Polyethylene and biodegradable mulches for agricultural applications: A review. In Agronomy for Sustainable Development, 32 (2), 501–529

Klarhorst, L.. in prep. Plastic pollution from agricultural plastic mulching. MSc thesis, Wageningen University & Research, Wageningen.

Li, Y., et al. 2023. The Plastic Age: River Pollution in China from Crop Production and Urbanization. Environ. Sci. Technol. 2023, 57, 12019−12032