NERM (Nutrients in Europe Research Meeting)

NERM 2024
16-17 April 2024
Brussels & hybrid

More than 150 participants attended the NERM (Nutrient in Europe Research Meeting) conference, organised by organised by ESPP and the RUR-08 Horizon2020 sister projects FERTIMANURE, LEX4BIO, RUSTICA, SEA2LAND, and WALNUT. This follows on from **PERM5** (the 5th Phosphorus Research in Europe Meeting, SCOPE Newsletter n° 143).

Summaries of previous PERMs

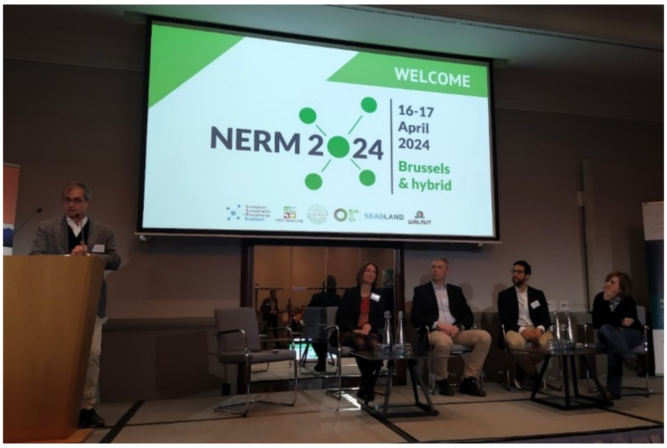
PERM4*, online, June 2021, 370 participants, with Biorefine, SCOPE Newsletter n°141*
PERM3*, Rimini, November 2018, with Smart-Plant, ESPP eNews n°28*
PERM2*, Basel, October 2017, with Phos4You SCOPE Newsletter n°126*
PERM1*, Berlin, 2015, conclusions published by the European Commission, summary in SCOPE Newsletter n°111*

The conference discussed key outcomes of recent nutrient recycling R&D projects under Horizon 2020, LIFE, Interreg and other programmes, nutrient recovery technologies and recycled fertiliser production, quality, application and use, stakeholder acceptance of secondary fertilisers, path from nutrient recovery to market and future R&D needs.

Slides from the conference, list of registrants with emails (where authorised) and recordings of hybridised sessions have been sent to all registrants.

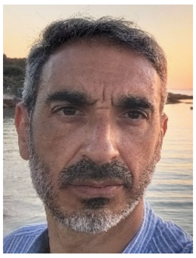
Robert van Spingelen, ESPP President, opened the meeting and introduced the coordinators of the five Horizon2020 projects funded under the RUR-08 call that jointly organised the conference with ESPP:

- **Fertimanure**, Laia Llenas Argelaguet (Beta Technological Center): "Innovative nutrient recovery from secondary sources – Production of high-added value FERTIlisers from animal MANURE".
- **Lex4bio**, Kari Ylivanio (Luke): "Optimizing Bio-based Fertilisers in Agriculture – Knowledgebase for New Policies"
- **Walnut**, Francisco Corona (Fundacion Cartif): "Closing waste water cycles for nutrient recovery"
- **Sea2Land**, Miriam Pinto (Neiker): "Producing advanced bio-based fertilizers from fisheries wastes"
- **Rustica**, Tessa Avermaete (KU Leuven): "Demonstration of circular biofertilisers and implementation of optimized fertiliser strategies and value chains in rural communities"



Context

EU R&I on nutrient recycling and managing



Luis Sanchez Alvarez, European Commission, Directorate-General for Agriculture and Rural Development (Research and Innovation), provided an overview of EU initiatives on nutrient management and recycling. The Common Agricultural Policy (CAP) contributes to reducing nutrient losses by 50% and fertilizer use by 20% by 2030, as outlined in the Farm to Fork Strategy. Initiatives include promoting organic waste recycling into renewable fertilisers and supporting informed decision-making by farmers. From 2014 to 2022, 90 Horizon2020 projects (funded with €623 million) and 26 Horizon Europe projects (€129 million) focused on nitrogen and phosphorus cycles, fertiliser production, nutrient pollution reduction, and efficient agricultural use. The Horizon Europe Strategic Plan for 2025-2027 continues to support sustainable fertilizer use, particularly in Cluster 6. Additional instruments include the EU CAP Network, PRIMA (Partnership for Research and Innovation in the Mediterranean Area), the Circular Bio-based Europe Joint Undertaking, the EJP Soil, and the "A Soil Deal for Europe" mission (see SCOPE Newsletter n°150). Projects funded under the Horizon Europe Cluster 6 support research and innovation on nutrient budgets in agriculture and the environmental impacts of alternative fertilising products, among others. To facilitate adoption of research outcomes, Mission Soil living labs (groups of 10-20 sites) and lighthouses (individual exemplary farms) are being established for co-creating and testing new technologies adapted to local conditions and showcasing good practices.

Societal impact of publicly funded circular bioeconomy projects

Ana Sofia Brandão, Instituto Politécnico de Bragança, explained that the circular bioeconomy is based on circular economy principles, focusing on efficient biological resource use. To assess the benefits of circular bioeconomy research, leaders of 11 EU-funded projects (Horizon2020, FP7, and Interreg) completed within the last two years were surveyed. The aim was to evaluate the societal, environmental, and economic short, medium, and long-term benefits. Spain emerged as a leader in coordinating and participating in these projects, likely due to its bioeconomy and circular economy strategies and its network of sustainability-focused entities. The survey showed, , in the project leaders' view, that these projects mainly deliver short- and medium-term social benefits, such as knowledge sharing, collaborative learning and capacity building. Intended long-term benefits, such as policy development, network development and economic market dimensions were cited but not clearly evaluated, while environmental benefits were less frequently noted. Therefore, capacity building, community empowerment, networking, policy development, and sustainable business practices should be prioritised in designing new circular bioeconomy projects to ensure lasting impacts.

ESPP comments that this analysis is based on the project leaders' self-assessment. Independent evaluation does not seem to be made of impacts of projects on e.g. policies or markets, a year or several after the project completion.

Nutrient recovery technologies

Laia Llenas Argelaguet, BETA Technological Center, summarised key outcomes of the H2020 Fertimanure project, which aimed to recover valuable agronomic products like fertilisers, organic amendments and biostimulants from animal manure. Various technologies were used on pig slurry, cattle manure, and poultry manure to produce bio-based fertilisers. These fertilisers, produced through physical, thermal, chemical, or biological processes, can be used directly in fields or as raw materials for custom fertilisers production. Eighteen bio-based fertilizers were tested in laboratory and field conditions across 14 locations and 10 crops. Results showed similar crop yields and environmental impacts compared to synthetic fertilisers, including nitrate residue and greenhouse gas emissions. Life Cycle Analysis (LCA) indicated positive impacts on global warming potential, freshwater eutrophication, and ionising radiation. However, electricity and chemical consumption were significant impact hotspots. Techno-economic LCAs revealed that pilot plant costs outweigh returns over 20 years, partly due to low revenues from bio-based fertilisers. Optimising on-site energy production and automating activities could improve net cash flow, and cooperative business models could facilitate industrial-scale transition. Stakeholder analysis showed farmer willingness to try bio-based fertilisers, but emphasised the importance of fertiliser form, price, infection risk (contaminant ? pathogen ?), and rate of nutrient release. Most respondents were unwilling to pay more for bio-based fertilisers than mineral fertilisers, and identified barriers to adoption included financial (high capital requirements, lack of specialised financing), market (price volatility, unclear market pathways), and regulatory issues (strict inspections, uncertainties).

Implementation and adoption of nutrient recovery technologies

A panel moderated by **Sergio Ponsá (BETA-UVIC),** including **Oscar Schoumans (Wageningen University and Research), Ludwig Hermann (Proman), Lennert Dockx (Aquafin),** and **Javier Martín Sanz (Veolia),** discussed challenges hindering the implementation of nutrient recovery technologies:

- Investment and financial challenges: investors find the long-term nature of nutrient recycling projects unattractive, making it difficult to secure funding, but moving from pilot to full scale requires high-risk investments, incentives, and social acceptance.
- Indirect gains as environmental benefits, resource recovery, and reduced reliance on virgin materials could make business models viable if they were monetarised. Legislation can support this shift.
- Manure, despite being a significant nutrient source, faces business case difficulties since farmers resist additional costs. Sewage sludge recovery costs are covered by citizens, applying the polluter-pays principle. Slaughterhouse residues face regulatory challenges due to current practices and safety uncertainties.
- Fertiliser emissions mainly occur during application, complicating the assessment of nutrient recycling sustainability.

- Technologies that recycle nutrients and other elements like Fe, Al, and metals are more likely to be viable if these are recovered in an economically marketable form.
- Another challenge is related to the low concentration of nutrients in secondary streams.
- There is a need to link stakeholders, including policymakers and end-users, with potential technologies.
- Technologies should match regional nutrient demands, product types, and available waste.
- Farmers and end-users are particularly interested in nutrient recovery where excess manure is a problem. They seek evidence of agronomic benefits, sustainability, and profitability, alongside incentives to offset implementation risks.
- Recovery technologies should complement existing processes, like wastewater treatment.
- Addressing market acceptance, pricing, legal aspects, and reducing operational (OPEX) and capital expenditures (CAPEX) is crucial for sustainability and efficiency.

Overall, aligning technological capabilities with market demands, financial incentives, and regulatory support is key to advancing nutrient recovery technologies.

Summaries of parallel sessions

Nutrient recovery from manure

Boris Jansen, UVA, rapporteur
Session moderated by **Xialei You, LEITAT**

Results from the FERTIMANURE pilot plants:

- The Spanish pilot plant treated pig slurry and poultry manure to produce five different recycled fertilisers. The pilot obtained satisfactory recovery yields but low mass efficiency (% of inlet transformed into fertilisers with actual value). The obtained fertilisers are compliant with fertilising products categories (CMC and PFC) identified from the EU FPR, although some products need to be further concentrated and P-rich ashes and phosphoric acid still contain Zn and Cu. The technological configuration was not economically feasible for the liquid fraction, while for the solid fraction it is feasible for > 5.000 heads' farms.
- The Belgian pilot (see Site Visit description below) focused on the production of ammonium nitrate and ammonium sulphate from manure using a Flemish farm as case study. Trials showed that intensification of the treatment train can reduce the overall costs of the plants by 10%, while increasing the circularity and sustainability of manure management.
- The Dutch pilot (digestate liquid-solid separation with nitrogen striping on the liquid fraction) focussed on the economic feasibility of nutrient recovery from cattle manure at the farm level. According to the farmer, the products (ammonium sulphate solution, liquid K fertiliser, soil conditioner and organic P-rich fertiliser) meet with requirements at farm and for other farmers; the variation in composition of the products over time is small; the farmer became less dependent on mineral fertilisers; the produced ammonium sulphate is as good as synthetic mineral fertilisers; biogas is important to make a strong business case.

Other processes:

- Vivianite (iron(II) phosphate) precipitation (see SCOPE Newsletter N°138): The presence of organics in pig manure poses challenges to vivianite precipitation and P removal. Alkalinity is also hypothesised to be an important factor, explaining the differences in vivianite formation in digested manure and raw manure (more efficient in the latter) (Wetsus).
- Use of manure digestate for growing algae: the high ammonia content of digestate can cause toxicity to algae cells, but was reduced at pilot scale through the installation of artificial lights and an automatic pH control via CO_2 injection together with a fed-batch approach. Once the cultivation protocol was optimized, algal growth on digestate was similar to algae grown using commercial mineral medium (Ghent University).

The NOVAFERT project database of available nutrient recovery technologies and derived products in the EU was also presented, including the methodology to create it.

Wastewater and sewage sludge

Sophie Schönfeld, FRAUNHOFER, rapporteur
Session moderated by **Francisco Corona (CARTIF)**

Innovative approaches for wastewater treatment and resource recovery were presented:

- Ammonium sulphate production from urban wastewater with a two-step technology was demonstrated with more than 400 L of wastewater. The process used ammonium adsorption/desorption with zeolites, resulting in a ammonium sulphate solution (specify xxx% ammonium sulphate = ???% N w/w) (Walnut project).
- Nitrogen recovery from municipal high-rate activated sludge effluent via column adsorption with natural zeolites, generating N and K-rich outputs. The N-saturated zeolites contained 1.4-8.4 mg/g FW NH_4^+-N and 14-19 mg K^+/g FW, making them suitable as materials under the EU FPR. The effluent from zeolite regeneration contained 25-845 mg NH_4^+-N/L and around 14 g K^+/L, which could be diluted with water for fertigation (Walnut project).

- Phosphorus recovery as iron or aluminium phosphates at the tertiary treatment phase of a 1000 p.e. pilot and a full-scale wastewater treatment process (specify the scale of operation) through post-precipitation with aluminum or iron. Then possible processing for phosphorus extraction for the chemical industry, see the RAVITA process in SCOPE Newsletter N° 138 (Helsinki Region Environmental Services).
- Wet chemical phosphorus extraction from sewage sludge ashes collected from cyclone downstream of fluidised bed incinerator and co-precipitated with Mg-rich mining by-products (feedstocks classified as CMC1 and CMC12). The process was optimized to achieve good extraction (>85%) and overall recovery efficiency (>80%), resulting in magnesium-phosphate compliant with EU FPR (PHOSTER project).
- Removal of PFASs and associated organic fluorine during sludge-char production from sewage sludge pyrolysis. PFASs and organic fluorine were removed at temperatures above 400°C (Prague University).

Other nutrient streams and technologies

Veronica Santoro, ESPP, rapporteur
Session moderated by **Andrea Bauerle, U. Hohenheim**

The session presented different technologies to recover nutrients and other materials for diverse uses and products.

- Production of N-rich microalgal bio-based fertiliser from tuna cooking brines. A non-photosynthetic microalga was grown on these brines (characterised by high salinity, fats, suspended solids, and organic matter), and subjected to enzymatic hydrolysis, producing a fertiliser with 0.6% (w/v) total N and containing amino acids and other nutrients. The process removed 100% of free amino acids and organic carbon from the brine and reduced the medium's disposal cost by 90% (Sea2Land project).
- Recycled liming agents from mollusc shells: incubation trials suggests similar pH corrective power to $CaCO_3$. Field trials in Northern Norway are ongoing (Sea2Land project).
- Lake restoration through sediment removal and phosphorus recycling using biodegradable polymeric substances for flocculation and dewatering (University of Southern Denmark).
- Valorisation of iron-based waste materials, such as arc furnace dust from the steelmaking industry. Materials were functionalised to increase P adsorption capacity, and can be used as adsorbents for phosphorus removal (Agh University, Poland).
  ESPP comment: further work would be needed to demonstrate possible valorisation of the resulting material: contaminants ? crop P availability ?
- Use of additives, such as kieserite ($MgSO_4$), to increase phosphorus partitioning to the solid phase of digestate during solid-liquid separation. Under the tested conditions, this led to a 20% increase in P partitioning in the solid phase (University of Hohenheim).
- Extraction of phosphorus from solid sources through a non-aqueous liquid-phase process. This method produces pure phosphorus compounds for the chemical industry and agriculture, using inputs like bone-meal ash, sewage sludge incineration ash, fish bone ash, and vivianite (Sinfert, University College Dublin, see ESPP eNews n°87).

Conclusion:

- Most presented processes are at the laboratory or pilot scale, and their economic feasibility for large-scale implementation needs further investigation.
- Common concerns include possible contaminants such as heavy metals or microplastics in the products.
- Compliance with legislation and market value of these products are key considerations.
- Farmers are interested in alternative solutions not only for fertilisation, but also for soil pH correction (soil “liming”).

Bio-based fertilising products

Silvia Maltagliati, European Commission, Directorate-General for Research and Innovation (Healthy Planet), provided an overview of bio-based sector research opportunities funded by Horizon Europe (Pillar II) and the Circular Bio-based Europe Joint Undertaking, a €2 billion partnership between the EU and the Bio-based Industries Consortium. A key objective of the research programmes is to upscale demonstrations to higher Technology Readiness Levels (TRLs). To this aim, flagship projects, reaching TRL 8, involve industrial installations and the entire value chain (producers to end users, including local governments and authorities), demonstrating replicability. A review of recent funding calls identified challenges such as the need for a holistic approach to nutrient recovery including the environmental impact of nutrients and better economic incentives to reduce agricultural nutrient overuse. The Horizon Europe 2021-2024 Programme funded projects to maintain nitrogen and phosphorus flows within safe ecological boundaries, including nutrient recovery from secondary raw materials, through initiatives like Norbaldt Ecosafe, NEW Harmonica, NAPSEA, Novafert, and FerPlay. Future calls should compile information on these technologies to create a database of best practices and demonstrate a regional multi-actor approach involving local governance, civil society, farmers, industry, and research. In 2024, two new calls from the Circular Bio-based Europe JU will focus on "Sustainable, bio-based alternatives for crop protection" (€10M, 2 projects) and "Bio-based materials and products for biodegradable in-soil applications" (€15M, 2 projects). The next Horizon Europe and Circular Bio-based Europe JU Work Programmes will be published at the end of this year, continuing support for research and innovation.

Kari Ylivainio, LUKE and Lex4Bio, discussed nutrient flow in the EU and the potential of bio-based fertilisers. In 2021, the EU used 1.1 Mt of P and 9.8 Mt of N fertilisers, and imported 1.0 Mt of P through food and feed. Nutrient-rich side streams such as manure, municipal biowaste, sewage sludge, and food industry waste contained 1.7 Mt of P and 9.7 Mt of N in 2020. Manure, the main side-stream, is mostly used locally. Regions with high livestock density, such as Belgium and the Netherlands, have significant surpluses of manure-based N (over 200 kg/ha) and P (50 kg/ha), leading to N leaching and NH_3 emissions exceeding 50 kg/ha. Eastern Europe, in contrast, has negative balances. Currently, manure is often recycled sub-optimally and still considered waste. Sewage sludge and other side streams are less used in agriculture in some countries due to perceived lower agronomic efficiency and potential due to perceived lower agronomic efficiency and potential contaminants. However, these streams can be sources for bio-based fertilisers, which have high carbon content and can enhance soil productivity and carbon sequestration. Lex4bio found that nutrient-rich side streams could potentially meet 86% of the EU's phosphorus fertilisation needs. However this assumes that sewage sludge and manure phosphorus are today not recycled, whereas around 50% of EU sewage sludge is valorised to agriculture and a large proportion of manure. Despite the Fertilising Product Regulation (FPR) providing a legal framework for bio-based fertilisers, farmers face barriers like low nutrient concentration, high transportation costs, specialised equipment needs, and imbalanced nutrient ratios. Other concerns include unknown agronomic efficiency, variable P solubility, organic contaminants (PCBs, PAHs, PFAS, pharmaceuticals, pesticides, plastics), heavy metals, and risks of antimicrobial resistance. To increase acceptance, bio-based fertilisers must ensure consistent agronomic performance across EU climates, be economically viable, and pose no environmental or health risks. A clear legal framework for their production and use is essential.

Path to market of bio-based fertilisers

A panel moderated by **Robert van Spingelen (ESPP)** with **Ignasi Salaet (FERTINAGRO Biotech), Ana-Marija Spicnagel (IPS Konzalting), Else Bünemann (FiBL), Erik Meers (UGENT),** and **Daniel Egas (BETA-UVIC)** proposed several conclusions:

- bio-based fertilisers can offer crop fertilisation as good a mineral fertilisers, depending on the processing, but application can be more complex.
- Better data is needed on the environmental impact of production and application (LCA data).
- More testing is also needed on how biostimulants can improve agronomic performance of recycled and organic fertilisers.
- Considerable quantities of secondary nutrient are already today recycled to fields, both through manure and sewage sludge use, and in commercial organic and organo-mineral fertilisers. Nonetheless, significant potentials remain for increasing nutrient recycling, from improved manure application and recycling of underused or developing secondary nutrient streams (e.g. food wastes, aquaculture sludges).
- A significant challenge is costs of decentralised processing (small-scale), distribution and transport. The mineral fertiliser industry, blenders and wholesalers can provide logistics, storage and distribution networks.
- Another challenge is reliability of supply and quality of secondary nutrient materials.
- Certified Organic farming in Europe needs to increase nutrient inputs to increase production, but without facilitating intensive livestock production (manure from intensive livestock is excluded). Struvite from municipal wastewater was authorised for Certified Organic farming in 2023 but the decision procedure for recycled nutrient products, addressing proposals on by one, is too slow.
- Participants did not agree on whether bio-based fertilisers need market subsidies. Proposals included funding carbon benefits of recycled fertilising products into the CAP.

Summaries of parallel sessions

Results from sister projects

Kimo Van Dijk, Wageningen UR, rapporteur
Session moderated by **Cağrı Akyol, University of Gent**

Some 100 field trials, pot trials and laboratory extraction tests of bio-based fertilising products were presented, carried out by the four Horizon 2020 projects (Lex4Bio, Sea2Land, Fertimanure and Rustica). Overall, most recycled materials tested provided good agronomic performance, often supplying nutrients progressively over more than one year.

Struvite showed the highest agronomic performance, equal to commercial mineral phosphate fertilisers. Recovered ammonium sulphate showed equivalent nitrogen availability to commercial nitrogen fertilisers (as is to be expected). Pyrolysis and organic materials showed lower phosphorus availability at just over half that of commercial fertilisers.

Input materials to recycling processes will define phosphorus content, but do not define nutrient availability, which depends on the recovery process.

The projects showed that attentive formulation is necessary for fertilising products using the recycled products with lower nutrient availability, in order to deliver products adapted to crop needs.

The limited testing carried out suggests that atmospheric nitrogen emissions in use of the bio-based fertilisers is similar to that from mineral fertilisers.

Where quality products are produced, then financial incentives are not needed for uptake by farmers, but the price must be competitive with mineral fertilisers, including logistics and transport costs which can be higher for recycled or organic materials.

Fertiliser production from fish sludge (aquaculture waste) is technically ready today. With marine aquaculture sludge, a question is salinity, but this is not a problem in North / West Europe, with rainy climates.

Nutrient budgets

Nagore Guerra Gorostegi, BETA Technology Centre, University of Vic, rapporteur
Session moderated by **Daan Kuiper, Cropeye**

This session also showed agronomic testing of recycled fertilising products, again showing agronomic performance comparable to mineral fertilisers, but depending on secondary input materials, processing and soil conditions. Estimates of secondary nutrient flows suggest significant potential for replacement of mineral fertilisers, especially for phosphorus. ??? For example, from animal manures which are at present poorly used (Mariana Devault, Roulier ?????).

Analysis of bio-based fertilisers presented, showed that contaminant levels vary depending on input material and processing, but are generally low.

Modelling of nitrogen and phosphorus losses with bio-based fertilisers suggests that phosphorus leaching will generally be lower than with mineral fertilisers (because the recycled products show lower water solubility). Nitrogen losses can be reduced if bio-based fertilisers are applied below legal application limits, but this results in some crop productivity loss. Use of organic nitrogen sources up to crop nitrogen needs can result in increased nitrogen losses, because some of the nitrogen will be released progressively after the crop has been harvested. In all cases, good information on the properties of the bio-based fertilisers is necessary for appropriate management.

Sustainability, market and acceptance

Jeroen Buysse, University of Gent, rapporteur
Session moderated by **Alicia González, Cetaqua**

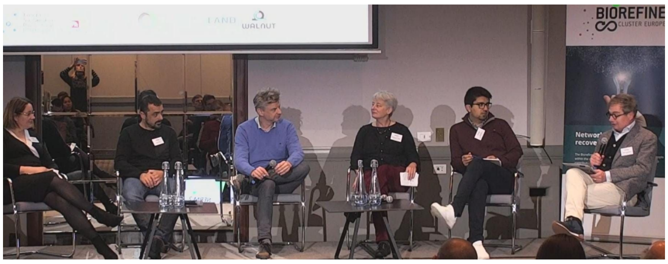
This session included a number of studies of environmental impact and social acceptance studies on bio-based fertilisers.

The Life Cycle Analysis (LCA) studies concluded that bio-based fertilisers with less processing had lower environmental impacts, but this does not take into account crop nutrient efficiency, nutrient losses in use, which could be expected to be lower with a more refined product.

Social acceptance surveys show that farmers expect to pay a lower price for bio-based fertilisers than for mineral fertilisers (if the recycled product is less refined) and have concerns about possible contaminants. Ease of use (i.e. forms that require no purchase of new machinery) and guaranteed/certified nutrient content are also major concerns.

Economics of nutrient recycling are found to be largely driven by the "gate fee" (price paid by waste operator or livestock farmer for disposal or waste or manure) and by logistics. Where nutrients can be used locally, minimum processing offers the cheapest solution and the best LCA.

A study by PROMAN estimated that recycling phosphorus from municipal sewage in Europe could potentially cover c. 10 – 20% of phosphorus needs of grain cereals (wheat, barley, rye only, not other crops) in Denmark, Germany and Spain. This estimated does not take into account nor that significant amounts of sewage sludge are currently today spread to agriculture, so already recycling the phosphorus.

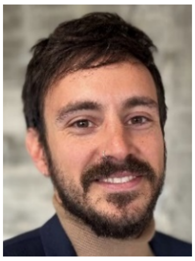


Adoption and impact of the R&D results

From R&D to farmer information

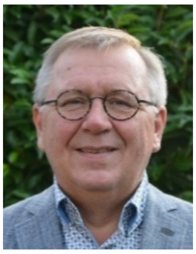
Margarida Ambar, EIP-AGRI (EU CAP Network support unit for Innovation and Knowledge exchange), presented the new Agricultural Knowledge and Innovation System (AKIS) put in place by the European Commission, DG AGRI. The aim is to take R&D knowledge to farmers and other agriculture operators. This will be supported by a new database, bringing together outcomes of the 3000 Operational Groups supported by EIP-Agri to date, 500 R&D projects, Horizon Thematic Networks and others. Over 1000 of these address nutrients, amongst other themes.

Peter Rakers, Esset Engage, summarised the EU-FarmBook project https://eufarmbook.eu/en. This will develop an online information platform to provide information on R&D outcomes, including text documents, videos and other tools, for farmers, foresters and advisors. This will provide a permanent access to R&D project outcomes, which currently often "disappear" when the project website is turned off at the end of the project. Use of metadata should facilitate finding the required information. EU-FarmBook will focus on practice-oriented materials of EU-funded projects and EIP-AGRI Operational Groups. Over time, materials and platform services will be auto-translated in every EU language. "Ambassadors" across Europe are facilitating the use of the platform for contributors and practitioners.



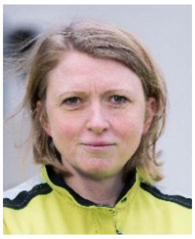
Victor Carbajal, Beta Technology Centre, University of Vic, presented the Horizon Thematic Network Nutri-Know. This will communicate outcomes from 12 Operational Groups in which project consortium members participated. The aim is to communicate outcomes widely, in particular to farmers and stakeholders.

On-farm and industry implementation

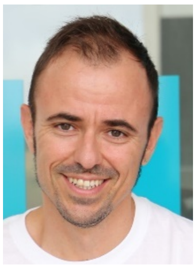


Oscar Schoumans, Wageningen University Research, summarised conclusions of the SYSTEMIC project, with 5 full scale nutrient recycling installations from manure biogas production, and a community of 40 further participant plants. This showed that technologies are today operational and proven and applicable large-scale. Analysis of these plants shows that manure processing and nutrient recovery from manure are high-risk investments for farmers. Each site has specific drivers but in general the objectives are to reduce transport costs for manure disposal, by optimising local use or exporting nutrients to other regions. In all cases the economics were negative, and manure management remains a cost.

Javier Brañas, Fertiberia, presented the B-FERST project, which aims to define the conditions for the recycling of nutrients, mainly phosphorus and potassium, in the fertiliser industry. Mineral and organo-mineral fertilizers have been developed, combined with biostimulants and biodegradable coatings, and their implementation has been tested on a demo scale. Different biowastes were evaluated for nutrient content, contaminants, physical handling, and other parameters. A process for the solubilisation of phosphates from ash (i.e., from sewage sludge incineration) has been developed and is being scaled up in a Fertiberia demo facility with sulfuric or hydrochloric acidification in a thermocoupled reactor to optimize process costs and recover a soluble calcium phosphate. Agronomic trials showed that biobased fertilisers do not always achieve the same crop yields as mineral NPK fertilizers, although this can be compensated by coating with biostimulants and coating agents. The biostimulant also has positive effects on the rhizosphere microbiome, promoting the abundance and predominance of beneficial bacteria.



Anna Lundbom, EasyMining, presented the company's nitrogen recovery process Aqua2N, which recovers N as ammonium sulphate solution (40%) from ammonia-rich liquors (see SCOPE Newsletter n°145). The process operates by precipitating struvite, then redissolving the struvite using sulphuric acid, so recycling the magnesium and phosphate back to the N-recovery process, and recovering the nitrogen as ammonium sulphate. 95% ammonia removal can be achieved. Life Cycle Analysis is positive, even without considering N_2O reductions in the sewage works resulting from the N load reduction. Following successful trials of a 4 m^3/h pilot with EU LIFE funding, EasyMining is now looking for financial risk-sharing for a first full scale plant.



Martin Soriano, Cetenma, presented the HOOP project, which aims to facilitate replication of city or regional nutrient recycling projects:

- LIPOR, Greater Porto, Portugal: In 2023, 10,000 tonnes/year of compost (Nutrimais) were produced and it has obtained approval for use in Certified Organic farming in Portugal, but cannot to date be CE-marked under the EU Fertilising Products Regulation (FPR) due to process conditions (work in progress to overcome this). In addition, ongoing pyrolysis project to treat compost refuse and waste streams that cannot be processed in the composting plant (e.g. invasive plants) for the production of biochar for agriculture.
- Münster: pyrolysis of green waste and digestate. Currently under development.
- Kuopio, Finland: forestry biomass biochar project.

NERM conference conclusions

The five sister Horizon projects, co-organisers of NERM with ESPP, made conclusions, with Kari Ylivainio for LEX4BIO, Laia Llenas for Fertimanure, Miriam Pinto for Sea2Land, Tessa Avermaete for Rustica, and Francisco Corona for Walnut.

Contaminants and safety

Ensuring food safety, human health and environmental protection is vital to ensure wider acceptance of recycled fertilisers, so it is important to assess the various risks associated with their use.

Organic contaminants in recycled fertilisers were all below the EU Fertilising Products Regulation limits

Studied recycled fertilisers did not pose a risk of enriching antibiotic resistance in the soil.

Recycling technologies can reduce contaminants.

Harmonised methodologies are needed for the assessment of emerging contaminants.

Agronomic efficiency/product quality

Recycled fertilisers show different levels of agronomic effectiveness. Some are as effective as mineral N fertilisers

Atmospheric ammonia losses in application of recycled nitrogen fertilisers vary considerably and can be higher than with mineral fertilisers, but can be very considerably reduced by soil incorporation.

Path to market

Fertilisers are a significant cost for many farmers, often their highest operating cost.

Variability of inputs in a circular economy leads to uncertainty in production costs for recycled fertilisers. The sales price is however dependent on market mineral fertiliser nutrient prices, except for high quality specialist application products.

Farmers want reliable, consistent supply.

Production scale and transport are a challenge for recycled fertilisers.

The are regional variabilities in needs and preferences for recycled fertilisers, as for mineral fertilisers.

Differences in scale between the production of recycled fertilisers and mineral fertilisers.

There is today no database on recycled fertilisers, nor indeed on organic fertilisers, meaning that the market is case-by-case.

Regulatory barriers

Inconsistent regulations between European (EU FPR) and national fertilisers legislations, in particular for allowed input materials and labelling requirements.

Clear and recognised (CEN standardised) definitions of "bio-based" and "recycled" nutrients are needed. As are clearer definition of agro-industrial and industrial wastewater and sludge

Nitrates Directive limitations on manure in a processed form are an obstacle to recycled nitrogen fertilisers.

End-of-Waste is a problem for fertilisers sold under national regulations (whereas the EU FPR CE-mark confers End-of-Waste status)

The EU Animal By-Products Regulations limits processing methods for manure. This should be widened to other methods which are already tried and tested in different Member States.

EU policies should incite farmers to use recycled fertilisers, given their nutrient circularity benefits and better environmental performance.

Future research and innovation needs

Nutrient recycling technology R&D to address: variability in the feedstock composition, improving product agronomic quality, ensuring contaminant removal, scale-up (cost-effective solutions for different treatment capacities), reducing energy and chemicals consumption.

Sustainability assessment: methodological gaps, need for more information on long-term effects and on field application, developing LCA data for the wide variety of recycled fertilisers (input materials, processes) and for different scale.

Site visit: Bio Sterco Farm manure processing

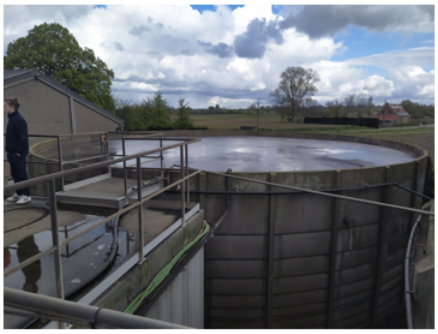
NERM participants were able to visit the Bio Sterco Farm manure processing installations, Hooglede, Belgium, a participant in the Fertimanure project. The farm itself has nearly 5000 pigs. The manure treatment installations were set up in 2008 to treat the farm's own pig manure and are also funded by a gate fee for treating manure from other nearby farms, and today have a capacity to treat 45 000 t/y wet weight of manure. Lorries delivering manure leave filled with treated manure (low in nitrogen, so can be spread to fields). The treatment process chain is:

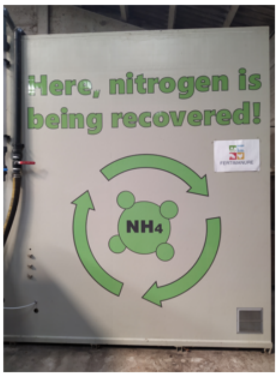
1. centrifuge solid-liquid separation. Solid fraction goes to composting
2. part of the liquid fraction goes to ammonia stripping – scrubbing (Detricon process). Sulphuric acid is used for scrubbing, generating ammonium sulphate solution. Nitric acid has been used on this installation in the mast, creating ammonium nitrate.
3. liquid fraction (partially treated by stripping-scrubbing) goes to biological nitrification – denitrification, enhanced by oxygen injection.
4. treated liquor then goes to a large surface holding pond, chemical phosphorus precipitation if needed and then a 1,2 ha artificial wetland, before discharge to a stream. The holding pond ensures that the artificial wetland and the receiving stream can accept the discharge, depending on weather.

The Detricon ammonia stripping and recovery process (see SCOPE Newsletter n°149) does not require caustic chemical dosing. Ammonia is driven off into air by temperature (55°C) and enhanced by driving off CO_2 which increases the pH. The ammonia is transported by internally recirculated air flow and is then recovered by passing this air through the acid scrubber, after which it is reused thus eliminating an emission point. If sulphuric acid is used, ammonium sulphate up to c. 8% N w/w can be obtained. This is used locally as a fertiliser.

Explanatory video


Here, nitrogen is
being recovered!
FERTIMANURE




being recovered!
NH4