

PROJECT - RESEARCH AND INNOVATION

Closing waste water cycles for nutrient recovery

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 ONGOING | 2021 - 2026

 Spain, Italy, Belgium, Greece, Hungary, France

Context

The EU-funded WALNUT project will develop concepts and technological solutions to re-design the value and supply chains of nutrients from wastewater and brine. Researchers will tailor five pilot plants for nutrient recovery from wastewater and brine by combining multiple process units selected from a pool of technologies. The pilot plants will target highly efficient nutrient recovery and minimisation of environmental impacts, in addition to showcasing the full potential of wastewater and brine as a raw material for biofertiliser production. WALNUT therefore aims to create and disseminate a new paradigm shift from wastewater and brine treatment to resource recovery, which is essential for the EU to sustain industries and societies for the long term.

Objectives

WALNUT aims to develop the necessary concepts and technological solutions to re-design the value and supply chains of nutrients from waste water and brine, while staying in line with the objectives of the EIP on Agrifood and Raw Materials. A wide range of technological processes (physico-chemical, electro-chemical, biological) will be validated in labscale. 5 pilot plants for the nutrient recovery from waste water and brine will be tailored by combining multiple process units selected from the pool of technologies studied at lab scale and from partners previous relevant projects. The pilot plants will target not only high nutrient recovery efficiencies but also minimisation of environmental impacts.

Thorough quality assessment of the resulting products shall be made in order to establish a concrete view of their market positioning. The multicriteria evaluation of pilot plants performance as well as the use of LCA, LCC, sLCA, will lead to the efficient validation of the technologies reaching TRL 4-6. Also, the project aims to create and disseminate a new paradigm shift from waste water and brine treatment to resource recovery which is essential for EU to sustain industries and societies for the long-term. Public and scientific awareness of the project will be raised and all relevant stakeholders will be informed about the possible pathways for waste water and brine valorisation. The project will be implemented by a consortium composed of partners with varied and complimentary experience, qualifications, skills and perspectives including research institutes, technology providers and industrial partners involved in waste water management. The involvement of representatives covering the whole supply chain of waste water, brine and nutrient recovery will provide an excellent opportunity to showcase the full potential of waste water and brine as a raw material for biofertilisers production.

Activities

The project has developed a series of publications, aim to showcase and share project's results, updates and achievements. The list includes:

- Factsheets on project's pilots
- Best Practice Book
- White Paper
- Pageflow

Project details

Main funding source

Horizon Europe (EU Research and Innovation Programme)

Type of Horizon project

Other Horizon funded projects

Project acronym

WaINUT

[CORDIS Fact sheet](#) 

Project contribution to CAP specific objectives

- SO2. Increasing competitiveness: the role of productivity
- SO3. Farmer position in value chains
- SO4. Agriculture and climate mitigation
- SO6. Biodiversity and farmed landscapes
- SO9. Health, Food & Antimicrobial Resistance

Project contribution to EU Strategies

- Reducing the overall use and risk of chemical pesticides and/or use of more hazardous pesticides
- Fostering organic farming and/or organic aquaculture, with the aim of increased uptake
- Reducing nutrient losses and the use of fertilisers, while maintaining soil fertility

EUR 947 250.00

Total budget

Total contributions including EU funding.

EUR 947 250.00

EU contribution

Any type of EU funding.

Project keyword(s)

Circular economy, incl. waste, by-products and residues

Plant nutrients

Water

54 Practice Abstracts

Comparison of agronomic efficacy and environmental risks of digested sewage sludge on rapeseed, based on our trials and on modelling

The Chambres of Agriculture conducted two experiments on rapeseed, set up on a plot in Saint-Laurent-de-la-Prée, France, which demonstrated the fertilising capacity of locally sourced digested sewage sludge and food bio-waste used as a reference for comparison with the organic materials proposed in WalNUT.

Each trial was then simulated using the STICS modelling engine (source: INRAe). Each simulation reproduced a fertilisation schedule corresponding to one of the trial conditions. The aim was to use the simulation results to explain and better understand the experimental results.

These simulations provide us with assessments of the various nitrogen flows involved in crop development, in particular

- Mineralised nitrogen inputs from soil organic matter (OM) and inputs from the organic materials tested;
- Nitrogen losses through leaching or volatilisation.

Comparative analysis of the experimental results and simulations shows that the absolute values of these simulations should be treated with caution, as we sometimes observe significant discrepancies. However, it is still interesting to compare the orders of magnitude.

In particular, the rates of nitrogen available through mineralisation were:

- 30% to 45% for digested lagoon sludge, depending on the date of application
- around 2% for food bio-waste

These values for available nitrogen proposed by the simulations are very close to the estimates obtained from the agronomic characterisation of the materials.

In terms of environmental impact, leaching losses vary from one system to another, from 0 to almost 20 kg N/ha due to differences in initial soil nitrogen stocks. Leaching losses are found to be fairly similar regardless of the fertilisation method used. Simulated losses for the farmer's practices remain higher.

Volatilisation losses are estimated to be higher, from 15 to 30 kg N/ha, for mineral inputs than for organic inputs, less than 5 kg N/ha. The farmer's practices have a slightly greater impact.

Geographical Location

 France

Comparison of agronomic efficacy and environmental risks of algae powder and digested sewage sludge on durum wheat, based on our trials and on modelling

The Chambres of Agriculture conducted two experiments on durum wheat, set up on two plots in Saint-Laurent-de-la-Prée, France, which demonstrated the fertilising capacity of an algae powder produced by

the project, compared to a local sewage sludge digestate and food bio-waste.

Each experiment was simulated using the STICS modeling engine (source: INRAe). Each simulation reproduced a fertilisation schedule corresponding to one of the experimental conditions. The aim was to use the simulation results to provide explanations that would help us better understand the experimental results.

These simulations provide us with assessments of the various nitrogen flows involved in crop development, in particular

- The mineralised nitrogen inputs from soil organic matter (OM) and the inputs from the organic materials tested;
- Nitrogen losses through leaching or volatilisation.

Comparative analysis of the experimental results and simulations shows us that the absolute values of these simulations should be treated with caution, as we sometimes observe significant discrepancies. However, it is still interesting to compare the orders of magnitude.

In particular, the rates of nitrogen available through mineralisation were:

- more than 40% for seaweed powder
- nearly 30% for digested lagoon sludge
- 0% for food bio-waste

These values for available nitrogen proposed by the simulations are very close to the estimates obtained from the agronomic characterisations of the materials.

In terms of environmental impacts, leaching losses are estimated to be less than 5 kg N/ha up to 20 kg N/ha, depending on the nature of the soil. It can be seen that leaching losses are fairly similar regardless of the fertilisation method. Simulated losses for the farmer's practices remain higher.

Volatilisation losses are estimated to be higher, from 15 to 30 kg N/ha, for mineral inputs than for organic inputs, less than 5 kg N/ha. The farmer's practices have a slightly greater impact.

Geographical Location

 France

Quality requirements of the bio-based fertilisers produced within the WaLNUT project

Within the WaLNUT project, a comprehensive quality assessment was carried out on ten bio-based fertilisers (BBFs) produced at five pilot sites: ammonium sulphate, N-loaded zeolite, a blend of virgin zeolite and ammonium sulphate, regeneration water, Smart BBF, BIO-NPK-C compound fertiliser, algae powder, recovered salts from brine (KCl and $Mg(OH)_2$), and $CaCO_3$.

The evaluation focused on nutrient composition and key quality assurance parameters, with particular attention to trace metals and persistent organic pollutants, pharmaceuticals, and microbial

contaminants. Compliance was assessed against the EU Fertilising Products Regulation 2019/1009 (FPR).

Results indicate that three BBFs (ammonium sulphate, the blend of ammonium sulphate and virgin zeolite, and algae powder) are expected to comply with the current FPR requirements. The BIO-NPK-C compound shows potential for compliance; however, due to its complex formulation with multiple added components, further component-level assessment is required. CaCO_3 may be eligible under the FPR, provided its purity exceeds 95%, and pollutant concentrations remain below regulatory thresholds. N-loaded zeolite, KCl and Mg(OH)_2 salts would require either a new Component Material Category (CMC) or formal inclusion under an existing category. Smart BBF does not comply in its current form, while the regeneration effluent is more closely aligned with the Water Reuse Regulation (EU) 2020/741.

These findings support farmers, advisors, and policymakers by clarifying regulatory pathways and quality requirements for bio-based fertilisers, contributing to safer nutrient recycling and improved market uptake.

Geographical Location

 Belgium

Farmer-oriented manual for innovative fertiliser application

The WalNUT project has developed a Farmer Manual providing practical guidance on the characteristics, correct use, and agronomic performance of bio-based fertilisers (BBFs) tested within the project. The manual supports farmers and advisors in integrating these products into nutrient management plans and improving fertiliser efficiency.

The manual covers the following WalNUT BBFs: ammonium sulphate, nitrogen-loaded zeolite, algae powder, BIO-NPK-C compound fertiliser, Smart BBF, and recovered salts from brine. For each product, farmer-oriented information is provided on composition and characteristics, storage and handling, recommended application methods and rates, agronomic and environmental performance, legal considerations, and options for further optimisation.

Results show that WalNUT BBFs have strong potential to partially or fully replace conventional mineral fertilisers. They contribute to improved nutrient recycling and more sustainable soil management. However, further product optimisation is recommended to enhance nutrient use efficiency, ease of handling, and farmer acceptance. Due to variability in nutrient content, regular laboratory analysis is necessary to ensure accurate dosing and safe application. Application strategies must consider soil properties, crop nutrient requirements, and environmental risks.

The manual is specifically designed for farmers and advisors and will be available in nine European languages to support wide uptake. Overall, WalNUT BBFs represent a promising solution for sustainable nutrient management and long-term soil health, while regulatory frameworks continue to evolve.

Geographical Location

 Belgium

Two-year field evaluation of recovered ammonium sulphate alone and blended with virgin zeolite

Belgian field trials evaluated the nitrogen (N) fertiliser value of two bio-based fertilisers (BBFs) produced at the pilot plant of AQUAFIN:

- Ammonium sulphate (AS), recovered from digested sewage sludge via ammonia stripping and scrubbing
- A blend of AS with virgin zeolite (AS+VZ), developed to simulate N-saturated zeolite from high-rate activated sludge (HRAS) wastewater treatment.

Over two growing seasons, AS and AS+VZ were compared with calcium ammonium nitrate (CAN), farmer practice (cattle manure + CAN), and an unfertilised control. Performance was assessed through crop yield, N uptake, nitrogen fertiliser replacement value (NFRV), soil nutrient status, and nitrate residues.

Both BBFs delivered crop yields and nitrate leaching risks comparable to mineral fertiliser. Results indicate that 80–92% of mineral N can be replaced by AS and 65–90% by the AS+VZ blend. These findings highlight the strong potential of recovered ammonium sulphate as a circular alternative to synthetic N fertilisers.

No significant differences were found between AS and AS+VZ, suggesting that under the tested conditions, zeolite addition did not provide additional agronomic or environmental benefits.

Geographical Location

 Belgium

The environmental sustainability assessment of ammonium recovery from wastewater using HRAS and Ion Exchange Technology

Municipal wastewater treatment plants remove nutrients such as carbon, nitrogen (N), and phosphorus (P) to avoid pollution of surface water streams. Conventional activated sludge (CAS) systems are usually used to remove nitrogen but require high aeration energy. New treatment concepts aim to increase energy efficiency and enable recovery instead of the removal of nutrients, contributing to circularity. A pilot system combining High-Rate Activated Sludge (HRAS) with an ion exchange (IEX) unit was tested by a Belgian waste water treatment company and the University of Ghent. Minerals used in the ion exchange unit could recover ammonium and be used as an alternative bio-based fertilizer.

The Life Cycle Assessment (LCA) results of this system showed that, under current pilot conditions, the IEX process caused considerably higher environmental impacts than the conventional wastewater treatment system. The main hotspot (>90% of impacts) was the production and large quantity required of synthetic zeolite adsorbent due to its low ammonium adsorption capacity.

Switching to higher-capacity adsorbents, such as resin, reduced impacts by more than 90% compared to the initial design, but overall impacts remained higher than the conventional reference system. Other possibilities for optimization include using the IEX unit on a wastewater stream with a higher N content, or testing waste-based recycled adsorbents, such as ones made of fly ash or coffee grounds, to improve

the impacts of adsorbent production. Overall. While HRAS shows energy-saving potential, ammonium recovery via IEX requires further optimisation to become environmentally competitive.

Geographical Location

 Denmark

Zero-liquid discharge systems could potentially offer an answer to direct brine discharge

Seawater desalination produces large volumes of concentrated brine that are commonly discharged into surface waters, potentially affecting marine ecosystems and wasting valuable minerals. At the same time, brine contains recoverable resources such as magnesium, potassium, and salts that could be recovered. Treatment solutions must be evaluated from a system perspective to ensure that the circularity benefits of material recovery don't result in more serious environmental damage elsewhere.

An ex-ante life cycle assessment study was carried out on the lab-scale setup of a multi-stage Zero Liquid Discharge (ZLD) system developed by the National Technical University of Athens as an alternative to direct brine discharge. The system combines precipitation, nanofiltration, multi-effect distillation (MED), crystallization, and flotation to recover magnesium hydroxide, sodium sulphate, sodium chloride, potassium chloride, calcium carbonate, and high-purity water.

Electricity demand, especially in the MED evaporation stage, and chemical use were identified as the main environmental hotspots. Replacing NaOH with $\text{Ca}(\text{OH})_2$ reduced climate impacts. The addition of a supplementary calcination step may result in better market acceptance of the MgO and, therefore, lower environmental impact. The recovery of $\text{Mg}(\text{OH})_2$, Na_2SO_4 , and KCl generated the highest environmental benefits, while CaCO_3 and deionized water contributed marginally. Supplying the system with renewable electricity could reduce climate change impacts by up to 84%.

Practice recommendations include prioritising energy-efficient design for the evaporation process, optimizing chemical inputs (especially NaOH and Na_2CO_3), and substitution of NaOH with $\text{Ca}(\text{OH})_2$.

Geographical Location

 Denmark, Greece

Environmental assessment of ion-exchange and membrane contactors technology for nitrogen recovery from waste water

The recovery of nutrients in wastewater treatment plants (WWTPs) aims to reduce pollutant emissions and produce fertilizers for agricultural use, though it can generate environmental impacts that must be analyzed in Life Cycle Assessment (LCA) studies. This LCA assesses the potential environmental impacts of fertilizer production using ion-exchange and membrane contactors (IEX-MC) technology at pilot scale for nitrogen recovery (as ammonium sulfate – AS) at the Ourense WWTP, located in Galicia, Spain, and operated by Cetaqua. The LCA compares AS production via IEX-MC technology with a reference scenario: conventional AS production. Impacts were calculated for the production of 1 kg of nitrogen (as AS), using the Environmental Footprint (EF 3.1) method.

The main impacts of IEX-MC are associated with the excessive use of sodium hydroxide and sulfuric acid. The IEX-MC scenario generally performs worse than the reference scenario, except in three categories: Freshwater Ecotoxicity, Marine Eutrophication, and Terrestrial Eutrophication. In these categories, the largest contributor to IEX-MC impact is the excessive use of sodium hydroxide, which is currently nearly three times the theoretical requirement. It is worth noting that integrating the technology IEX-MC into the WWTP as a combined system could reduce N₂O emissions and energy consumption. However, it is unlikely that these reductions would significantly change the results.

Environmental assessment of a bio-based fertiliser production based on animal bone char and dairy waste water

This study assessed the environmental performance of a pilot technology that turns dairy wastewater (acid whey) and animal bones into a bio-based fertiliser (BBF). The process, developed by 3R-BioPhosphate Ltd. in Hungary, uses liquid and solid-state fermentation and bone char from pyrolysis to recover nutrients. An environmental Life Cycle Assessment (LCA) compared this BBF, produced on a pilot scale, with conventional mineral fertilisers (assuming a total NPK substitution). When cow bones are treated as a “burden-free” recyclable byproduct, the new fertiliser shows lower environmental impacts in 13 out of 16 Environmental Footprint (EF) indicators. The main contributors to its impacts are the pyrolysis of bones (mainly NO_x gas emissions from bio-oil combustion) and the use of tomato pulp and electricity (Hungary mix, largely based on coal). However, when part of the environmental burdens of cattle rearing are assigned to the bones, the new BBF performs better in only 6 of the 16 environmental indicators. These results show how we account for the burdens of cow bones greatly influences the outcome, which depends on the current and future market applications of cow bones, as well as the LCA approach and rules adopted. Further studies using a broader LCA approach could better capture the potential benefits of replacing current dairy wastewater treatments.

Geographical Location

 Portugal, Hungary

Hybrid Microalgae Cultivation System: An Efficient and Circular Solution for Waste Water Treatment and Nutrient Recovery

The study conducted at the laboratory level on microalgae cultivation focuses on its use for nutrient recovery from waste water. This approach employs two main cultivation methods: photoautotrophic and heterotrophic. Microalgae were grown under controlled conditions to maximise the absorption of nutrients such as nitrogen and phosphorus, which are abundant in industrial waste water.

Photoautotrophic cultivation depends on light for photosynthesis, while heterotrophic cultivation does not require light and uses dissolved organic carbon as an energy source. This latter method demonstrated several advantages over the photoautotrophic method, such as higher growth rates and biomass density.

The experimental tests carried out evaluated the effectiveness of different species and cultivation conditions in pollutant removal, nutrient recovery, and biomass production. The results showed that microalgae are not only effective in cleaning waste water, recovering a high proportion of nitrogen and phosphorus, but also produce a significant amount of biomass. The dry product of this biomass can later be used as a bio-based fertiliser.

Additionally, various operational parameters were investigated to optimise the cultivation process, such as inoculum concentration, temperature, and airflow, to improve the economic and technical viability of the process on a larger scale.

The progress achieved indicates that microalgae cultivation not only offers a sustainable solution for waste water treatment but also contributes to the circular economy by turning waste into valuable resources. This technology has the potential to be a viable alternative for large-scale nutrient recovery, standing out for its efficiency and environmental benefits.

Geographical Location

 Spain

BIO-NPK-C fertilizer boosts maize and tomato yields under commercial field and greenhouse conditions

Field and greenhouse trials in 2024–2025 confirmed that BIO-NPK-C bio-based fertiliser is highly effective for maize and tomato. It generally outperformed conventional mineral fertilisers, especially at higher application rates.

For silage maize in 2025, untreated plots produced 4.5 t/ha, while the standard mineral fertiliser (Genezis NPK 8:20:30 at 300 kg/ha) reached 5.7 t/ha. BIO-NPK-C at 800 kg/ha achieved 7.6 t/ha, showing clear yield benefits. Grain moisture was similar across treatments, so higher yields were due to better fertilisation.

In 2024 open-field tomato trials, increasing phosphorus doses in mineral fertiliser steadily improved yields, from 6.23 t/ha in untreated plots up to 10.4 t/ha at the highest mineral dose (100 kg P/ha). BIO-NPK-C treatments performed even better, with the highest application (100 kg P/ha) nearly doubling the yield to 21.97 t/ha, demonstrating a strong dose-response effect.

In 2025 greenhouse tomato trials, BIO-NPK-C again showed its superior potential. While untreated plants produced around 82 t/ha, and mineral fertiliser at high dose (100 kg P/ha) reached 114 t/ha, BIO-NPK-C at 50 kg P/ha delivered 135 t/ha, and the highest dose reached (100 kg P/ha) 149 t/ha. This means that under controlled, favourable conditions, BIO-NPK-C almost doubled the output compared to untreated plants and clearly outperformed conventional mineral fertilisation, enhancing both vegetative growth and fruit production.

Overall, BIO-NPK-C is a reliable, high-performing fertiliser for both maize and tomato. Its benefits are strongest when environmental stress is minimised, making it a practical, sustainable choice for farmers aiming for higher yields, better crop quality, and more efficient nutrient management.

Geographical Location

 Hungary

Circular bio-based fertilizer production from dairy and food industry by-product streams: industrially scalable BIO-NPK-C solution for EU agriculture

Pilot Plant 3 demonstrates a new, circular way to turn dairy and food industry by-products into high-value bio-based fertilizers and clean irrigation water. The system combines liquid and solid fermentation with ABC-BioPhosphate adsorption technology to transform acidic whey and industrial wastewater into safe, effective BIO-NPK-C fertilisers, while also producing surplus green electricity and beneficial microbial biomass.

For farmers, this means access to a competitive, EU-compliant bio-fertilizer that improves soil fertility, supports healthy crop growth, and reduces dependency on conventional mineral fertilizers. BIO-NPK-C products were successfully tested under real farm conditions in Hungary and Italy, proving their practical performance and safety. BIO-NPK-C supports better nutrient use efficiency, improved soil life, and long-term soil health.

BIO-NPK-C offers a cost-effective alternative with strong market potential. A full-scale plant can produce more than 25,000 tonnes per year, create quality rural jobs, and support local agricultural value chains. The technology is designed to be easily scalable and replicable across Europe before 2030.

Environmental benefits include zero-emission, carbon-negative, recovery of nutrients from waste streams and food industrial by-products, reduced water pollution, and the reuse of treated water. Surplus renewable electricity is also generated, improving overall resource efficiency.

BIO-NPK-C fully complies with the EU Fertilising Products Regulation and REACH, ensuring safe and lawful market use. It provides farmers and agri-food actors with a practical, scalable solution that supports the EU Green Deal, circular economy goals, and sustainable agricultural production.

Geographical Location

 Hungary

EU-REACH registration and regulatory compliance certification of the ABC Animal Bone Char-BioPhosphate for safety of BIO-NPK-C compound biofertiliser

Regulation (EC) No 1907/2006 on the Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH) is the main EU legislation protecting human health and the environment from chemical risks. Animal Bone Char – BioPhosphate (tricalcium diphosphate) used in BIO-NPK biofertilisers has been fully assessed and registered under REACH for the >1,000 tonnes per year band. This registration provides formal EU authority recognition and confirms compliance with strict requirements for chemical safety, environmental protection, and lawful market placement.

The REACH process was based on comprehensive substance identification, including chemical composition, main constituents, and impurities, supported by accredited analytical data. Substance sameness was confirmed within a joint submission. As a preparatory step, the substance had previously been assessed under the 1–10 tonnes per year tonnage band, enabling structured data sharing and a smooth transition to full industrial-scale registration.

Access to a comprehensive Chemical Safety Report (CSR) covering human health hazards, environmental effects, and fertiliser-relevant exposure scenarios was obtained through data sharing, avoiding unnecessary testing and ensuring compliance with REACH obligations. The registration

dossier was prepared in IUCLID 6, an official software tool, and submitted via REACH-IT, the official online submission platform, where it successfully passed the completeness check. For farmers and end-users, this REACH registration confirms that BIO-NPK containing BioPhosphate complies with EU chemical safety legislation and can be used reliably as recycled nutrient products, supporting circular fertiliser value chains in the EU.

Geographical Location

 Hungary

Creation of a collaborative BBFs network - WalNUT White Paper recommendation

One of the strongest barriers slowing down the adoption of biobased fertilisers (BBFs) is the fragmentation of the value chain. Many actors (from technology developers and treatment plants to farmers, advisors, manufacturers, and policymakers) work in isolation, missing opportunities for collaboration and shared solutions. This leads to duplicated efforts, unclear business models, and limited trust.

The last WalNUT White Paper recommendation is to create a Collaborative BBFs Network, combining regional hubs with a central digital platform to connect all stakeholders. Regional hubs would act as meeting points where farmers, cooperatives, companies, and researchers can exchange knowledge, plan joint projects, and test practical solutions. Activities could include stakeholder mapping, shared logistics trials, innovation workshops, and annual circularity forums. Digital tools such as interactive mapping, matchmaking, contract templates, and a shared library of technical results would further support cooperation. This network would help farmers access reliable partners, proven products, and practical advice, while enabling producers to better understand market needs and scale up BBFs through stable, long-term relationships. Public authorities could also use the hubs to coordinate regional strategies and support local circular initiatives. With stronger connections along the value chain, BBFs can reach the market faster, reduce risks for users, and contribute to a more resilient, circular fertilisation system across Europe.

Geographical Location

 Italy

Enhance social acceptance and technical capacity for BBFs - WalNUT White Paper recommendation

Limited social acceptance and low technical knowledge remain major barriers to the adoption of biobased fertilisers (BBFs). Many farmers are still unsure about what BBFs are, how they work, and the real benefits they can bring to soil, yields, and farm profitability. This lack of awareness reduces trust and prevents BBFs from entering mainstream fertilisation practices.

To address this challenge, the sixth WalNUT White Paper recommendation is to launch a multi-level European programme to raise awareness, build technical capacity, and strengthen community engagement around BBFs. Practical actions include producing easy-to-understand videos, infographics, and short guides based on real farm results; organising demonstration days and field visits led by experienced users; and integrating BBF modules into existing advisory and CAP training systems. Certified training for technicians and peer-learning networks in cooperatives can further support

hands-on learning. Communication campaigns, BBF Days at agricultural fairs, and user-friendly digital tools can help farmers access reliable information adapted to local conditions.

This approach encourages farmers to see BBFs not as complex innovations but as practical, profitable solutions that complement their experience. With better knowledge and trusted examples, farmers can make informed decisions, reduce fertiliser costs, protect soil health, and confidently adopt BBFs as part of a more circular and resilient farming system.

Geographical Location

 Italy

Support long-term agronomic validation - WalNUT White Paper recommendation

Although many studies show that biobased fertilisers (BBFs) can improve soil fertility, nutrient efficiency, and yields, most trials only run for one or two years. This short duration limits the ability to measure long-term effects on soil health, emissions, and productivity. Trials are often carried out in specific regions or under controlled conditions, so farmers cannot easily compare results across Europe's diverse soils and climates. As a result, practical evidence remains fragmented, and farmers, advisers, and public buyers lack the confidence needed to adopt BBFs widely.

The fifth WalNUT White Paper recommendation is to create a coordinated system for long-term, full-scale agronomic validation. This includes multi-year trials funded through Horizon Europe and the CAP, and a European network of demonstration plots that test BBFs in different farming systems using harmonised protocols. Integrating BBFs into major research programmes and creating open, accessible datasets would give farmers clear, comparable information on performance, costs, and environmental benefits. Demonstration farms would allow producers, advisors, and cooperatives to see BBFs in real conditions and share practical experiences. This coordinated effort would generate trustworthy evidence, accelerate technology transfer, and help farmers choose BBFs that improve productivity while supporting soil regeneration and reducing emissions. Over time, this system would build a strong scientific foundation for policies, subsidies, and commercial uptake across the EU.

Geographical Location

 Italy

Ensuring the circularity of BBFs - WalNUT White Paper recommendation

Although biobased fertilisers (BBFs) are promoted as circular solutions, many are still produced and used linearly: nutrients are recovered, processed, transported long distances, and applied without considering local agronomic needs. Without tools to measure circularity, BBFs risk repeating the same patterns as synthetic fertilisers, only with a different source.

The fourth WalNUT White Paper recommendation is to create a standardised EU system to assess and monitor BBF circularity, using existing life-cycle and circularity indicators. This system would track nutrient flow from the original waste stream to the field, measure nutrient use efficiency, emissions, and soil benefits, and combine technical and economic indicators. A verified circularity label could help farmers and public buyers identify products that truly regenerate soils and reduce losses. Producers could use digital tools to calculate their circularity score and highlight environmental advantages when

marketing their products. Once integrated into platforms such as the future BBFs Observatory, farmers could easily compare products and choose those offering better nutrient efficiency and lower transport emissions. By applying these indicators across the value chain, the EU could cut unnecessary logistics emissions, improve market transparency, and ensure BBFs genuinely support Green Deal goals. This approach would strengthen trust, avoid greenwashing, and help farmers select high-performing fertilisers that close nutrient cycles and protect long-term soil health.

Geographical Location

 Italy

Economic incentives for BBFs - WalNUT White Paper recommendation

Many studies show that biobased fertilisers (BBFs) often appear more expensive than synthetic fertilisers, but real production costs vary widely depending on feedstock, technology, scale, and location. This means that simple statements such as “BBFs cost more” are misleading. More accurate EU-wide and case-specific techno-economic analyses are needed to identify when BBFs can be competitive and how support measures can close the cost gap. Fertiliser expenses already represent up to 12% of arable farmers’ costs, and future geopolitical uncertainty may increase prices further.

To ensure farmers can adopt BBFs without risking profitability, the third WalNUT White Paper recommendation is to introduce targeted economic incentives such as subsidies, VAT reductions, carbon credits, and green public procurement rules. These tools can reward nutrient recycling, help equalise prices with synthetic products, and make BBF use more attractive. Subsidies linked to recovered nutrients, tax breaks for fertiliser companies incorporating BBFs, and certified carbon credits for regenerative practices could provide additional income streams for farmers and producers. Public tenders could also prioritise fertilisers containing a minimum share of recycled nutrients. By coordinating actions across CAP, taxation, carbon certification, and procurement, the EU can remove key economic barriers and speed up BBF market uptake. If implemented, these measures could reduce BBF costs by 30% by 2030 and stimulate large-scale adoption across Europe.

Geographical Location

 Italy

European BBFs observatory - WalNUT White Paper recommendation

The lack of a European database on biobased fertilisers (BBFs) makes it difficult for farmers, advisers, companies, and authorities to make informed decisions. Today, information on BBF availability, nutrient content, prices, certification, and field performance is scattered or missing, creating market fragmentation and slowing adoption.

The second recommendation of the WalNUT White Paper suggests the creation of a European BBFs Observatory, a single digital platform gathering reliable and comparable data on BBFs. This tool would help end-users quickly understand product quality, costs, and suitable uses, reducing risks when choosing new fertilisers. Building this Observatory is feasible by expanding existing EU infrastructures, such as the EU Fertiliser Market Observatory or the Agri-Food Data Portal, keeping costs low and ensuring fast implementation. Farmers and advisers would benefit from easy access to updated product information, helping them choose cost-effective and high-quality recovered fertilisers. Policymakers

would gain evidence to design better incentives and monitor progress on nutrient recycling targets. Producers would increase transparency and trust by sharing verified data. If aligned with the future official definition of BBFs, the Observatory could be operational by 2028 and become a central hub for knowledge sharing, technical validation, and collaboration across Europe, accelerating the transition to a more circular nutrient economy.

Geographical Location

 Italy

Official definition of BBFs - WALNUT White Paper recommendation

Biobased fertilisers (BBFs) still lack an official EU definition, creating uncertainty for manufacturers and limiting their market access. Regulation (EU) 2019/1009 sets the rules for EU fertilisers, but without a clear definition of BBFs, it remains difficult to harmonise standards, ensure quality, and support their use in farming.

The WALNUT White Paper recommendation introduces a consensus-based definition of BBFs into the Regulation, building on previous EU projects. The proposed definition describes BBFs as fertilisers derived from biomass using nutrient recovery and reuse technologies (excluding composting and anaerobic digestion) to concentrate nutrients and improve their efficiency. A clear legal definition would help farmers access reliable recovered nutrient products with verified quality, offering more sustainable alternatives and potentially reducing fertiliser costs. To achieve this, an inter-project group (WALNUT, FERTIMANURE, LEX4BIO, Sea2Land, RUSTICA, plus ESPP and standardisation bodies) should finalise a common definition and submit it to the European Commission.

A harmonised definition would support market uptake, guide certification, and ensure consistent implementation across Member States.

Geographical Location

 Italy

Environmental Life Cycle Assessment of Ammonia Stripping-Scrubbing Technology for Nitrogen Recovery from Wastewater

Nutrient recovery from wastewater treatment plants (WWTPs) aims to reduce pollutant emissions and produce fertilizers for agriculture. However, it can also cause environmental impacts that must be identified through life cycle assessment (LCA) studies. This LCA assesses the potential environmental impacts of an ammonia stripping scrubbing (SS) pilot technology for nitrogen recovery (as ammonium sulfate – AS) integrated into two WWTPs: one in Leuven and one in Antwerp, both operated by Aquafin Inc., in Belgium.

The LCA compares an integrated SS-WWTP system to a reference scenario comprising a conventional WWTP and conventional AS production. The Leuven WWTP includes a SHARON (Single reactor system for High Ammonium Removal Over Nitrite) unit for nitrogen removal; therefore, the SS technology replaces the SHARON unit. The impacts were accounted for using the Environmental Footprint (EF 3.1) method for the production of 1 kg of nitrogen (as AS) and the corresponding amounts of treated urban wastewater and external sludge, which differ between Leuven and Antwerp. The main

impacts of SS are associated with the addition of sulfuric acid and sodium hydroxide. Overall, the integrated WWTP-SS system performs better than the reference scenario in both WWTPs. In Leuven, the introduction of the SS reduces climate change impact by nearly three times, as it prevents nitrous oxide (N₂O) emissions from the SHARON unit. Therefore, from an environmental perspective, nitrogen recovery via SS technology has demonstrated advantages in both WWTPs. However, for this to be effective, the recovered fertilizer must actually be used to replace conventional AS.

Geographical Location

 Portugal, Belgium

Nutrient Security of Supply in the EU and Nutrient Recovery from Wastewater

Phosphorus (P) and nitrogen (N) are essential nutrients for agricultural production, but their availability in the European Union faces increasing risks due to dependence on imports and resource losses. Ensuring their sustainable supply is crucial for food security and environmental protection. Within the scope of the WalNUT project, this study assesses the nutrient supply security in the European Union and examines how the recovery of P and N from wastewater can strengthen it. Four technologies were considered: ammonia stripping and scrubbing, struvite crystallization, and the application of digested sludge and sludge ash in agricultural soils.

A new indicator — Nutrient Supply Security (NSS) — based on the “Psecurity” index (El Wali et al., 2021), is proposed. The NSS accounts for nutrient availability relative to usage needs, considering recovery efficiency, biofertilizer quality, and the potential to replace conventional fertilizers. The results show that the EU produces little phosphorus (NSS: 13%; only Finland has significant production) and remains heavily dependent on imports. For nitrogen, the NSS is high (85%), although it is negligible in countries such as Portugal and Austria. Phosphorus recovery can increase supply security by up to 19% and nitrogen by around 3%, with notable gains in countries such as the Netherlands and Malta. Part of the nitrogen is lost to the atmosphere (up to 60%) or through effluent (14%), while some phosphorus in sludge and ash is not readily available to plants. Despite its modest impact on supply security, nutrient recovery brings social and environmental benefits, such as job creation and pollution reduction, warranting further research.

Geographical Location

 Portugal

Value from waste: innovative recovery of ammonium salts

In the literature, a business model describes the value logic of an organisation in terms of how it creates and captures customer value, being concisely represented by an interrelated set of elements that address the customer, value proposition, organisational architecture, and economic dimensions.

As the demand for sustainable agricultural practices increases, smart bio-based fertilisers (BBFs) based on wastewater-recovered nutrients technologies are emerging as a high-quality alternative to traditional chemical fertilisers. These BBFs, composed of ammonium sulphate, struvite, and plant growth-promoting bacteria (PGPBs), offer a rich source of **nitrogen** (N), **phosphorus** (P), and **sulfur** (S), while also being tailored to meet specific soil and crop needs.

Furthermore, the innovative technology behind these BBFs not only enables circular nutrient recovery but also generates new income streams from wastewater treatment processes. Aligned with the latest EU regulations and supported by the WaINUT platform, this approach reflects deep knowledge of fertiliser legislation at European, national (Spain), and regional (Galicia) levels.

Finally, by establishing strong stakeholder and customer networks, it fosters job creation and strengthens regional economic resilience, reinforcing the EU's broader goals for sustainability, autonomy, and green innovation.

Geographical Location

 Spain

Brine to bloom: unlocking nutrients from saline waste streams

The business model canvas offers insight into whether a model might be viable in a different context from where it was initially employed. Performs a description of the value that a company offers to one or several segments of customers and the architecture of the firm and its network of partners for creating, marketing, and delivering this value and relationship capital, to generate profitable and sustainable revenue streams.

Due to the high and volatile prices of synthetic fertilisers driven by limited global supply and increasing transportation costs, there is a growing demand for more stable, locally-sourced alternatives. In response, this innovative technology, which combines Multi-Effect Distillation (MED) with a crystallisation process, offers a dual benefit: generating income while treating wastewater.

Moreover, this approach reduces the EU's dependency on third countries for mineral resources, thereby strengthening regional autonomy and economic resilience. In addition, it contributes to solving major environmental challenges, such as eutrophication and water scarcity, by enabling more sustainable nutrient and water use.

Consequently, the technology not only enhances environmental sustainability but also supports the EU's circular economy ambitions and the long-term competitiveness of its agricultural sector.

Geographical Location

 Spain

Additional information

Keywords: Increases nutrient efficiency, Sustainability and self-sufficiency, Business model Canvas

Ferment to fertilise: unlocking nutrient value through innovative fermentation

A **canvas model** is a structured framework used in strategic management and entrepreneurship to depict the core elements of a business model.

It serves as a visual representation that outlines key aspects such as value proposition, customer segments, channels, revenue streams, cost structure, and key activities. This model enables

stakeholders to analyse, communicate, and iterate on the business concept efficiently, fostering strategic decision-making and innovation

For that reason, the core value of this business model delivered by this initiative lies in the circular upcycling of food industry wastewater streams and unexploited biomass, converting them into both financial and non-financial value for all stakeholders across the value chain. By integrating the management of compound biofertilizer and substrate production with green energy recovery, the technology enables on-site applications such as greenhouse cultivation. The resulting BioPhosphate products are designed for agricultural food crop producers, meeting high standards for safety, nutrient density, purity, and supply security. These BIO-NPK-C formulated, bio-based fertilizers offer cost-effective and nutrient-efficient solutions suitable for a wide range of climatic and soil conditions. This approach not only enhances the competitiveness of EU agricultural producers but also contributes to long-term food supply security and autonomy by supporting a robust, sustainable European agri-sector.

Geographical Location

 Spain

Additional information

Keywords: Safe and high-quality fertilisers, Less use of chemical fertilisers, Business model Canvas

Ammonia Loop: capturing value from nitrogen-rich sludge liquors

From now until 2030, the way we obtain water for human necessities is anticipated to shift due to heightened pressure on natural freshwater resources. This pressure is expected to mainly stem from agriculture, driven by rising demands for protein-rich diets and biofuel production, necessitating a substantial increase in agricultural water consumption.

For that reason, we focused on the business model for this innovative wastewater treatment technology, combining HRAS with anaerobic digestion (AD/IE) and ammonia stripping/scrubbing from sludge liquor, which will enable cost-effective nutrient recovery while generating revenue streams. By producing high-quality nitrogen-based bio-based fertilisers (BBFs) such as ammonium-loaded natural adsorbents, ammonium sulphate-loaded zeolites, ammonium-rich irrigation water, and solid-state ammonium sulphate, the system offers multiple marketable outputs.

These recovered products provide a sustainable alternative to chemical fertilisers, significantly reducing environmental impacts, including greenhouse gas emissions such as N_2O from conventional WWTP operations. Supporting the EU's shift toward a circular economy, this solution aligns resource recovery with climate goals and economic resilience.

Geographical Location

 Spain

Green Gold: A sustainable business model for nutrient recovery with microalgae

Currently, the market price of inorganic fertilisers is increasing, and their impurities usually produce damage to the soil ecosystem. Nutrient deficiencies, such as denitrification and leaching in water sources, cause accumulation of nutrients, contributing to acidification and eutrophication of ecosystems.

To know the viability of the technology, business models are one of the most important parts before starting an exploitation plan, which defines the activities to be carried out to enhance the successful exploitation of the project results (in terms of industrial development/creation of the products), and their placement on the market. Hence, after identifying the business opportunities and the full value chain, the next step is the creation of business models using the **Canvas methodology** for the microalgae technology developed as a **KER** of the project.

In this case, the value proposition offered is a sustainable BBF (Bio-Based Fertiliser) based on photoautotrophic and heterotrophic microalgal cultivation technology for wide uses in different sectors and environments, such as agriculture and animal feed.

Moreover, one of the main advantages is the cheaper access to nutrients such as N, P, C, and K, avoiding the use of chemical fertilisers with toxic impurities for the soil and the indirect emissions of their production/transportation.

Geographical Location

 Spain

Green growth: from wastewaters to bio-based fertilizers (White Paper WalNUT Project)

The developed **White Paper** highlights concrete steps needed to make bio-based fertilisers (BBFs) a real alternative for EU agriculture. Current barriers, lack of clear definition, regulatory gaps, fragmented markets, etc., risk slowing their implementation, but in this document, there were targeted actions that can unlock their full potential.

Recommendations include:

- Creating an official EU Observatory to provide farmers with reliable knowledge and market transparency;
- Increasing subsidies and fiscal incentives so BBFs can compete with mineral fertilizers;
- Revising the Fertilising Products Regulation (Regulation (EU) 2019/1009):
- Boosting field trials, advisory services, and demonstration activities to build farmer confidence.

For the end user, these measures mean access to affordable, locally sourced fertilisers that can cut dependence on imports, stabilise costs, and improve soil health. Farmers, cooperatives, and treatment plants can benefit from new business opportunities around nutrient recycling, while contributing to the **EU Green Deal goals**. It is believed that acting now is crucial, and that every year of delay in BBF uptake is a missed chance to recover nutrients, reduce emissions, and strengthen European food security.

BBFs Regulatory framework

Within the WalNUT project, an in-depth regulatory mapping was conducted to assess the European legislative framework affecting the production, certification, and application of bio-based fertilisers (BBFs). The analysis focused on both horizontal and sector-specific regulations relevant to nutrient recovery from wastewater, sludge, and other secondary raw materials. While the adoption of the new EU Fertilising Products Regulation [EU 2019/1009] marks a major step toward harmonized standards,

the study revealed that BBF producers still face regulatory uncertainty, inconsistent national interpretations, and burdensome approval processes, particularly for by-products and waste-derived inputs.

Additionally, the integration of recovered nutrients into the market is hindered by the complexity of End-of-Waste criteria, lack of harmonized contaminant thresholds, and overlapping environmental directives. The [assessment](#)  provides practical guidance for stakeholders on navigating the legal landscape and identifies areas where clearer rules and streamlined procedures could accelerate innovation. For practitioners, this work highlights both current constraints and strategic opportunities to scale up BBF use across the EU.

[Find out more about the assessment](#) 

Geographical Location

 Greece

Using the Daisy model to assess fertiliser impacts in Life Cycle Assessments

To understand how fertilization with bio-based fertilisers affects soil, crops, and the environment, the agro-ecosystem **model Daisy** can simulate their behavior in the field. In a recent study, Daisy was used to compare new bio-based fertilisers made from microalgae and conventional sludge from dairy wastewater treatment in a case study of maize cultivation in Castile and León, Spain. Conventional sludge is commonly spread on fields as an organic amendment in addition to mineral fertilisers, without accounting for the fertilizing effect of the sludge, resulting in higher nutrient inputs.

On the contrary, bio-based microalgae fertilizer can be spread in the form of pellets and substitute mineral fertilizers. The effects on crop yield, nitrogen leaching, and soil carbon storage were calculated with Daisy, and these parameters were then used as key inputs for a Life Cycle Assessment (LCA) on microalgae wastewater treatment with bio-based fertilizer production. By simulating nitrogen, carbon, and water dynamics in the soil, with respect to the regional Spanish weather, crop rotation, and soil type, Daisy improves the accuracy of environmental impact calculations, especially for nitrogen-related effects such as eutrophication.

To apply Daisy, users need soil and weather data and knowledge of crop and fertilizer management. Modelling with Daisy can support informed and more sustainable fertilizer choices.

Geographical Location

 Denmark

Microalgae treatment of dairy wastewater can recover nutrients for bio-based fertiliser

Dairy processing produces wastewater rich in nutrients, which must be treated before discharge. Conventional treatment systems require inputs of chemicals and energy to remove most of the nutrients from wastewater and often result in sludge with low fertilizer value. A new approach, which is tested in the WaINUT project, uses microalgae to treat wastewater while recovering nutrients to produce a high-quality bio-based fertiliser (BBF).

In a pilot plant in Spain, microalgae were cultivated in photobioreactors using light, CO₂, and dairy wastewater. A Life Cycle Assessment (LCA) investigated the environmental impacts of the upscaling of the microalgae technology, which involves harvesting, drying, and pelletising of microalgae to create BBF that can replace mineral fertilisers. The LCA showed that this system performs best when waste heat from a nearby industry can be used to keep microalgae tanks warm in winter, instead of burning biomass pellets.

While the microalgae system still has higher environmental impacts than conventional treatment in some categories, mainly due to energy and CO₂ use, it offers benefits like reducing eutrophication and improving nutrient recycling. To implement this practice, access to industrial waste heat and access to renewable energy sources are important. Future improvements should focus on reducing CO₂ use for algae and energy use for drying to reduce environmental impacts further.

Geographical Location

 Denmark

Field trials for the comparison of agronomic performances of algae powder, sewage sludge and dehydrated food waste

Four field trials were designed in 2 durum wheat fields and 1 rapeseed field in Saint-Laurent-de-la-Prée, France. A comparison was made between

1. Algae powder
2. Sewage sludge at different dates and doses
3. Dehydrated food waste
4. Mineral controls (simple and half dose)
5. Unfertilized control.

The fertilisers were not buried as they were applied in February when the wheat had already been sown. Due to the limited amount of algae powder available, this product was not applied to rapeseed fields and was mixed with mineral on one wheat field to reach the required amount of N (160kg/ha).

The rapeseed trials did not produce exploitable results as all treatments gave high yields, including the unfertilized control.

On the wheat trial, however, mineral fertilizers gave much better results than bio-based fertilisers, considering the same nitrogen dose. The difference was noticeable concerning yields, but the biggest gap was in the protein content. However, this gap might be much reduced by using a crop variety suited for organic fertilisers, burying the fertiliser, or adapting the dose.

The algae powder gave the same results as the sewage sludge. Dehydrated food waste, however, produced a lower crop development since the mineralisation of its nitrogen occurred too late for the plant to uptake it. Mixing algae powder and minerals gave the highest yield but was not competitive with the pure mineral in terms of protein content. Further investigation on this mix would be opportune.

Geographical Location

Field evaluation of WALNUT biobased fertilisers on tomato, lettuce and grape in Italy

Farmers need field-validated alternatives to mineral fertilisers that ensure comparable yields and crop quality under real farming conditions. Evidence from field trials is essential to confirm the effectiveness of biobased fertilisers observed in pot and nursery experiments.

Between 2024 and 2025, different BBFs were tested at varying doses in field trials in Italy on tomato, lettuce, and grape, and compared with an unfertilised control, and a mineral-fertilised control. For tomato and lettuce, different application timings were also evaluated, including application in the nursery (at sowing) combined with field application before transplanting.

On tomato, BBF-treated plants showed better development in the nursery and sustained growth in the field until harvest. The highest chlorophyll content index (CCI) was observed with a double application of BIO-NPK-C (nursery + field). Higher yields were obtained when BIO-NPK-C was applied in the field, with results similar to or better than mineral fertilisation.

On lettuce, no significant differences were observed in yields or CCI or in reducing biotic stresses (Fusarium wilt disease).

On grape, plants treated with BIO-NPK-C at high dosage showed a significantly higher CCI compared to other fertilisation plans. No significant differences were found in yield or °Babo or in biotic stress reduction.

Practical recommendations: for tomato, combine nursery and field application of BBFs, particularly BIO-NPK-C, to enhance crop vigour and yield; for lettuce and grape, BBFs can be used as an alternative to mineral fertilisers without negatively affecting yield or crop quality; adjust BBF dosage and timing according to crop needs, as responses differ among vegetables and perennial crops.

Geographical Location

Greenhouse gas emissions release of WALNUT BBFs

Short-term ammonia (NH₃) and greenhouse gas emissions (i.e., N₂O, CO₂, and CH₄) were determined on a laboratory scale via incubation assay for the following WALNUT BBFs:

1. **Nitrogen-loaded zeolites** (NZ);
2. **Ammonium sulphate** (AS);
3. **Mixture of ammonium sulphate and virgin zeolites** (AS+VZ);
4. **BIO-NPK-C compound**;
5. **Algae powder** (AP);
6. **Smart BBF**.

The BBFs were mixed with soil, in the absence of a crop, and at regular intervals, emissions were measured. Their performance was compared against using calcium ammonium nitrate (CAN) and unfertilised soil. Results showed no differences among treatments for CH₄ and NH₃ emissions. N₂O and

CO₂ emissions depended on BBF composition, i.e., mineral N/total N ratio and C/N ratio. More specifically, BBFs in mineral N form (i.e., with a high mineral N/total N ratio: NZ, AS, AS+VZ, and SMART) are expected to have a similar risk for N₂O and CO₂ emissions as CAN. The exception was SMART, because this BBF also contains plant growth-promoting bacteria that could actively promote nitrification and denitrification processes, and hence accelerate the release of N from the BBF and soil itself. BBFs that contain considerable amounts of C are expected to result in higher CO₂ emissions. However, C stability in the BBF also counts.

Therefore, BBFs as BIO-NPK-C (formulation of animal bone char) contain higher levels of stable C and hence result in low CO₂ emissions, similar to the levels of CAN. Finally, conditions used in this laboratory assay greatly differ from field conditions, as those are influenced by fluctuating weather conditions, soil type, applied management practices (e.g., tillage vs no-tillage), method of fertiliser application (e.g., injection vs incorporation vs. surface application), etc.

Geographical Location

 Belgium

Use of recovered salts in vegetable crops

Micronutrient supply is often critical for optimal crop growth, especially in intensive horticultural systems and soil-less cultivation. At the same time, the reuse of recovered nutrients from industrial processes can improve resource efficiency and sustainability. Recovered salts (KCl, CaCO₃, and Mg(OH)₂) produced from the NTUA brine desalination pilot plant were assessed as meso- and micronutrient sources.

The salts were used to upgrade N- and/or P-rich WALNUT BBFs and tested on tomato and lettuce grown in pots, on lettuce grown in soil-less systems.

Agronomic trials evaluated plant growth, biomass development, and potential phytotoxic effects. Results were compared with the use of BBFs alone or combined with commercially available micronutrients.

Recovered salts showed positive effects on plant growth when applied at low doses in combination with BBFs or other fertilisers.

High application rates caused phytotoxic effects, highlighting the importance of careful dosage management.

In pot trials, the addition of meso- and micronutrients did not significantly improve BBF efficacy, likely due to nutrient balance limitations (Liebig's law of the minimum).

In soil-less systems, the combination of BBFs with NTUA recovered micronutrients improved biomass production and plant development and helped mitigate biotic stresses.

Practical recommendations are: use recovered micronutrient salts at low doses when combined with other fertilizers, according to crop needs; consider the use of recovered micronutrients primarily in soil-

less systems, where nutrient availability can be better controlled, and benefits are more evident; always adjust micronutrient supply based on crop needs and existing nutrient levels.

Geographical Location

 Italy

Agronomic test results of CETAQUA's bio-based fertiliser

CETAQUA developed an experimental biofertiliser from wastewater treatment plant sludge. Initial pot trials tested a biological-based formulation containing four PGPB (*Plant Growth-Promoting Bacteria*) strains. However, laboratory-scale results showed that bacterial inoculum addition had no statistically significant positive or negative effects, leading to the removal of bacteria from the final formulation.

Subsequent field trials evaluated the fertiliser on corn and cabbage crops. Results demonstrated that CETAQUA fertiliser can effectively replace conventional inorganic fertiliser. For corn, it significantly increased forage production compared to conventional fertilizer, while grain yield was intermediate between conventional and no fertiliser treatments. No significant differences were found in physiological parameters (chlorophyll, flavonoids, anthocyanins, nitrogen balance), forage quality, or grain nutrient content.

For cabbage, CETAQUA fertiliser showed equivalent performance to conventional fertiliser in all agronomic and physiological parameters, with a trend toward increased fresh weight and glucosinolate content. These findings indicate that CETAQUA fertiliser can partially or totally replace conventional fertiliser, potentially improving agronomic results depending on crop use, though supplementation with specific macro or micronutrients may be beneficial.

Geographical Location

 Spain

Agronomic efficacy of WALNUT bio-based fertilisers

Farmers and nurseries need effective alternatives to conventional mineral fertilisers that maintain crop productivity while improving sustainability and resilience to stress conditions. Within the WalNUT project, the agronomic performance of several biobased fertilisers (BBFs) was evaluated, including ammonium sulphate, **N-zeolite**, **NK-zeolite**, **zeolite combined** with **ammonium sulphate**, **algae-based biofertiliser**, **BIO-NPK-C compound** and **Smart BBF**.

The trials tested BBFs under different conditions:

- soil types (potting substrate, sandy, loamy and clay soils);
- crops (cereals and vegetables);
- application timing (at seeding, before transplanting, or both);
- application methods and doses (nursery, soil, soil-less systems);
- stress conditions, including water deficit (abiotic stress) and soil-borne pathogens (biotic stress).

Results were compared with conventional mineral fertilisers.

BBFs showed agronomic performances comparable to mineral fertilisers across different crops and soil types. The most effective application strategy was identified as: 1% (v/v) BBF application in nursery before seeding, and 170 kg N/ha in pot trials integrated with mineral fertilisers if needed and according to crop needs.

The BBF BIO-NPK-C compound showed an additional benefit by partially reducing diseases caused by soil-borne pathogens.

Practical recommendations are: apply BBFs at low concentrations during the nursery phase to optimise early crop development; apply them according to crop needs and integrated with mineral fertilisers to balance crop performance and nutrient efficiency.

Geographical Location

 Italy

Phosphorus release of WalNUT BBFs

Phosphorus (P) release was studied via a dedicated plant growth assay using ryegrass as a test crop in a 4-month pot experiment. The following WalNUT BBFs were tested:

1. **Algae powder** (ALG);
2. **BIO-NPK-C compound**.

The performance of these BBFs was compared against a P unfertilised growing substrate (negative control) and two positive controls:

1. **Triple superphosphate** (TSP), as a fast P-release fertiliser;
2. **Struvite** (STR), as a slow P-release fertiliser.

The performance of BBFs was assessed in terms of crop yield, root biomass, P status of growing substrate, and P replacement use efficiency (PRUE). The PRUE (%) is an agri-environmental indicator that shows how effectively a BBF can replace or supplement traditional mineral P fertilisers as TSP.

Results have shown that algae powder (PRUE = 148%) outperformed TSP (theoretical value = 100%) and exhibited P dynamics comparable to those of struvite (PRUE = 158%). On the other hand, 78% of the phosphorus (P) applied with BIO-NPK-C was taken up by the crop, with the rest likely remaining in the soil for gradual release. This BBF is rich in both P and calcium (Ca), and the presence of Ca may have led to the formation of insoluble calcium-phosphate compounds, reducing immediate P availability.

BIO-NPK-C also contains Trichoderma fungus, which grows best in slightly acidic to neutral soils (pH 4–6). However, the substrate used in the ryegrass trial (over 85% sand, pH 7.7) likely limited fungal activity and root colonisation. Future testing for BIO-NPK-C is recommended on a range of more realistic soils with adequate organic carbon content to reflect field conditions.

Geographical Location

 Belgium

Nitrogen release potential of WalNUT BBFs

The nitrogen (N) release potential is defined as the percentage of total N applied that will be available for the crop during the 1st year of its cultivation. In the WalNUT project, this was assessed by incubating WalNUT BBFs with soil for 120 days, in the absence of a crop. Every 20 days, mixtures of respective BBFs and soil were analysed for mineral N content, to determine the N release of the following WalNUT BBFs:

1. Nitrogen-loaded zeolites;
2. Ammonium sulphate;
3. Blend of ammonium sulphate and virgin zeolites;
4. BIO-NPK-C compound;
5. Algae powder;
6. Smart BBF.

The N release of BBFs was compared against the use of conventional mineral N fertiliser (i.e., calcium ammonium nitrate (CAN)). The magnitude of the released N (%) for WalNUT BBFs, on average after 120 days of an incubation experiment, was in the following order: Smart BBF (109 ± 6) > CAN (90 ± 11) $\geq$ NZ (88 ± 11) $\geq$ AS+VZ (87 ± 12) $\geq$ AS (73 ± 9) > ALG (44 ± 15) > BIO-NPK-C compound (5.2 ± 5.6). These results indicate the % of total N that will be available for the crop in the 1st year of its cultivation.

In general, results show that the N release is highly dependent on the product's $\text{NH}_4^+\text{-N}/\text{N}_{\text{total}}$ ratio. The higher the ratio, the higher the N release can be expected. This was confirmed in the case of **Smart BBF**, **NZ**, **AS+VZ**, and **AS**. For organic N fertilisers, usually mineralisation is expected to occur. This was observed for ALG, but not for BIO-NPK-C compound microbiological product, which seems to be quite a stable product due to the presence of bone char.

Geographical Location

 Belgium

Agronomic performance of FERTIMANURE bio-based fertilisers

Currently, it is estimated that around 7.8 % of all livestock manure in Europe is processed. The FERTIMANURE project aims to stimulate further processing of animal manure and assess the agronomic and environmental performance of recovered biobased fertilisers (BBFs) as compared to their conventional counterparts.

The assessment of 15 FERTIMANURE produced BBFs is currently ongoing, both at the laboratory and field levels. A combination of fully controlled lab trials and the field full scale trials provides a full range of data that allows full comprehension and comparison of novel fertilising products against mineral fertilising products. To this end, the FERTIMANURE consortium conducted 13 field trials and 6 pot trials across Spain, France, Belgium and the Netherlands to assess fertiliser potential of manure-derived ammonium sulphate, ammonium nitrate, ammonium water, biochar, liquid K solution (i.e. mechanically separated liquid fraction of digestate or manure after ammonia stripping) and several tailor-made fertilisers (i.e. blend of the BBF(s) and synthetic mineral fertilisers) in cultivation of wheat, spinach, potatoes, maize, rye-grass, sauerkraut cabbage, sugar beet and grass. Preliminary results show that in terms of crop yield, nitrate residue, fertiliser efficiency and greenhouse gas emissions, ammonium salts

have the potential to be used as N fertilisers. Biochar has the potential to be used as C source, whereas liquid K solution can be used to replace synthetic K fertilisers. The validation of results through the second year of field trials is currently ongoing.

Geographical Location

 Belgium, Spain, France, Netherlands

Pilot 5: Use of cation exchange systems and hollow fiber membrane contactors for N recovery as fertiliser product

CETAQUA's technology was validated at pilot scale at the **Ourense** WWTP for nitrogen recovery from reject water generated during anaerobic digestion. The system combines a zeolite-based cation exchange unit with a hollow fibre membrane contactor for the conversion of recovered nitrogen into ammonium sulphate, complemented by a downstream unit for the formulation of bio-based fertilisers enriched with plant growth-promoting bacteria.

The pilot plant, designed to treat approximately 65 L/h of reject water, achieved average nitrogen removal efficiencies of 86% during adsorption and recovery rates of 76% in the desorption stage. Subsequently, 81% of the concentrated nitrogen stream was converted into ammonium sulphate through the membrane contactor system.

Operational results demonstrate high robustness under variable nitrogen loads and confirm the high selectivity of the process, yielding a final product free of organic micropollutants and heavy metals. Although the standalone economic feasibility based on fertiliser sales is limited, the technology shows strong potential for full-scale application due to reduced energy demand for nitrogen removal in WWTPs and associated CO₂ emission savings, supporting circular economy strategies and nutrient valorisation.

Geographical Location

 Spain

Pilot 4 results

As part of the WaINUT project, a pilot unit was designed and operated to demonstrate the complete recovery of water, nutrients, and salts from desalination brines through an integrated zero liquid discharge (ZLD) approach. The system combines precipitation technologies (chemical and physicochemical), membrane processes (Nanofiltration and Reverse Osmosis), and thermal methods such as Multi-Effect Distillation (MED) and vacuum crystallisation. During pilot operation, high recovery efficiencies were achieved, with magnesium hydroxide [Mg(OH)₂] and calcium carbonate (CaCO₃) recovered at purities exceeding 98%. Potassium chloride (KCl) and sodium chloride (NaCl) were successfully separated via flotation, achieving recovery yields above 80%. Nanofiltration removed sulphates with an efficiency greater than 99%, preparing the brine for more effective downstream processing, while the Reverse Osmosis unit produced high-purity water. Under optimal conditions, the MED unit reached water recovery rates of around 75%. These results confirm the feasibility of applying ZLD systems for brine valorisation, enabling the production of marketable fertiliser micronutrients and

industrial salts while minimizing environmental discharge. For end-users, the pilot plant offers a technically sound and scalable model, with documented operational parameters and performance, directly contributing to circular economy goals and nutrient self-sufficiency within the EU.

Geographical Location

 Greece

Operation of a pilot plant for nitrogen recovery from municipal wastewater sludge liquor using stripping/scrubbing

A pilot air stripper and acid scrubber was operated at the wastewater treatment plant Antwerp South. Stripping/scrubbing for the production of ammonium sulphate is a mature technology, but it is not commonly used on sludge liquor from municipal wastewater. The goal was to gain practical experience and assess energy use, chemical use, and N-recovery potential.

The sludge liquor first goes through a drum sieve (250 μm), then through a 1 m^3 air stripping unit, followed by 2 parallel 0.5 m^3 secondary stripping units with pH control (NaOH). In the scrubber (1.5 m^3), H_2SO_4 is added to regulate the pH between 2–3 and produce ammonium sulphate (200 g/L). The pilot is operated in batch mode. Each batch of 1 m^3 sludge liquor takes 2 h.

The ammonium sulphate complies with the Flemish waste regulations to be used as a resource to produce a fertiliser, and with the EU fertilizer regulation (proposed CMC15 and PFC(C)(I)).

The N-recovery was cost-effective at € 3/kgN, but had a low recovery potential: 5–10%. There were some operational problems with clogging due to suspended solids and condensation in the scrubber.

Geographical Location

 Belgium

Operation of a pilot plant for nitrogen recovery from municipal wastewater using high rate activated sludge and ion-exchange/adsorption

A novel 2-stage pilot was built and operated at the research hall of Aquafin, located at the wastewater treatment plant of Aartselaar.

The first stage (high rate activated sludge, HRAS) is a fully-automated sequential batch reactor, treating 1–2 m^3 per day. There was a stable BOD removal over time, with low nitrogen removal. Because the wastewater is diluted with rainwater, there were elevated levels of suspended solids during rainy conditions. With the addition of a mesh filter and FeCl_3 dosing, effluent limits for BOD, COD, P, and suspended solids were met. The N_2O emissions were very low: < 0.001 kg N_2O /kg N removed. The sludge had a high biomethane potential of 213 Nm^3 per ton dry solids.

The second stage, adsorption columns with natural zeolites, showed good N-removal (80%). The adsorption capacity of the zeolites was, however, low: 1.4–8.4 mgN/g. Regeneration of the zeolites was not financially viable.

The total system is able to recover 60–70% of the nitrogen, at an estimated cost of € 39/kg. The proposed system would be more successful on a less diluted wastewater stream (municipal wastewater without rainwater or wastewater from the food industry) or with an adsorption material with a higher adsorption capacity.

Geographical Location

 Belgium

WallAB

The WallAB methodology represents a systematic approach to scale up five innovative nutrient recovery technologies from laboratory to pilot level within the WalNUT project.

WallAB evaluates technical, economic, and environmental aspects to optimise technology selection and operational parameters for treating diverse wastewater streams (urban, industrial, food, sewage sludge, and desalination brine). Main results across all technologies demonstrate:

1. Microalgae cultivation achieved 90% total nitrogen and 98% phosphorus recovery from dairy wastewater.
2. HRAS/CS combined with zeolite adsorption reached 80% $\text{NH}_4^+\text{-N}$ removal efficiency with 57% recovery.
3. ABC-BioPhosphate fermentation successfully processed acidic whey, producing multifunctional biofertilisers.
4. Nanofiltration and selective crystallization from brine achieved >90% recovery of $\text{Mg}(\text{OH})_2$ and CaCO_3 .
5. Ion exchange with membrane contactors demonstrated effective nitrogen concentration and recovery from anaerobic supernatant.

These results provide the foundation for five pilot plants (500-800 L/day capacity) that will demonstrate integrated circular economy solutions for closing nutrient loops in European agriculture.

Geographical Location

 Spain

Lab scale technology

CETAQUA developed an integrated ion exchange and hollow fiber membrane contactor (HFMC) system for nitrogen recovery from municipal wastewater anaerobic supernatant.

The technology combines natural zeolites for NH_4^+ concentration with gas-permeable polypropylene membranes for selective ammonia extraction, producing high-quality ammonium salts as bio-based fertilizers. Laboratory-scale results demonstrated that zeolites in their original ionic state achieved treatment capacity of 140 bed volumes with 80% $\text{NH}_4^+\text{-N}$ removal efficiency and 57% recovery in the first adsorption cycle.

Comparative studies identified WWTP2 as optimal feedstock (443 mg N- $\text{NH}_4\text{/L}$, lower solids content), NaOH as a superior regenerant (70% ammonia release vs. 40% with NaCl after 7 bed volumes), and

filtration as a necessary pre-treatment (reducing solids from 1.54 to 0.51 g/L). The HFMC process offers advantages, including low energy consumption, high ammonia selectivity, modularity, and production of contaminant-free fertilizer products. These findings support pilot-scale design (800 L/day capacity) to be installed at WWTP2 in Galicia, Spain, demonstrating a sustainable approach for closing nitrogen loops while minimizing environmental impacts.

Geographical Location

 Spain

Lab scale results of Walnut pilot 4

Within the WalNUT project, bench-scale tests were conducted to validate the recovery of magnesium, calcium, and potassium from seawater desalination brines. These tests served as a base for designing a pilot plant targeting zero liquid discharge (ZLD) and the recovery of macronutrients that can be added to bio-based fertilisers.

Precipitation reactions were optimized for magnesium hydroxide [Mg(OH)₂] and calcium carbonate (CaCO₃), achieving purities up to 89% and 99%, respectively. For potassium chloride (KCl), flotation methods using different agents demonstrated the importance of reagent type, dosage, and particle size for yield and purity. Nanofiltration simulations further enabled selective sulphate removal with 92% efficiency using the NF270-2540 membrane.

These results informed the process design, proving that high-quality fertiliser components can be recovered from seawater desalination brine streams. For desalination technology providers, this research showcases tested parameters for scaling up, including reagent quantities, mixing times, and purification steps. By integrating this recovery train, desalination facilities can utilise brine discharge, reclaim freshwater, and generate marketable fertiliser macronutrients.

Geographical Location

 Greece

Upcycling of food industrial waste water at TRL5 lab scale with ABC-BioPhosphate solution

The objective of the ABC-BioPhosphate technology is to fully upcycle the dairy waste water stream, acidic whey, which is consisting 93% water content, extremely high biological and chemical oxygen demand, and total organic carbon, and has a low pH of 4.5, which is the overwhelmingly largest and problematic liquid wastewater by-product stream of the dairy food industry with significant economic importance. We successfully combined acidic whey in 50V/V% with tomato pulp as a fermentation medium. The liquid fermentation was made to a 3x3L capacity. The solid-state fermentation condition was successfully developed for the production of biotech-formulated BioPhosphate. The 3R liquid fermentation system eliminated the toxic compounds from the food industrial WW, and at the same time, high-concentration biomass of the agriculturally beneficial microbial strain was produced. During the fermentation process, the organic compounds were converted into safe and added value recovered and upgraded microbial biomass. The obtained microbial biomass was used for inoculation of the solid fermentation system, where Animal Bone Char (ABC) carrier was added. The end-product is P/Ca enriched biobased fertiliser. The biotech fermentation upcycling process is considered the main

treatment line, and the adsorption processing is a support to complete and close the nutrient and water cycle loops for the dairy farmers and processors, while reducing energy consumption and environmental/climate impacts. ABC, which is full-scale REACH certified, is highly optimal and efficient in adsorbing macromolecular organic contamination in the liquid stream, and can adjust the pH. The concept is successfully developed, and the TRL5 laboratory scale test resulted advanced multi-functional biofertiliser.

Geographical Location

 Hungary

Integration of high-rate activated sludge and adsorption technology for nitrogen recovery

The integration of high-rate activated sludge (HRAS) and adsorption technologies into a 2-stage nitrogen (N) recovery and wastewater treatment (WWT) system has been successfully demonstrated. Within a sequencing batch reactor (SBR) configuration, a conventional activated sludge system (CAS) in contact-stabilisation (CS) mode was converted into an HRAS/CS system. The conversion maintained stable BOD removal while reducing $\text{NH}_4^{+}\text{-N}$ oxidation, allowing $\text{NH}_4^{+}\text{-N}$ to be recovered in the effluent using downstream adsorption.

Compared to a CAS system, the HRAS/CS SBR system achieved a 16% energy saving due to reduced aeration. Zeolite, in its original ionic state, was selected for adsorption due to its cost-effectiveness and comparable performance to modified zeolite and synthetic resins. The system treated up to 186 bed volumes of wastewater before breakthrough and demonstrated improved treatment capacity with increased contact time.

The 2-stage system achieved an average removal efficiency of 92% for $\text{NH}_4^{+}\text{-N}$ and 83% for COD, meeting European and Flemish discharge limits. The N-rich zeolite produced contained 1.4 ± 0.1 g/kg $\text{NH}_4^{+}\text{-N}$, with the zeolite column showing good potential for regeneration using 3% KCl. The expected marketable products include ammonium and potassium-saturated zeolites, and concentrated $\text{NH}_4^{+}\text{-N}$ in regenerant solutions.

These findings informed the design of a TRL5 adsorption column linked to a TRL 6 HRAS/CS reactor and are useful (i) for technology providers to develop more energy-efficient processes for WWT, (ii) to inform policies regulating fertilising products recovered from the WWT sector, and (iii) for fertiliser producers and farmers to assess whether these alternatives are a good fit for their activities.

Geographical Location

 Belgium

Microbial Fuel Cells: A Sustainable Technology for Waste Water Nutrient Challenges

The lab-scale study in the project framework with Microbial Fuel Cells (MFCs) focuses on the use of these technologies for nutrient recovery from waste water. MFCs are bioelectrochemical systems that leverage the ability of certain microorganisms to convert the chemical energy of organic matter into electricity.

In the context of the project, MFCs were investigated as an alternative for waste water treatment and nutrient recovery, mainly nitrogen (N) and phosphorus (P). Tests were conducted using an experimental design that included H-shaped cells, separated by an ion-exchange membrane, where microorganisms at the anode break down organic matter, releasing electrons that travel to the cathode through an external circuit, thus generating an electric current.

The main results from the MFC tests showed that, although they can be effective for energy production and degradation of organic pollutants, the efficiency in nutrient recovery barely exceeded 20%. This is due to several factors, including the lower capacity of MFC-based systems to handle and process high concentrations of nitrogen and phosphorus in waste water.

Furthermore, the influence of various factors on the efficiency of the MFCs was investigated, including the type of electrode material, the shape of the electrode, and the type of waste water treated. Different configurations of electrodes and materials (such as graphite, titanium, and platinum) were used to determine their impact on the electron transfer rate and the process's effectiveness.

Despite the advances, the significant data generated, and MFCs being a promising technology for nutrient recovery, further optimisation is still required before MFCs can be considered a viable option for large-scale nutrient recovery in waste water treatment.

Geographical Location

 Spain

The WaINUT Platform

The WaINUT platform is an interactive digital tool developed to support the circular economy by enabling the recovery and valorisation of nutrients from wastewater and related secondary streams. Designed for a broad range of stakeholders, including wastewater producers, technology providers, bio-based fertiliser (BBF) producers, farmers, consultants, and aggregators, it facilitates matchmaking and knowledge sharing across the nutrient recovery value chain. Users register and define their role(s), input data on waste streams or nutrient needs, and are algorithmically matched based on proximity, quality, and quantity of available or required resources.

The platform creates value by increasing transparency and connectivity across sectors, reducing information gaps, and accelerating the adoption of nutrient recovery technologies. It supports the identification of potential business partnerships, tracks transactions, and provides statistics on market dynamics and nutrient flows. By offering a structured repository of secondary nutrient sources and BBF products, it enhances the market readiness of recovered nutrients. End users benefit from easier access to locally available BBFs, regulatory insights, and tools to reduce dependency on synthetic fertilisers and critical raw materials.

Geographical Location

 Greece

Bio-based fertilisers in the EU 27 matrix

Across the European Union, several waste and side-streams are increasingly recognised as valuable sources of nutrients for bio-based fertilisers (BBFs). Key flows include urban wastewater, sewage sludge, industrial effluents, food waste and brines. These are partly mapped in EU tools such as the Urban Waste Water Treatment Directive reporting platform, the Pollutant Release and Transfer Register, and the Industrial Emissions Portal. So far, most focus has been on recovering phosphorus and nitrogen, as both are essential for crop growth and their losses cause eutrophication and emissions. The European Sustainable Phosphorus Platform is a good example, with its catalogue of technologies like struvite precipitation and phosphorus recovery from sludge ash, showing how nutrients can be reintroduced into the agricultural cycle.

However, several obstacles remain. Monitoring systems mainly track pollutants rather than nutrients, leaving gaps in resource data. Contaminants such as heavy metals, pharmaceuticals and pathogens raise safety concerns. BBFs also face competition from cheaper mineral fertilisers, while EU rules can be complex, with exclusions (e.g. sewage sludge) and differences across Member States. Overcoming these issues will be key to scaling nutrient recovery and advancing Europe's circular bioeconomy.

Geographical Location

 Greece

Barriers to the development of Biobased Fertilisers

Nutrient recovery from wastewater for the development of bio-based fertilisers faces several barriers. A survey conducted by the National Technical University of Athens involved wastewater producers, wastewater treatment plant managers, bio-based fertilizer manufacturers, farmers, technology providers, and policymakers.

The main barriers identified by **wastewater treatment plant managers** include the limited market demand, high operational costs, questionable quality and safety of recovered nutrients, high initial costs for advanced technologies, and inconsistent nutrient reuse standards. Lack of awareness about regulations and the need for regional policy implementation, redefining wastewater as a resource, and increasing acceptance of recovered nutrients are also significant challenges. For **bio-based fertilizer producers**, cost-effective and high-quality processes are very important. Distribution, transportation, and viable application options pose issues. **Farmers** are important for creating demand, but find soil testing expensive and data limited. They prioritize competitive pricing and compliance with standards and have concerns about crop yields, dosage, equipment compatibility, and potential contaminants like heavy metals. Farmers are generally unwilling to pay more for bio-based fertilizers unless the advantages of such products are clearly stated.

Although rising traditional fertilizer prices have increased interest in alternatives like bio-based fertilizers, economic incentives for nutrient recovery remain limited. Furthermore, efforts should focus on raising awareness, fostering innovation in nutrient recovery technologies, involving policymakers in setting stricter disposal limits, and ensuring reliable certification. Collaboration between wastewater treatment plants and technology providers is also crucial for effective NR processes.

Geographical Location

 Greece

Understanding Nitrogen and Phosphorus flows in Europe: balancing the scales

Nutrient excess in the form of N and P runoff from the use of fertilisers in agricultural activities ends up in water bodies all across Europe, resulting in increased environmental pressure on natural ecosystems. Existing studies highlight that the levels of Nitrogen (N) and Phosphorus (P) in the environment have been on a declining trend. However, there still is significant imbalance at EU level.

Using EU-wide data, WalNUT evaluated N and P content in waste water streams (both urban and industrial), the demand for nutrients for agricultural activities and current consumption levels of fertilisers. With all this information, a regional analysis of the distribution of nutrient flows and balances was calculated resulting in a detail picture of the EU's nutrient stocks and flows.

The data has also been used to evaluate to what extent the current demand for inorganic fertilisers could be replaced by secondary nutrients.

The results show that there still is a significant nutrient surplus across the EU, especially for N. For P, the situation has improved in the last years.

The country-by-country analysis reveals that there are significant differences even between regions within a same country, which makes difficult to use general assumptions and stresses the need for tailored nutrient management practices.

There is also a strong need to match supply and demand for optimum management of recovered nutrients to ensure the environmental and socio-economic soundness of the process.

Finally, the results also show that the effluent from WWTPs has a strong potential as a source of secondary nutrients that can be used to reduce the need for inorganic fertilisers and support the transition towards a circular nutrient ecosystem.

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