

Policy Brief

Applying Urban Wastewater and Sludge as Nutrients for Agriculture Use

Recommendations for EU Policy Reforms



Abstract

The European Union (EU) has set an ambitious goal to reduce nutrient losses to the environment (air, water, soil) by 50% by 2030. This reduction aims to address the impact of nutrient pollution on ecosystems and human health, and manage nitrogen (N) and phosphorus (P) better throughout their lifecycle across all sectors. Two key EU policies that influence nutrients recovery and management include the Integrated Nutrient Management Action Plan (INMAP)¹ and the Urban Wastewater Treatment Directive (UWWTD). The INMAP was announced during the publication of this policy brief in 2022 but is yet to be published and operationalized. The INMAP is a comprehensive strategy to improve nutrient management, enhance agricultural practices, and protect the environment. Its implementation will contribute to achieving the EU's Net Zero target and ensuring sustainable agriculture and pollution reduction. The revision of the EU's Urban Wastewater Treatment Directive (UWWTD) has recently been adopted by the European Parliament and awaits formal approval by the Council of the European Union before entering into force. The revision entails changes regarding the way wastewater utilities will have to recover and reuse nutrients from wastewater and sludge² including for agriculture. Over 90% of urban wastewater currently meets EU standards but the revision aims to make the wastewater sector energy-neutral, promote water reuse, and utilize sludge for biogas and agriculture production. Under the principles of circular economy, "The Commission will develop an Integrated Nutrient Management Plan, with a view to ensuring more sustainable application of nutrients and stimulating the markets for recovered nutrients. The Commission will also consider reviewing directives on wastewater treatment and sewage sludge and will assess natural means of nutrient removal such as algae³."

This policy brief looks at the challenges and opportunities of realising the ambitious target enshrined in both the above policies and provides policy recommendations to stakeholders involved in the implementation process at the EU and national levels. It draws on insights from the EU Horizon 2020 project B-WaterSmart (grant agreement No. 869171), which explores different wastewater-to-agriculture solutions, focusing on Living Labs (LLs) in Spain and Italy and by exploring other ongoing practices within the EU outside the LLs.

¹ Grizzetti et al. 2023).

² Sludge is the matter resulting from wastewater treatment, containing water, organic material, nutrients, and valuable resources like carbon, nitrogen, and phosphorus. It can be used for energy production or as a soil conditioner in agriculture.

³ European Commission 2020.

Background

Nutrient and Sludge Management in Europe: Current status, challenges and opportunities

Current status

Wastewater collection and treatment is governed by the EU Wastewater Treatment Directive. For processing, transporting and using sewage sludge also the EU Waste Framework Directive, the Sewage Sludge Directive and the Industrial Emissions Directive apply. The environmental impacts of sewage sludge are furthermore governed by the Nitrate Directive and the Water Framework Directive including the related directives.

The proposed recast of the EU Wastewater Treatment Directive aims to align the Directive with other EU policies, including the European Green Deal (EGD) which aims to increase circularity and reduce environmental degradation. The wastewater sector currently makes up 0.86% of total CO₂ emissions and 0.8% of energy consumption in the EU⁴. This is addressed in the Directive through nitrogen and phosphorus recycling as well as water reuse (Recast WWTD).

The Recast WWTD requires that sludge has to be treated, recycled and recovered when appropriate according to specifications in the Waste Framework Directive and the Sludge Directive and gives the

⁴Vikolainen 2023.



The European Environmental Agency (EEA) estimates that nitrogen and phosphorus losses in Europe exceed safe and sustainable levels by a factor of 3.3 and 2 respectively. This means that the use of nitrogen in agriculture and other activities is unsustainable and contributes to water pollution. The Nitrates Directive aims to protect waters from nitrates from agricultural sources, safeguarding drinking water and preventing damage from eutrophication. In its latest implementation report, the EC (2018) stressed that, while water pollution caused by agriculture nitrates has been reduced across Europe over the last 20 years, some areas show persisting pollution and require action. More than 30% of EU surface water and over 80% of EU marine waters are eutrophic (excessively nutrient-rich). Additionally, 14% of groundwater exceeds legal nitrate thresholds for drinking water (EEA). Overall, nutrient pollution costs the EU approximately €22 billion annually due to water pollution⁵.

Recent statistics indicate that the agricultural sector accounts for the largest portion of sewage sludge utilization across the European Union⁶. The Council Directive 86/278/EEC, which regulates the application of sludge in agriculture, was adopted over 35 years ago and remains pertinent, despite ongoing discussions about the need to update the directive.



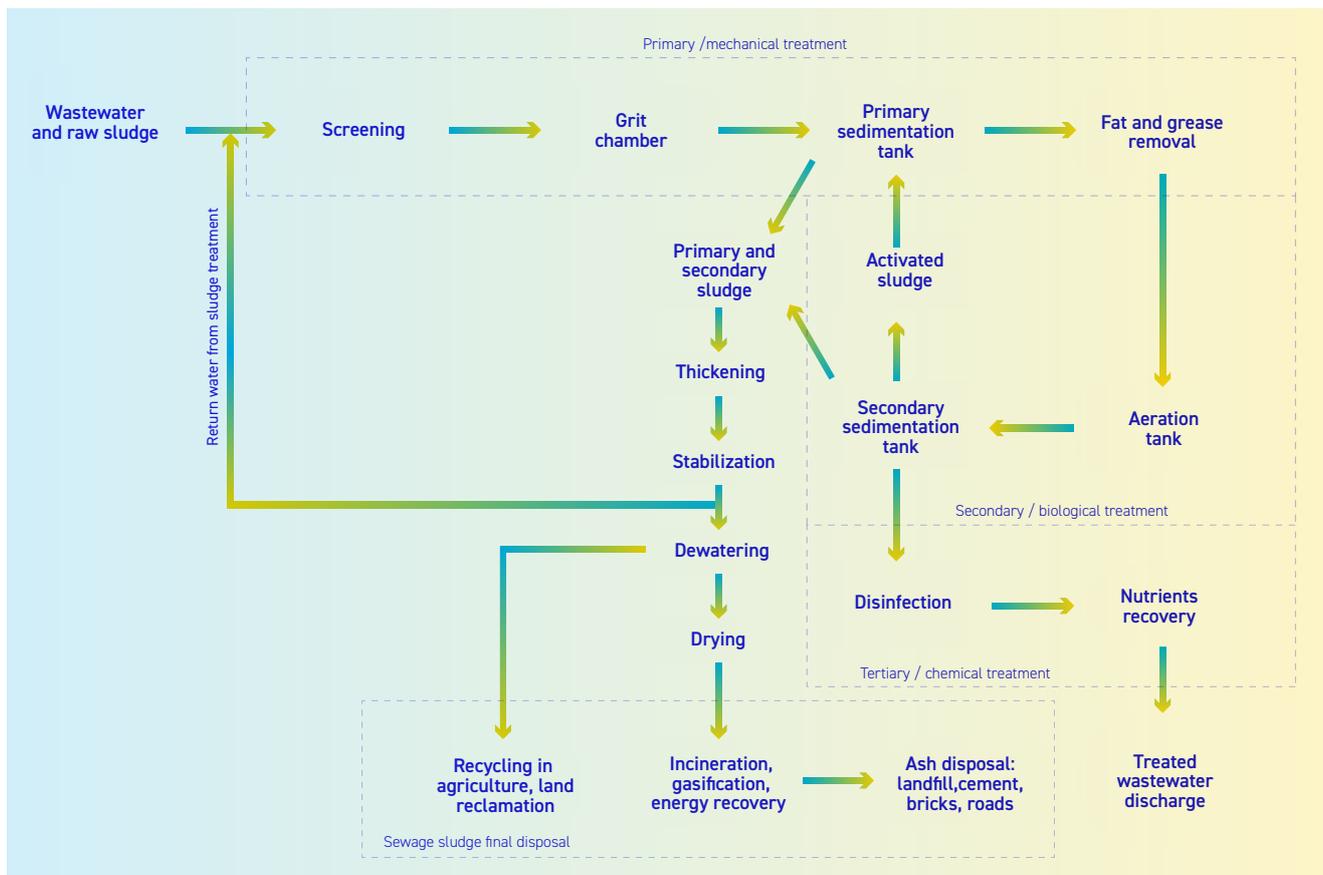
⁵ Mottershead et al. 2021.

⁶ Valchev et al. 2024.

Opportunities

Application of sewage sludge in agriculture provides the soil with phosphorus as well as organic matter. A Life Cycle Assessment (LCA) study on nutrient recycling from wastewater highlights the positive environmental outcomes, particularly when chemical inputs are minimized, and human excreta are source-separated. HELCOM's Recommendation 38/1 on sewage sludge handling, adopted in March 2017, emphasizes sustainable agricultural and energy-related uses, avoiding landfilling, and targeted nutrient recycling, particularly phosphorus⁷. It aims to reduce environmentally hazardous inputs, current treatment measures, suggest agricultural application restrictions, and promote cost-effective solutions and regional knowledge exchange, with contracting states reporting regularly on sludge handling, quality, and phosphorus recovery. Among the various sources of nutrients, sludge that is produced across domestic nutrients includes most importantly nitrogen, phosphorus, and potassium. Water and wastewater include nitrogen, phosphorus, and potassium, which can be efficiently reused to help combat nutrient pollution in the EU (see Figure 1).

Figure 1: Wastewater and sewage sludge treatment methods in the EU (Đurđević et al. 2022)

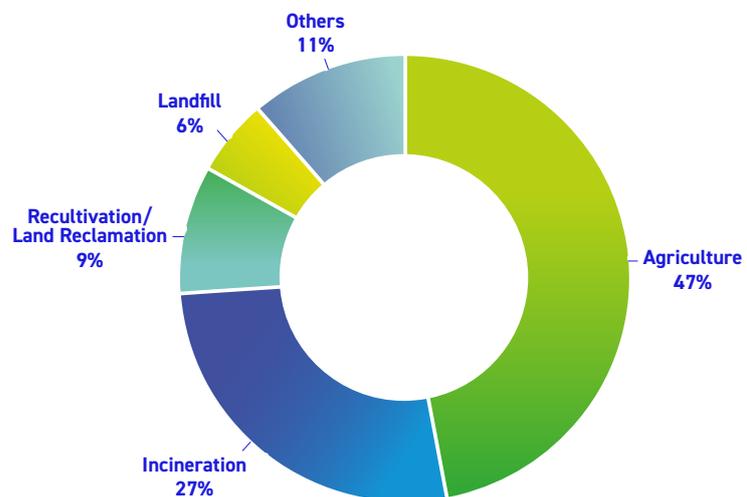


⁷Roskosch and Heidecke 2018.

Challenges

However, the document also identifies challenges such as the spatial disconnect between recycled nutrient products and local factors, such as soil conditions and the types of fertilizers that are avoided, underscoring the need for tailored approaches to maximize the benefits of wastewater-based nutrient recycling⁸. Unregulated or unknown substances can be contained in sewage sludge and represent health concerns for humans and the environment, especially since pollutants may accumulate in the soil. Furthermore, there is a risk of over-fertilization as well as groundwater pollution due to nutrient leaching. In 2016, approximately half of the nutrients, predominantly nitrogen and phosphorus, utilized in agriculture were recycled from waste streams. More than 90% were recovered from manure while smaller fractions were recovered from sewage sludge and food waste⁹, since manure is a key externality influencing sludge recovery [See Box: [Role of Externalities for sludge recovery](#)]. In Europe, approximately 8.5 million tonnes (dry solids) of sludge are produced per year. The destination of sludge varies significantly among European countries. Countries with a high fraction of sludge used in the agricultural sector include Cyprus, France, Norway, Portugal, Slovakia and Spain. Germany uses 23.7% of its sewage sludge for agricultural purposes, while Norway uses 61.7% and Spain 74.5%¹⁰. The abundant availability of manure in Netherlands and Germany is the key reasons why sludge application is possible in Norway.

Figure 2: Sludge use in Europe (EurEau 2021)



⁸ Lam et al. 2020.

⁹ Buckwell and Nadeu 2016.

¹⁰ Roskosch and Heidecke 2018.

Box: Role of Externalities for sludge recovery

Externalities play a pivotal role in shaping the feasibility and implementation of nutrient recovery practices from wastewater, profoundly influencing the strategies employed by water utilities. Two of the most significant externalities are competition from manure and the availability of land, which greatly impact the recycling and reuse of sludge in agriculture. Understanding these factors is essential for developing effective and sustainable nutrient recovery solutions.

In countries like the Netherlands and Germany, the abundant availability of manure from livestock operations diminishes the perceived value of sludge as a fertilizer. Manure, being a readily available and nutrient-rich resource, directly competes with sludge, making it less attractive for agricultural use. This competition highlights a critical externality that water utilities must consider when promoting sludge-based products. The importance of addressing regional externalities to create new markets for nutrient recovery products is important. These include externalities such as urbanization and land availability when developing nutrient recovery strategies.

Another critical externality is the regulatory environment. While regulations are often perceived as a barrier, they can also provide a framework that supports the safe and effective use of recovered nutrients. However, the emphasis on regulations in discussions about nutrient recovery often overshadows other important externalities. For instance, the economic competition from industrial fertilizers, which are available cheaply and in large quantities, poses a significant challenge. The market value of recovered phosphorus products like struvite is hard to estimate, and farmers may be hesitant to adopt them due to a lack of knowledge and trust in their efficacy. This economic externality needs to be addressed through public education and demonstration of the benefits of nutrient recovery products.

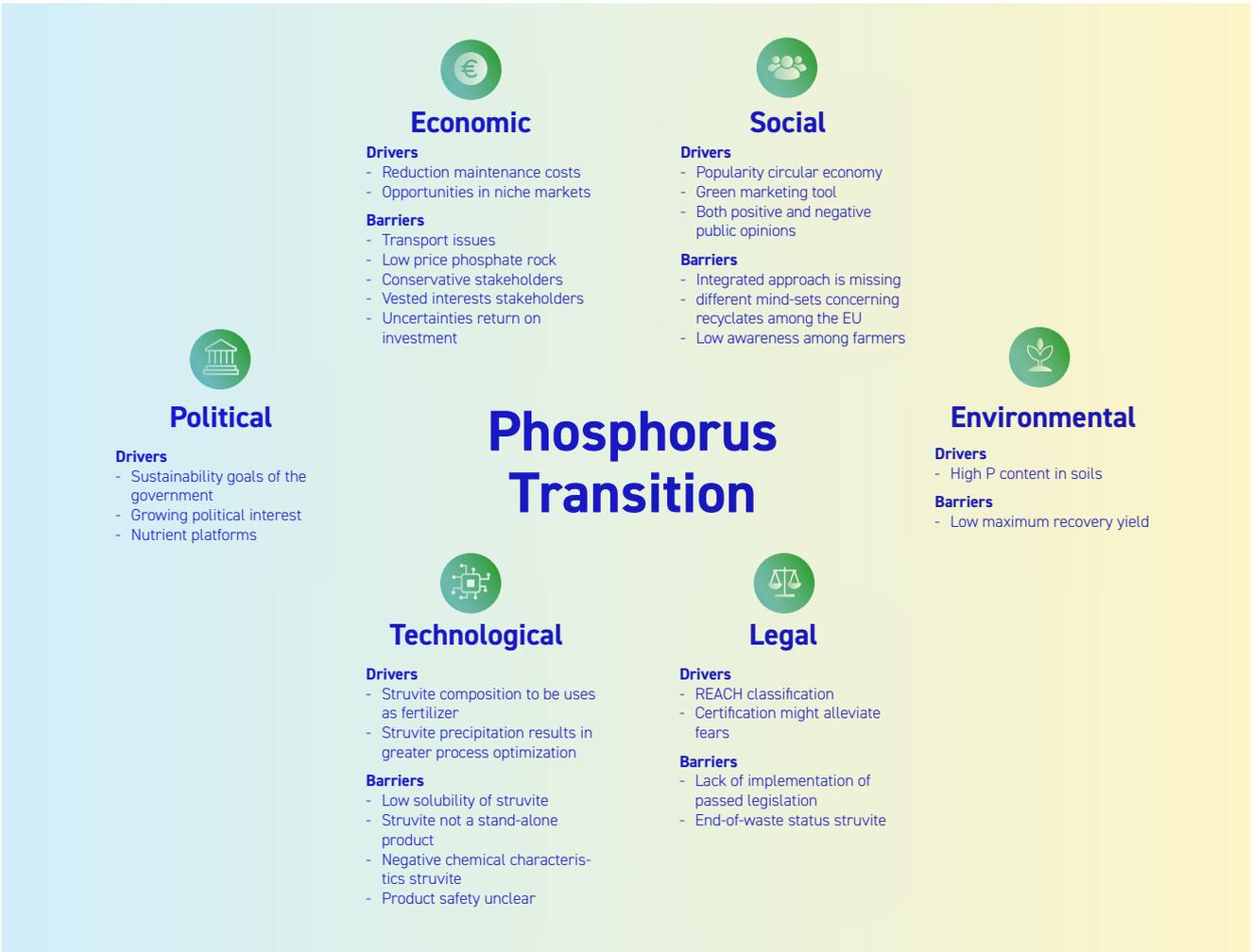
Transport and distribution costs represent significant externalities that can impede the use of sludge-based fertilizers. The high water content of sludge makes it expensive to transport, particularly over long distances from wastewater treatment plants to agricultural fields. This logistical challenge underscores the need for localized solutions and innovations in sludge processing to reduce its volume and improve its marketability.

Social acceptance is another crucial externality influencing nutrient recovery. Negative public perception of products derived from sewage can hinder their adoption, necessitating robust public education campaigns to build trust and acceptance. Geographic, climatic, and population factors further complicate the picture, as they affect both the feasibility of traditional recovery methods and the characteristics of the effluent being treated.

Insights from B-WaterSmart

Figure 3. An Assessment of the Drivers and Barriers for the Deployment of Urban Phosphorus Recovery Technologies: A Case Study of The Netherlands (Boer et al. 2018)

As part of the B-WaterSmart project, two Living Labs (LLs) – the water utilities of Alicante and Venice – have undertaken initiatives to explore the recovery of nutrients from wastewater and sludge for agricultural and other purposes. Alicante’s efforts are focused to transform wastewater treatment plants in Alicante into eco-factories through nutrient recovery, specifically ammonia, while addressing technological, regulatory, and market challenges. The case study from Venice focuses on on developing a decision support system (DSS) for sustainable water reuse, nutrient recovery, and sludge management. Their experiences, summarized below, highlight numerous lessons which include barriers and drivers. In addition, literature review of two countries, Germany and the Netherlands, further enriches this policy brief with lessons from nutrient recovery related policies and initiatives (See Table 1). The results, visualised in Figure 3, further substantiate the findings of the LLs. Besides policy and regulation related topics, to make nutrient recovery and market access viable for the products, two business case examples from Germany and Norway are elaborated below. These insights necessitate policy, regulatory, technical, and financial solutions to ensure the viability of these initiatives.



Drivers and barriers identified in the B-WaterSmart Living Labs in Alicante and Venice

Alicante, Spain

Nitrate-selective electrodialysis reversal (EDR) Piloting of novel membrane for nutrients separation from brines and use in fertigation¹¹.

Brine Electro-chlorination Piloting of technology for on-site production of sodium hypochlorite, used for disinfection.

Ammonia evaporation CEVAP Piloting of a novel low thermal evaporation technology (CEVAP) for ammonia recovery from anaerobic co-digested sludge.

The project is led by Aguas de Alicante that manages the wastewater treatment plant in Alicante. In Alicante, there are demands for nutrients recovery as there is a shortage of ammonia-based products and there exist several potential consumers of the recovered product. Generally, in Spain, approximately 12%¹² of wastewater is reused for agriculture, with significant regional variation. Most sludge in Spain is not treated in composting plants, leading to basic applications that fail to interest agricultural stakeholders due to potential pollution risks. Aguas de Alicante, which operates two wastewater treatment plants in Alicante, is relatively new to nutrient recovery topics.

The project aims to transform wastewater treatment plants into eco-factories or bio-factories, building on an existing strategy developed before the pilot project. Among the various tested technologies, one focuses on nutrient recovery, specifically ammonia. Traditional ammonia production has a high carbon footprint, but the tested process offers a more environmentally friendly alternative, presenting a promising solution. Despite being at the pilot scale and not yet a viable business case, the initiative has engaged with potential nutrient users. The ambition extends to converting wastewater treatment into bio-factories, with ongoing pilots targeting sludge post-digestion and exploring innovative, low-temperature ammonia recovery technologies.

Despite the potential benefits of nutrient recovery from wastewater, several barriers and drivers impede its implementation in Alicante. These barriers span technological, capacity, policy, and business domains, requiring comprehensive solutions to overcome them and realize the project's ambition of transforming wastewater treatment plants into eco-factories.

Technological Barriers

- Low Ammonia Concentration: Current ammonia concentrations are far below commercial viability (25,000 mg is minimum).
- pH Adjustment Needs: Processes sometimes require pH adjustments, complicating operations.



Selective electrodialysis: takes RO brine and separates divalent ions from monovalent ions. The stream with divalent ions will serve as reclaimed water. The stream with monovalent ions will serve as feed for the electrochlorinator



CEVAP

¹¹ Fertigation is an agricultural practice that combines fertilization and irrigation. It involves the application of fertilizers, soil amendments, or other water-soluble products through an irrigation system.

¹² AEDyR 2019.

- Salinity Issues: The presence of brine complicates nutrient recovery processes.
- Complex Laboratory Analysis: Analyzing and researching sludge in the lab is difficult due to its complex nature.

Capacity Barriers

- High Equipment Costs: The necessary equipment for nutrient recovery is expensive.
- Transport Costs: Product transport costs are high.
- Energy Consumption: Conventional ammonia production is energy-intensive, but alternative processes offer lower carbon footprints.
- Lack of Composting Plants: There are few composting plants in the region, leading to low agricultural interest in untreated sludge.

Policy Barriers

- Inconsistent Regulatory Framework: The current regulatory framework is fragmented and inconsistent, leading to uncertainty and lack of confidence among stakeholders.
- Lack of Regulation for Sludge Reuse: There is no clear regulation for the reuse of sludge, creating a grey area for nutrient recovery.
- Missing Nutrient Recovery Definitions: Existing EU directives (Wastewater Treatment Directive, Water Directive) do not address nutrient recovery or set thresholds for nutrients.
- Need for Regulation Updates: Regulations need updating to incorporate technological advancements, international best practices, and sustainability objectives.

Business Barriers

- Competitive Market: Market penetration is challenging due to the competitive agricultural sector.
- Lack of Business Case: Currently, there is no viable business case for nutrient recovery, though contact has been made with potential nutrient users. For now, sludge in Alicante is sent mainly to a cement factory for dewatering and usage, while roughly one third goes to agriculture and composting.
- Symbiosis with Industrial Partners: There is a need for collaboration with industrial partners, such as fertilizer producers and cement plants, to integrate nutrient recovery into

Recommended Measures

To make nutrient reuse for agriculture more viable in Alicante, several measures need to be implemented. Firstly, it is crucial to develop a supportive regulatory framework that clearly defines nutrient recovery processes and sets thresholds for nutrient content in treated sludge, aligning with technological advancements and international best practices. Financial incentives should be provided to encourage fertilizer producers to adopt these alternative processes, which reduces reliance on conventional, carbon-intensive methods. Additionally, efforts should focus on scaling up the nutrient recovery technology, ensuring the concentration of nutrients meets industry requirements for fertilizer production without increasing costs compared to conventional methods. Enhanced collaboration with waste managers and industrial partners, such as cement plants, can facilitate the integration of nutrient recovery into existing processes. Increased funding and support from regional governments are necessary, alongside maintaining a stable operational budget despite savings or alternative income streams from the wastewater treatment plant. Building local leadership and competencies in circular economy practices, along with more comprehensive research and discussions with waste managers, will further promote the successful implementation of nutrient recovery and its contribution to sustainable wastewater management in Alicante.



Venice, Italy

Ammonia stripping technologies to recover nitrogen from the concentrated liquid digestate of the anaerobic digestion. Assessment of the deviation of Liquid Organic Waste (usually oxidatively treated in the main WWTP) to the anaerobic digestion, to produce biogas and energy for supporting the process.

Digital Enablers: Integrated digital support system for Sludge and Effluent management, to create conditions (mainly in terms of an objective and sharable knowledge for quality and risks assessment) to sustain reuse and address resources to the right valorisation paths.

A collaborative, multidisciplinary environment of key stakeholders, established through the Decision Support System (DSS) development, capable of jointly identifying challenges, proposing solutions, and developing tailored strategies to achieve targeted, shared valorization goals.



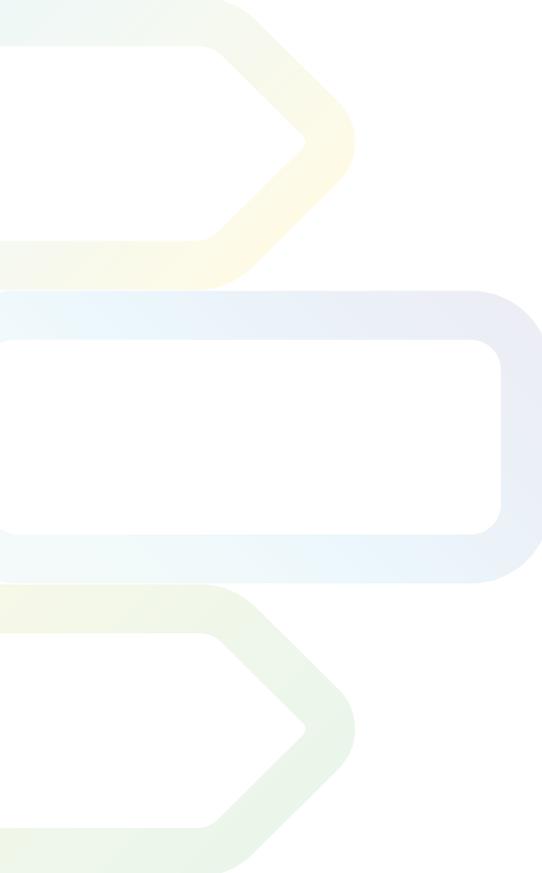
AIR – stripping



AIR – stripping



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In a public-private partnership, the public water utility VERITAS, Venice and the private company Engineering (ENG) develop together a Decision support system for water reuse and sludge management. The Veneto region, contributing approximately 7% to Italy's national water withdrawal, primarily relies on groundwater (90%) while the complement comes from surface water (mainly rivers). The wastewater, treated by more than 200 WWTPs in the region, allows indirect effluent reuse for agricultural, industrial, and recreational purposes.

Additionally, the Integrated Fusina Project (PIF) is part of the Regional Plan for Lagoon Protection and is located within the VERITAS area. The project employs a range of treatments, including nature-based solutions (NBS), to achieve non-potable reuse of treated municipal wastewater effluent.

The Venice Living Lab's ambition extends beyond immediate regional objectives, aiming to ensure proper resource valorization. Where applicable, it also seeks to enable the direct reuse of effluent for industrial, agricultural, and urban applications as part of a regional plan for climate change mitigation.

Special emphasis is placed on applying nutrient recovery technologies to wastewater treatment plants and developing shared evaluation model tools for a sustainable valorisation of WWTP effluents and sludge.

The specific key objectives are: i) to demonstrating both indirect and incentivising direct reuse of treated municipal wastewater; and ii) to identify and promote best practices in carbon and nitrogen recovery. These strategic objectives are pursued through the implementation of ammonia stripping technologies for nitrogen recovery, the development of two integrated, transferable, and interoperable DSS systems for sludge and effluent management and valorization, and the establishment of a Community of Practice (CoP) comprising key stakeholders working collaboratively on assessment and planning.

Technology Barriers

- Complexity of technologies, which vary depending on the technology applied (such as pre-treatment requirements for CS technology or the high energy consumption associated with AS technology) hampers the implementation of nitrogen recovery through ammonia stripping.
- Energy consumption is an implication common to both technologies studied

Capacity Barriers

- Fragmented knowledge and a lack of objective data on the risks and benefits of resource reuse, leading regulators to adopt overly cautious approaches. This, in turn, prevents the extraction of value from resources and reinforces negative perceptions, creating a significant barrier to fully exploiting reuse potential. Developing tools like the DSS to provide traceability, objectivity, and transferability in the evaluation process can help overcome these barriers.

Policy Barriers

- Fragmented and unclear regulatory framework at national and regional levels for circular economy development.
- Lack of interlinkage between water and waste policies, affecting resource valorisations; The presence of contradictions between policies at different levels, makes goal achievement difficult.

Business Barriers

- Ambiguity among the several regulations regarding sludge use (as described in current status), hampering viable business models. This situation leads to uncertainty allows room to economic speculation (which in turns determines the utilities choices), reinforcing prejudices.
- Lack of specific regulations for nutrient recovery, creating uncertainty concerning technological standards and hampering financial incentives. In this field, the choice has been delegated to the arbitrariness of different local authorities with the result of hindering the identification of a business model and the implementation of recovery itself.





Recommended Measures

To address policy and capacity barriers in the Venice case study, it is crucial to develop a cohesive regulatory framework that aligns water and waste policies at national and regional levels, ensuring clarity and consistency for nutrient recovery and sludge reuse. Introducing specific regulations with clear standards for nutrient recovery can reduce uncertainty and support viable business models. Enhancing collaboration between regulators, utilities, and industry stakeholders can help update regulations in line with technological advancements. Additionally, building knowledge-sharing mechanisms, like DSS, can provide objective data on resource reuse, while training programs can enhance stakeholders' understanding of nutrient recovery technologies. Encouraging regional partnerships can further support joint investments, helping to address energy consumption and technology complexity in nutrient recovery efforts. To address business barriers identified within the case study, fostering collaboration among water supply chain stakeholders can reduce ambiguity and regulatory uncertainty regarding sludge use and nutrient recovery. Leveraging EU and national incentives, such as the ARERA's MTI4 tariff method¹³, helps make nutrient recovery and treated effluent reuse more financially viable by providing clear support and recognition for resource reuse efforts. Implementing nature-based solutions where feasible can reduce reliance on costly, energy-intensive technologies, making nutrient recovery more cost-effective and appealing to businesses. Additionally, optimizing upstream wastewater control through direct collaboration with industries can ensure consistent and high-quality inputs for nutrient recovery, creating a more stable environment for developing business models around treated sludge and nutrient recovery.

¹³The ARERA's MTI4 tariff method is a regulatory framework established by the Italian Regulatory Authority for Energy, Networks, and Environment (ARERA) that sets guidelines for water service tariffs, including incentives for utilities to invest in resource valorization and sustainable water reuse practices.

A brief review of two country case studies from literature

Germany

[Roskosch and Heidecke 2018]

A paper titled “Sewage Sludge Disposal in the Federal Republic of Germany” by the German Environment Agency aims to provide an in-depth analysis of sewage sludge management practices in Germany, focusing on environmental impacts, regulatory frameworks, and technological advancements. It seeks to promote sustainable sludge treatment and phosphorus recovery, ensuring safe and efficient recycling methods. The key findings of the report are highlighted below.

Policy & Regulation

- Amended Sewage Sludge Ordinance mandates the phase-out of direct sewage sludge utilization on soil by 2029/2032.
- Recovery of phosphorus is mandatory when levels reach $\geq 20\text{g}$, with 80% recovery required when sludge is thermally treated.

Benefits and Drivers

- Reduced dependence on mineral phosphate imports amid rising demand and prices.
- New market opportunities and employment potential.

Barriers

- Lack of specific hygiene guidelines, except for salmonellae, leading to heavily restricted sludge application.

¹³In the context of nutrient recovery from wastewater sludge, under the Waste Framework Directive (2008/98/EC), achieving EoW status means that the recovered nutrients (such as nitrogen and phosphorus) are no longer considered waste but are recognized as valuable products that can be safely and effectively used, for example, as fertilizers in agriculture.

Netherlands

[Boer et al. 2018]

The study titled “An Assessment of the Drivers and Barriers for the Deployment of Urban Phosphorus Recovery Technologies: A Case Study of The Netherlands” aims to evaluate the key factors influencing the adoption of phosphorus recovery technologies in urban settings. By using the Netherlands as a case study, the research identifies the primary drivers and barriers from various stakeholders’ perspectives, focusing on economic, technological, legislative, and social aspects to better understand the transition towards sustainable phosphorus management in wastewater treatment facilities.

Policy and Regulation

- The Dutch Nutrient Platform: Has positively promoted wastewater-based nutrient recycling.
- Fertilizer Regulations and End-of-Waste (EoW)¹³ Status: Implementation has been a lengthy process, creating delays in the market acceptance of recovered nutrients.
- Shipment of Waste Regulation: Requires time-consuming contracts and authorizations for cross-border export, giving phosphate ore a market advantage due to fewer regulatory hurdles.
- Phosphorus EoW Status: Phosphorus lacks EoW status, which classifies Wastewater Treatment Plants (WWTPs) as waste management facilities subject to stricter rules.

Benefits and Drivers

- Reduced Maintenance Costs: For WWTPs through struvite precipitation, leading to cost savings.
- Process Optimization: Enabled by struvite precipitation, improving efficiency.
- Sustainable Labeling: For phosphorus recovery fertilizers, appealing to environmentally conscious consumers.
- Struvite Approval under REACH Regulation: Facilitates market acceptance.
- Geopolitical Tensions and Potential Scarcity: Future scarcity of phosphate rock increases the strategic importance of recycled phosphorus.

Barriers

- Transportation Issues: Limits the application of recycled nutrients outside the Netherlands due to phosphate-rich soils in the region.
- Low Sludge Production: In WWTPs, reducing the availability of raw material for nutrient recovery.
- Low Prices for Competing Phosphate Rock Products: Makes it difficult for recycled products to compete economically.

Barriers

- Regulations on phosphorus and nitrogen limit the permissible amount of sewage sludge fertilization.
- Technological limitations for advanced phosphorus recovery.

Recommendations

- Complete withdrawal from sewage sludge utilization on soil.
- Effective separation of pollutants from sewage sludge.
 - Wastewater treatment systems should support phosphorus recovery.
- Expand incineration capacities.
- Implement cost- and energy-efficient sewage sludge drying solutions.
- Provide financial assistance for phosphorus recovery.
- Facilitate market access for newly developed fertilizers.

Barriers

- High Investment Costs: Initial setup and maintenance costs for nutrient recovery technologies are substantial.
- Lack of Common Interest and Differing Mindsets:
 - Across the EU, there is a varied approach and interest in recycles.
 - Low Awareness and Preference for Traditional Fertilizers: Among farmers, leading to slower adoption of recycled nutrients.
- Infrastructure Limitations: Such as the lack of urine/ rainwater separation, which limits the maximum recovery yield.
- Low Solubility of Recovered Nutrients: Affecting their effectiveness as fertilizers.
- Overly Complex Solutions: Researchers sometimes develop solutions that are not market-oriented.
- Investment Return Uncertainty: Prevents long-term contracts with water boards, creating financial instability.

Recommendations

- Accelerate Regulatory Processes: Streamline the implementation of fertilizer regulations and the EoW status for phosphorus to reduce market entry barriers for recycled nutrients.
- Enhance Infrastructure: Invest in infrastructure improvements, such as urine/rainwater separation, to maximize nutrient recovery yields.
- Increase Awareness: Conduct targeted campaigns to raise awareness among farmers about the benefits and availability of recycled nutrients.
- Subsidize Initial Investments: Provide financial incentives or subsidies to lower the initial investment costs for nutrient recovery technologies.
- Promote Collaboration: Foster collaboration between researchers, policymakers, and industry stakeholders to ensure that solutions are market-oriented and address practical needs.
- Encourage Long-Term Contracts: Develop mechanisms to reduce investment return uncertainties, encouraging water boards to enter into long-term contracts.
- Leverage Geopolitical Advantages: Highlight the strategic importance of phosphorus recovery in the context of global supply uncertainties to attract investment and policy support.
- Facilitate Cross-Border Trade: Simplify the Shipment of Waste Regulation processes to make it easier to export recycled nutrients, levelling the playing field with phosphate ore.

Barriers to implementation

The integration of nutrient recovery from wastewater sludge into agricultural applications faces multifaceted technological, capacity, policy, and business barriers, as evidenced by examples from Venice, Alicante, Germany, and the Netherlands. Technologically, low ammonia concentrations, pH adjustment needs, and high salinity complicate the recovery processes, while the complex nature of sludge further hinders laboratory analyses and contaminant separation. These issues are exacerbated by the high costs and energy consumption associated with nutrient recovery equipment. Capacity barriers include scattered data, lack of decision support systems, and insufficient coordination among stakeholders, all of which impede the implementation of circular economy initiatives. Additionally, the limited number of composting plants and high transport costs restrict the viability of untreated sludge use in agriculture, leading to low agricultural interest in utilizing recovered nutrients. Policy and business barriers are equally significant in linking nutrient recovery to agricultural applications. The fragmented and inconsistent regulatory frameworks create uncertainty, lack of clear guidelines for sludge reuse, and no specific regulations for nutrient recovery, making it challenging to develop a viable business model for agricultural use. The absence of interlinked water and waste policies further complicates the classification and valorization of recovered nutrients, impacting their acceptance in agriculture. Business-wise, market penetration is difficult due to low awareness and preference for traditional fertilizers among farmers, compounded by the economic challenge posed by the low prices of competing phosphate rock products. High investment costs and the lack of financial incentives deter new investments, while the need for collaboration with industrial partners and the uncertainty surrounding investment returns further impede progress. Externalities outside of the utilities and wastewater processes are important to be considered while formulating an enabling environment, policies and businesses for sludge recovery and usage. Analysing the externalities can convert some of the barriers into opportunities. These barriers collectively highlight the need for comprehensive strategic planning, regulatory updates, and targeted incentives to foster the development of nutrient recovery and reuse markets, specifically tailored for agricultural applications.



Box: Business case for nutrient recovery and reuse

Despite the numerous barriers pointed out above, the business of nutrient recovery from organic waste streams is gaining momentum due to several factors. This includes the need to feed a growing global population with limited resources, climate change, diminishing global nutrient reserves (such as peak phosphorus), rising fertilizer prices, and stricter environmental regulations¹⁴. Examples of business cases, both on nitrogen and phosphorus, highlight the potential for companies to invest in nutrient recycling. The examples also refer to some of the challenges that businesses encounter for nutrient recovery and their application within the agro-food industry.

Phosphorus Recovery (UK and Germany)

The first phosphorus recovery plant in Europe was established through a public-private partnership (PPP) between Thames Water, a London utility, and Ostara Nutrient Recovery Technologies, a Canadian firm¹⁵. Ostara designed, built, and financed the facility, receiving monthly payments from Thames Water based on the cost savings from eliminating struvite build-up in the infrastructure. This arrangement enhanced the efficiency of wastewater treatment and improved environmental compliance.

In Dinslaken, Germany, a large-scale demonstration plant for phosphorus recovery and indoor food production exemplifies the business case¹⁶. By reclaiming phosphorus from waste streams, this cooperative venture funded by the BMBF (Regionales Phosphor Recycling) addresses resource scarcity and legal challenges. However, market access remains an obstacle due to recycled products still being classified as waste. Similarly, SF-SoepenberG GmbH plans a small-scale phosphorus recovery plant. Legal complexities persist, but the economic benefits—such as cost savings and revenue from hydroponics—make a compelling case.

Nitrogen Recovery (Norway)

In Norway, VEAS-Yara's nitrogen recovery from wastewater demonstrates a successful business model¹⁷. Ammonium nitrate solution is sold directly to industrial users, with surpluses recycled in fertilizer production. The alignment of economic gains, environmental benefits, and health considerations strengthens the case.

¹⁴ Otoo 2018.

¹⁵ Water World 2010; Jenks 2024.

¹⁶ Agrobusiness Niederrhein e.V. 2023.

¹⁷ Buckwell and Nadeu 2016.

Opportunities and Recommendations

The opportunities for sludge management and nutrient recovery in the EU are substantial, bolstered by policy support and funding from initiatives such as the LIFE ENRICH project, Water2Return project, and WalNUT program. These efforts highlight the potential for turning waste into valuable resources, transforming wastewater treatment plants into revenue-generating entities. For instance, the annual sewage sludge volume in Germany alone could yield 50,000 tons of phosphorus, significantly reducing the need for imported fertilizers and enhancing food security¹⁸. Moreover, successful examples like the Oslo wastewater treatment plant, which recovers 750 tons of nitrogen annually, underline the potential for similar projects to decrease operational costs and attract private investments¹⁹. With sludge treatment and disposal accounting for up to 60% of a plant's operating costs, integrating nutrient and energy recovery processes, such as co-digestion, can substantially enhance efficiency and sustainability in the sector.

At EU level



Policy and regulations

Develop an EU Roadmap for Biosolids/Sludge Management

Co-produce a comprehensive roadmap that includes societal benefits, nutrient bioavailability, and energy content considerations.

Harmonize policies

Ensure coherence between biosolids recovery and biogas production policies and targets.

Revise Biosolids Directives

Update the EU directive on biosolids use in agriculture, setting clear standards and responsibilities along the biosolids value chain. Exclude biosolids from waste legislation to foster a circular economy.

Create comprehensive regulations

Establish EU-wide regulations for organic fertilizers from urban wastewater, ensuring market acceptance and clear responsibility allocation.

Monitor Phosphorus as a critical material

Implement ongoing monitoring and update regulations to adjust phosphorus recovery targets from urban wastewater.

Promote nutrient recovery research

Encourage research on nutrient recovery technologies and their impacts on soil, vegetation, animals, and humans.

¹⁸ European Commission 2024 (a,b,c).

¹⁹ Buckwell and Nadeu 2016



Finance

Investment incentives

Provide financial incentives for water utilities and private firms to invest in nutrient recovery technologies.

Funding for Research

Allocate EU funds for research on advanced nutrient recovery technologies and their environmental impacts.



Technical

Standardize technology

Develop and promote standards for nutrient recovery technologies to ensure compatibility and efficiency across the EU.

Promote advanced technologies

Support the development and deployment of technologies that recover nutrients in concentrated forms, improving reuse potential and transportation efficiency.



Policy and regulations

Local adaptation

Integrate local specificities into nutrient and biosolids management systems to ensure context-appropriate solutions. This can include withdrawal of direct sludge based on the availability, externalities and specific recommendations at a member state level

Sludge round table

Establish a “Sludge Round Table” to monitor and evaluate sludge management practices, involving all relevant stakeholders to update regulations and address legal concerns.

Address Externalities

Assessment of externalities, which are mostly local or regional should inform formulation of policies and businesses for sludge recovery and usage. Externalities can become opportunities instead of barriers



Finance

Optimize existing infrastructures

Prioritize the adaptation of existing sludge infrastructures for co-digestion, maximizing resource use and benefits.

Regional funding

Provide regional funds for the optimization and upgrade of existing sludge management facilities, rather than solely focusing on new infrastructure.



Technical

Infrastructure upgrades

Focus on upgrading existing sludge treatment facilities to incorporate co-digestion processes, enhancing efficiency and resource recovery.

Local solutions

Develop tailored technical solutions that address the specific needs and conditions of different regions, ensuring effective nutrient and biosolids management.

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