Resource-oriented sanitation

Closing the gap between fork and farm for circular nutrient flows

Key takeaways

- Resource-oriented sanitation is an alternative sanitation approach that focuses on enabling nutrient recovery and reuse, either through source separation of human excreta or nutrient recovery.
- It is a solution to a quadruple crisis: the disruption of nutrient flows, pollution of water bodies, novel entity introductions to the planet, and climate change – four planetary boundaries that have already been crossed.
- It is also fully aligned with the European Green Deal and has the potential for delivering on key dimensions that are climate neutrality, sustainable food production, a circular economy and zero pollution.
- Developing resource-oriented sanitation makes it necessary to adapt the wastewater policy framework, as well as to support the development of a market for recycled nutrients in agriculture.

The quadruple crisis

Nitrogen (N) and phosphorus (P) are two essential nutrients for life on Earth that go through natural cycles. With the advent of conventional sanitation and industrial agriculture, **these cycles have been severely disrupted, to the point of breaching planetary boundaries**[1]. This has led to a paradoxical situation: on the one hand, nutrient accumulation from wastewater and agriculture is polluting water (and groundwater) bodies, leading to eutrophication and devastating aquatic ecosystems[2], all in a context of growing water scarcity. On the other hand, with conventional sanitation, nutrients must be removed from wastewater through a costly process, while at the same time fertilisers used in agriculture rely on geopolitical-dependent finite phosphorus resources (P) and on the energy-intensive Haber-Bosch process for nitrogen fertilisers.

What is Resource-oriented sanitation?

To these multiple challenges, resource-oriented sanitation appears as a promising answer. Rather than focusing on disposal, as conventional sanitation does, **this alternative approach focuses on enabling nutrient recovery and reuse,** including through source separation of human excreta (urine and faeces) for fertiliser and wastewater reclamation for fertigation of land. It presents several benefits: besides the production of renewable fertilisers, it can generate savings in water and energy, and help to protect aquatic ecosystems as well as water resources. Relying on circular economy principles, resource-oriented sanitation covers a wide range of solutions, from high- over medium-to low-tech, and from decentralised to hybrid-centralised[3]. Practically, it poses an excellent solution to achieving the increased nutrient removal requirements posed by the UWWTD amendment[4]. Decades of research and pilots in countries like Sweden, Switzerland, France and Germany have demonstrated that resource-oriented sanitation not only works, while there is growing evidence that is as safe as

[1] Earth beyond six of nine planetary boundaries, Richardson et al., 2023

[2] Jansson, T., Andersen, H. E., Gustafsson, B. G., Hasler, B., Höglind, L., & Choi, H. (2019). Baltic Sea eutrophication status is not improved by the first pillar of the European Union Common Agricultural Policy. Regional Environmental Change, 19(8), 2465–2476.

[3] Resource Oriented Sanitation, International Water Association

[4] Revision of the Urban Wastewater Treatment Directive In "A European Green Deal"

conventional sanitation[5] (considering pathogens but also pharmaceuticals or heavy metals)[6], on top of being beneficial for communities and the environment.

Why is this important for Europe?

Resource-oriented sanitation has the potential to contribute to the four key pillars of the EU green Deal: **climate neutrality**, the **farm to fork strategy, the circular economy action plan** and the **zero pollution ambition.**

- **Climate neutrality**: Resource-oriented sanitation can greatly reduce GHG emissions associated on the one hand with the production of non-recycled fertilisers and their use, on the other with wastewater treatment[7].
- **Farm to Fork Strategy:** An essential component of integrated nutrient management, resource-oriented sanitation can contribute to more sustainable, self-sufficient local food production by lessening reliance on fertiliser imports and dependency on energy markets. As a rough estimate, European human excreta nitrogen equates to twice the amount of current net synthetic nitrogen fertilisers imports to Europe.
- **Circular Economy Action Plan**: circular nutrient flows can create new circular revenue streams, through recycled nutrients and wastewater reuse. As a comparison, the value of the EU fertiliser market reached EUR 17 billion in 2017, roughly half of it being imported[8].
- **Zero-Pollution Ambition:** with a focus on prevention (the first step of the zero pollution hierarchy[9]), resource-oriented sanitation has a greater potential for improving water quality in Europe and reducing eutrophication[10] (whereas conventional sanitation focuses on minimising and controlling). It links to the Mission Ocean for restoring our waters and oceans by 2030.

What should be done?

Eco-villages and research projects in the 1990s proved the feasibility of the concept, and resource-oriented sanitation has now reached global diffusion[11]. However, currently in the EU, the recycling rate of nitrogen from human excreta is below 10%,[12] and only 2.4 % of the total treated urban wastewater is being reclaimed and reused.[13]

A series of challenges remain that require concerted and decisive action from policy-makers to mainstream resource-oriented sanitation and ultimately contribute to the Green Deal objectives.

1. Adopt an enabling framework for resource-oriented sanitation, including:

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[5] Minier, Paul, Esculier, Fabien, Tassin, Bruno, Chatzis, Konstantinos, 2023. Can sewerage be considered safe management of human feces ? City and Environment Interactions (Vol. 19, p. 100107).

[6] Guidelines for the safe use of wastewater, excreta and greywater - Volume 4, WHO

[7] Martin showed in 2021 that a shift to source separation could divide GHG emissions by 3.5 and eutrophication by 8 in wastewater management. Source: https://hal.science/tel-03189185

[8] https://agriculture.ec.europa.eu/data-and-analysis/markets/overviews/market-observatories/fertilisers_en

[9] EU Action Plan: 'Towards Zero Pollution for Air, Water and Soil'

[10] Martin (2021), ibid.

[11] The potential contribution of urine source separation to the SDG agenda – a review of the progress so far and future development options, Larson et al., 2021,

[12] Fate of nitrogen in French human excreta: Current waste and agronomic opportunities for the future, Science of The Total Environment, Starck, Fardet, Esculier, 2024.

[13] Water reuse, WISE-freshwater, European Commission, 2024

- **Ambitious targets for nutrient reuse and recovery**, as well as ambitious targets for reduced nutrient concentrations in water bodies.
- **Full alignment with the zero-pollution hierarchy,** where prevention is better than cure. Source separation of urine and faeces should be preferred whenever possible, as it has the greatest potential for eliminating wastewater contaminants in a targeted manner, and reaching both higher nutrient recovery rates and lower nutrient concentration in effluents.
- **Flexibility in implementation:** the framework should accommodate various sanitation solutions, adapted to the great diversity of human settlement in Europe. It should not mandate centralised nutrient recovery which will create sanitation system lock-in, nor restrict resource-oriented sanitation use to recover nutrients only in the face of local restraints (such as lack of space, high infrastructure costs and high energy requirements of incorporating nutrient removal into a given wastewater treatment plant).

2. **Support the uptake of recycled nutrients in agriculture**:

- **Regulatory barriers to the use of secondary nutrients should be lifted.** Legislative frameworks should make provision for appropriate procedures to allow and incentivise their use. Uniform requirements across the EU to allow their use and appropriate standards to ensure compliance should be developed.
- **A level-playing field should be established with mineral fertilisers.** This includes the introduction of a tax on non-recycled nutrients or a tax on pollution (including GHG emissions and nitrogen).
- **Raise awareness** and **support farmers** in using recycled nutrients as part of the Common Agricultural Policy (CAP): early adopters in the farming community should be supported, with subsidies but also training. **Information campaigns** should be carried out towards all actors of the food supply chain.

3. **Break silos and bring all actors together:** 'Pull' and 'Push' policies and actions must be supplemented by cross-cutting actions, as resource-oriented sanitation is nothing less than a paradigm shift. This includes **awareness-raising**, towards all stakeholders and the wider public, as well as **engagement of all actors** to defuse oppositions and identify opportunities for collaboration. A **platform** to bring together all stakeholders should be created to exchange knowledge, connect all levels of government and geographies, and clearly delineate roles and responsibilities.

To go further

- Do we need New Alternative Sanitation Systems in Germany?, DWA, 2010.
- Quel intérêt pour la séparation à la source dans la gestion des eaux usées domestiques en France ?, ARCEAU Ile-de-France, 2023. (FRENCH)
- **Stay tuned!** Reports and guidance on resource-oriented sanitation will be developed in P2GreeN in 2025 and 2026.

Who are we?

Funded by the EU under the Horizon Europe program, P2GreeN aims to foster a paradigm shift, from a linearly organised resource and nutrient system within the agri-food supply chain, towards a circular material flow system between urban and rural areas. It will demonstrate innovative N & P recovery solutions for the utilisation of human sanitary waste from urban settlements and its conversion into safe bio-based fertilisers for agricultural production in three pilot regions – the island of Gotland (SE), the North German Plain (DE), and the region of Axarquia (ES).

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Funded by the European Union