Closing waste water cycles for nutrient recovery

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United Nations (UN) projections estimate that the world's population will reach 8.6 billion in 2030 and 9.8 billion in 2050 (United Nations, 2017). Then, population and consumption will add a huge pressure on food industry to increase its production. To meet this additional demand requires an increase of the intensive agricultural practices, leading to a high land, water, energy, and fertilisers use (Godfray et al., 2010). Therefore, a demand on plant nutrients is expected. Non-renewable mineral fertilisers, formed by N, P, K and Mg, base current agricultural system. From an agronomic point of view, crops take up to the 31-49% of the N and 35% of the P supplied. Nutrient inefficiencies such as denitrification, volatilisation, leaching, runoff losses and mineralisation cause accumulation of nutrients in soil and water sources contributing to the acidification and eutrophication of ecosystems (Timilsena et al., 2015). Additionally, the resulting emissions of NO_x, CO_2 and NH_3 etc. poses in serious environmental threats like global warming and tropospheric ozone formation. Furthermore the discharge of high amounts of nutrients causes coastal eutrophication, which removes oxygen from water, creating 'dead zones', waste water (WW) also conduct mercury, lead, emerging pollutants and marine litter.

The EU is highly dependent on imports of raw materials for fertilising purposes. According to Fertilizers Europe (2020), in 2019 the EU imported 28% of N, 66% of P and 71% of K of the total nutrients that were consumed as fertiliser products. Some of them such as P or Mg have been qualified as Critical Raw Materials by the EU COM(2017)490. These are crucial for EU growth, competitiveness and especially for a sustainable food industry. Furthermore, their transport requires high amounts of fuel consumption.

European soils are an invaluable and limited resource which are suffering N and P surplus or deficit due to agricultural practices leading to inter and intraregional imbalances. Emerging technologies to recover nutrient from bioresources such as, animal manure, by-products of the agri-food, fisheries, aquaculture or forestry sectors and WW and sewage sludge are considered a sustainable alternative to solve this imbalances.

WW is considered a promising resource to recover nutrients for plant fertilising purposes. Large-scale nutrient recovery (NR) from these streams and their processing as bio-based fertilisers (BBFs) will offer a new, circular and sustainable model tackling both, the limited nutrient-mineral reserves, and their crucial environmental issues. N and P removal from WW is required under the WW Directive (91/271/EEC). However, this directive not requires nor incites to recover or reuse those valuable nutrients, while only focusses on N and P removal. Conventional WW plants consume high amounts of energy for nutrient removal via aerobic activated sludge, nitrification-denitrification, chemical phosphorus removal and coagulation-sedimentation. This model represents a linear approach, and it is necessary to urgently shift it towards a circular one (Figure 1). NR is a more valuable alternative to treat WW from nutrients because: (i) it produces nutrient-based fertilisers ensuring food safety (the new EU 2019/1009 revision on fertilisers includes the use of fertilisers recovered from various waste streams); (ii) it minimises the environmental carbon footprint of WW treatment (less sludge and eutrophication); (iii) it uses the nutrients as secondary resources for preserving natural reserves and saving costs associated with N fixation.

Focusing on NR technologies, variables to consider: inlet stream origin, recovery efficiency, cost, end-products purity, geographical conditions, social, economic and environmental factors. Their identification and quantification are the key element to identify lock-ins and barriers in the performance technologies targeting the synthesis of BBFs. Recovered nutrients, integrated with improved fertiliser design will enhance a sustainable impact. Agronomic efficiency and limited presence of contaminants/pathogens in BBFs guarantees that EU farmers receive high quality and sustainable products while protecting consumer's heath. Only then, these novel fertilisers could disrupt into the market.

WalNUT project addresses the current gaps in nutrient cycles of different European WW treatment systems and their related environmental problems by implementing optimised management systems whilst having a positive trade–off with productivity, quality and environmental impact. WalNUT is a partnership which includes applied practice oriented research institutes and universities, WW treatment companies, agro-businesses, non-profit stakeholder associations and regional governments.

The overall objective of WalNUT is to develop, assess and test 5 new integrated and sustainable technological solutions for highly efficient and effective NR from 5 WW streams (urban, industrial, food, sewage sludge, brine from water desalination and demineralisation plants). Thus, by the cutting-edge sustainable innovations proposed in terms of techno-economic feasible solutions and safe and high-quality products (BBFs) from different WW streams, WalNUT will assure BBFs' public and regulatory acceptance and market incursion. Promoting a circular economy context towards the replacement of non-renewable mineral fertilisers in the EU agricultural sector.

Main objectives.

- Detailed analysis and evaluation of inter and intraregional nutrient imbalances (surplus and deficit) based on a sustainable transferability model.
- Develop sustainable and resource-efficient technological solutions for nutrient recovery from waste water streams.
- Comprehensive identification and assessment of the environmental and socio-economic impacts of the new proposed solutions for nutrient recovery through a life-cycle assessment.
- Evaluation of agronomic efficiency of safe bio-fertilisers and their potential to replace conventional, non-renewable mineral obtained via more sustainable processes.

Expected results.

- Reincorporate materials that are currently "leaking" from EU economy.
- Implement more sustainable waste water treatment models.
- Protect the environment.
- Define a food system that promotes food security, human and ecosystem health.
- Promotion and development of policies at all levels for the use and marketing of fertilisers.
- Promote new EU economic business models to ensure the development of competitive bio-ferttilisers.

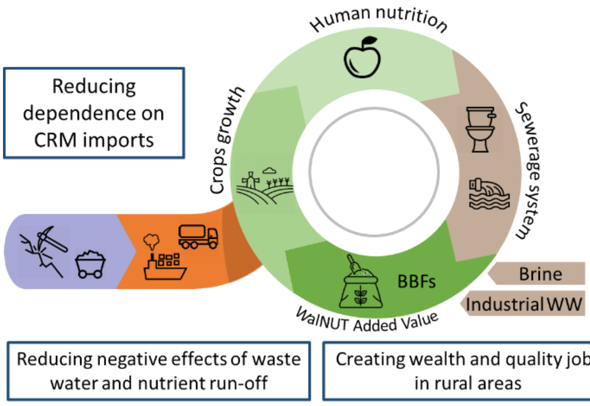

Figure 1. WalNUT Roadmap

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