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Potential recovery of phosphorus in the Portuguese urban sector: an opportunity for a critical raw materials supply?

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Abstract

Phosphorus (P), which plays an important role in the food sector, is facing a global shortage. It has been identified as one of the materials at risk of scarcity, and in 2014 was declared as a critical raw material by the European Union. Studies indicate that the only way to close the P loop in the European Union is to recycle P from waste streams back into the food chain. In Portugal, the loss of P after wastewater treatment and landfilling has considerable value, motivating the evaluation of recovery and potential recovery of phosphorus. In addition, sludge from wastewater treatment plants (WWTP), which represents a specific flow of this sector, was also identified as having a high potential for P recovery. This work presents a preliminary assessment of the circularity of phosphorus in the urban cycle and the corresponding technical and political issues involved.

Author Keywords. agricultural fertilizers, Circular economy, Phosphorus, Valorization potential, WWTP sludge,

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1. Introduction

Studies indicate that the only way to close the phosphorus (P) loop in the European Union is to recycle this nutrient from waste streams back into the food chain, it plays an important role as agricultural fertilizer for food production, and it is facing a global shortage, been identified as one of the materials at risk of scarcity, and in 2014 was declared as a critical raw material by the European Union (Blankesteijn, 2019).

The Urban Wastewater Treatment Directive (Directive 91/271/EEC, 1991) and its recent proposal, the Waste Framework Directive (Directive2008/98/EC, 2008), as well as the new EU Fertilizing Product Regulation (Regulation(EU)2019/1009, 2019), within the framework of the EU Circular Economy Package (COM98, 2020), all point to increase recycling efforts, to improve resource efficiency, and to strengthen biowaste management. These directives have been reformulated to consider nutrients recovered from wastes as raw materials. Also, the specification of valued materials for raw material sources has been provided by the European

Fertilizing Product Regulation, contributing to closing nutrient cycles within the EU member states (Garske et al., 2020).

Experimental studies have already proved the significance of P recovery from wastewater, which could enable the provision of supplementary fonts to fertilizer stocks, indicating that P recycling from different EU waste streams can potentially meet up to 30% of national demand (El Wali et al., 2019). The Global Compendium of Phosphorus recovery from Sewage/Sludge/Ash (2019), points out that no environmental protection measure would have been implemented without law enforcement, especially when it leads to additional costs since the legal framework is tailored for the existing status quo and is very slow in adapting to future challenges. The re-definition of *End-of-Waste* criteria is a tough process, but also a prerequisite to enable value chains to bridge the gap between recovery and recycling. Most of the technologies can also be adapted and applied in anaerobic digesters in landfills.

Portugal, according to Van Dijk et al. (2016) ranks third among European countries with the highest concentration of phosphorus in agricultural soils (13.2 kg P/ha·year), has a significant potential to reduce imports of phosphate fertilizers, and/or to market the recovered P, to countries with a lower nutrient balance.

This research focuses on estimating the potential value of P recovery in the Portuguese waste and wastewater sectors by characterizing and evaluating the circularity of phosphorus within its production and consumption chain, based on demographic, spatial, and economic data.

2. P in wastewater and solid waste in Portugal - potential for resources recovery

Golroudbary et al. (2020) found that some countries (in which Portugal is included) would not improve their decisions related to phosphorus recovery and use, concluding that reuse policies represent a higher limitation than resource recovery technologies.

Based on recent data concerning P present in WWTP sludge, provided by the Portuguese waste and water reports (ERSAR, 2023), and in solid waste, according to the *Code of good agricultural practices* (2018), and expanding analysis for P consumption in agricultural soils (INE, 2021), it is possible to clearly visualize that the potential for P recovery through the solid waste and wastewater sectors would be sufficient to supply all P soil demand, as depicted in Figure 1, and even to explore its commercial value as a recovered raw material.

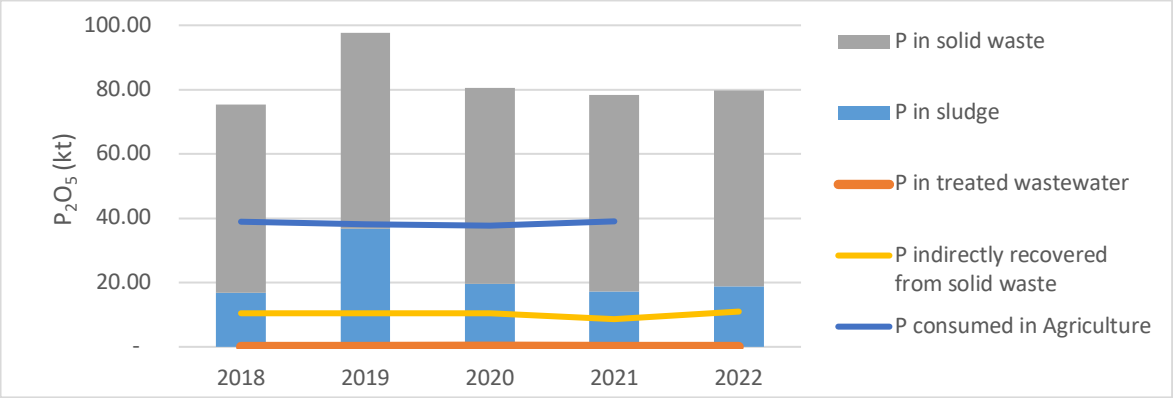

Figure 1: Evolution of P content in wastewater and solid waste (2018-2022)

According to the *Decreto Lei Nº. 276/2009*, which regulates sludge management and its use in agricultural soils, even after its recovery, the reuse of P still faces some challenges, related to sludge and soil characteristics, the dependence on spatial and climate conditions, suggesting the need for a strategic sludge plan management. However, nutrient products resulting from the crystallization of phosphorus, having the possibility of being used as

fertilizers, must pass through the scrutiny of the national regulations related to the fertilizer market.

3. Conclusions

This study constitutes an initial approach to the implementation of phosphorus circularity and the promotion of the circular economy through its valorization. From the work carried out, it can be concluded that the wastewater and waste sectors have great potential for enhancing phosphorus recovery throughout their life cycle. Portugal, in addition to presenting a great potential for P recovery, presents a considerably favorable soil P balance, which would generate a surplus of recovered P, that can be valued.

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