Sustainable Phosphorus Recycling from Secondary Resources in Europe: Challenges and Opportunities

Aleksandra Bibow [1]*, Monika Karsznia [1], Piotr Skowron[1], Damian Wach[1], Agata Witorożec-Piechnik[1], Cheryl Marie Cordeiro[2], Erik Sindhoj[2]

1 IUNG Institute of Soil Science and Plant Cultivation – State Research Institute, Czartoryskich 8, 24-100 Puławy, Poland, abibow@iung.pulawy

2 RISE Research Institutes of Sweden, Box 14092, 40020 Göteborg, Sweden, cheryl.marie.cordeiro@ri.se

FERTITEC – INNOVATIVE RECOVERY TECHNIQUES FOR ALTERNATIVE FERTILISERS

BACKGROUND

Phosphorus (P) is an essential nutrient for global food production, yet its management faces growing environmental, economic and geopolitical pressures. Secondary resources, such as manure, sewage, sewage sludge, food waste and industrial by-products, offer significant potential for phosphorus recycling, particularly in the face of increasingly limited access to high-quality phosphate rock. Despite growing interest in nutrient recycling in agriculture and increasing EU policy support in this area, the sector still faces numerous challenges, highlighting the need to develop strategies for phosphorus recovery and recycling.

METHODOLOGY

This study utilised secondary data analysis, based on a review of the literature, to assess the current state of technology development for the recovery and recycling of secondary raw materials, identify the main obstacles, and suggest possible directions for further development. The analysis is based on an extensive review of the scientific literature using publicly available databases and on the results obtained to date by the project consortium.

CHALLENGES

Economic and regulatory

- high variability in the composition of raw materials and dispersed sources of raw material
- risk of contamination (heavy metals, pathogens, plastic)
- low solubility of natural forms of phosphorus, it is crucial to convert insoluble P forms into assimilable
- lack of standard methods for the labelling of recycled P-forms (difficult quality assessment)
- complex, energy-intensive, requiring large amounts of reactants)
- difficulties in transporting and storing large volumes of materials

Economic and regulatory

- high cost of transport and processing/production of recycled fertilizers
- struvite 2–14× more expensive than phosphate rock fertilizers
- complicated waste treatment procedures
- strict FPR and REACH regulations for struvite, biochar, ash
- low competitiveness compared to conventional fertilizes
- limited production scale

Environmental and social

- uneven release rate of components
- rate of release of components uneven
- difficult to apply in the field, requiring specialized equipment (dusty or large volumes)
- sanitary concerns and low acceptance among farmers

MAIN RESOURCES FOR P RECOVERY AND THEIR ESTIMATED CONTRIBUTION

Manure	15-20 Mt P/year^{-1}
Food waste	570 Mt/year (global)
Sewage sludge	10-40% (standard), 60-70% (vivianite)
Ash from sludge and bones	high P content ~ 3-5%
Bioprocessing industry	high P content ~1-3%

OPPORTUNITIES

- reducing dependence on phosphate rock imports
- the development of technologies combining acidification and thermal hydrolysis increases recovery by 13-50% (in the case of manure alone, by an additional 131 kt P yr^{-1})
- development of high-purity vivianite and struvite technologies use of existing infrastructure of treatment plants and biogas plants
- standardization of analytical methods for the determination of recycled phosphorus forms
- improving the logistics of waste collection and transport
- increasing the scale of production of recycled phosphorus fertilizers
- economic incentives (e.g. tax breaks)
- improving soil quality with the use of composts and biochar
- education and building social acceptance

CONCLUSIONS

Phosphate rock is a finite source of phosphorus. Measures must be implemented to facilitate the recovery of phosphorus from sources that can be replenished without causing concern for depletion. Such sources may include nutrients derived from various waste streams, and replenishing them is part of the circular economy. From a technological perspective, nutrient recovery systems are advancing but remain constrained by complexity, energy intensity, and scalability. Developing innovative solutions is essential for creating tools to address phosphorus recovery challenges from secondary sources in Europe.

VISIT: fertitec-project.eu
CONTACT US: info@fertitec-project.eu

RISE Research Institutes of Sweden · Q-PLAN INTERNATIONAL · cetenma · Luke · IUNG · AgroApps · EAFF

Funded by the European Union under GA no. 101181513. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or REA. Neither the European Union nor the granting authority can be held responsible for them.

Funded by the European Union