Environmental evaluation of phosphorus recovery processes from wastewater sludge using LCA

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1. Introduction

An environmental analysis has been performed on phosphorus recovery from sewage sludge technologies (EuPhoRe®, Struvia™, Parforce and PULSE). The aim was to quantify the environmental impacts of these technologies and to compare their environmental performance with these of the reference system. The life cycle assessment method has been used for this purpose.

This analysis has been performed on the entire project in order to identify the most impactful steps for each demonstrator and based on those to draft eco-design advice.

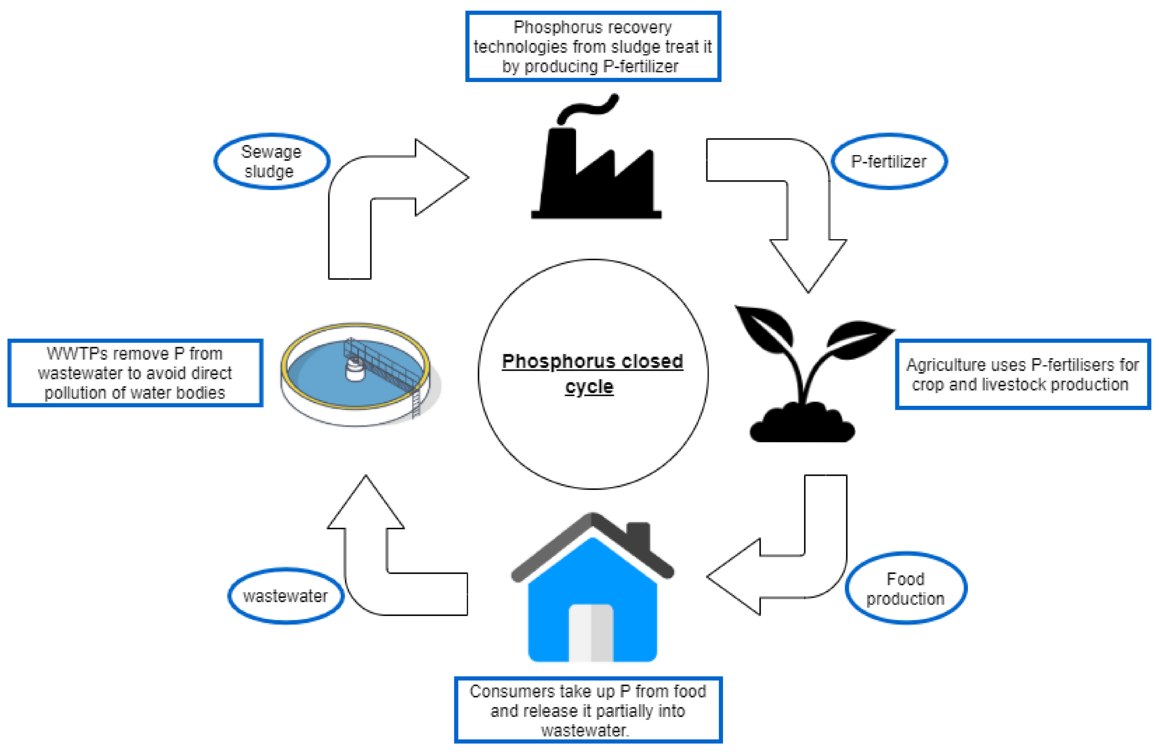

Figure 1: Basic principle of the closed anthropogenic phosphorus cycle

2. P-recovery LCA methodology

- Included: impacts of the wastewater treatment plant that produces the sludge used for phosphorus recovery.
- Two LCA methodological approaches: system expansion and avoided burden.
- Reference systems: included:
  - Sludge-producing treatment plant
  - Bio-digestion of the raw sludge & cogeneration of the biogas produced
  - Incineration of the digested sludge

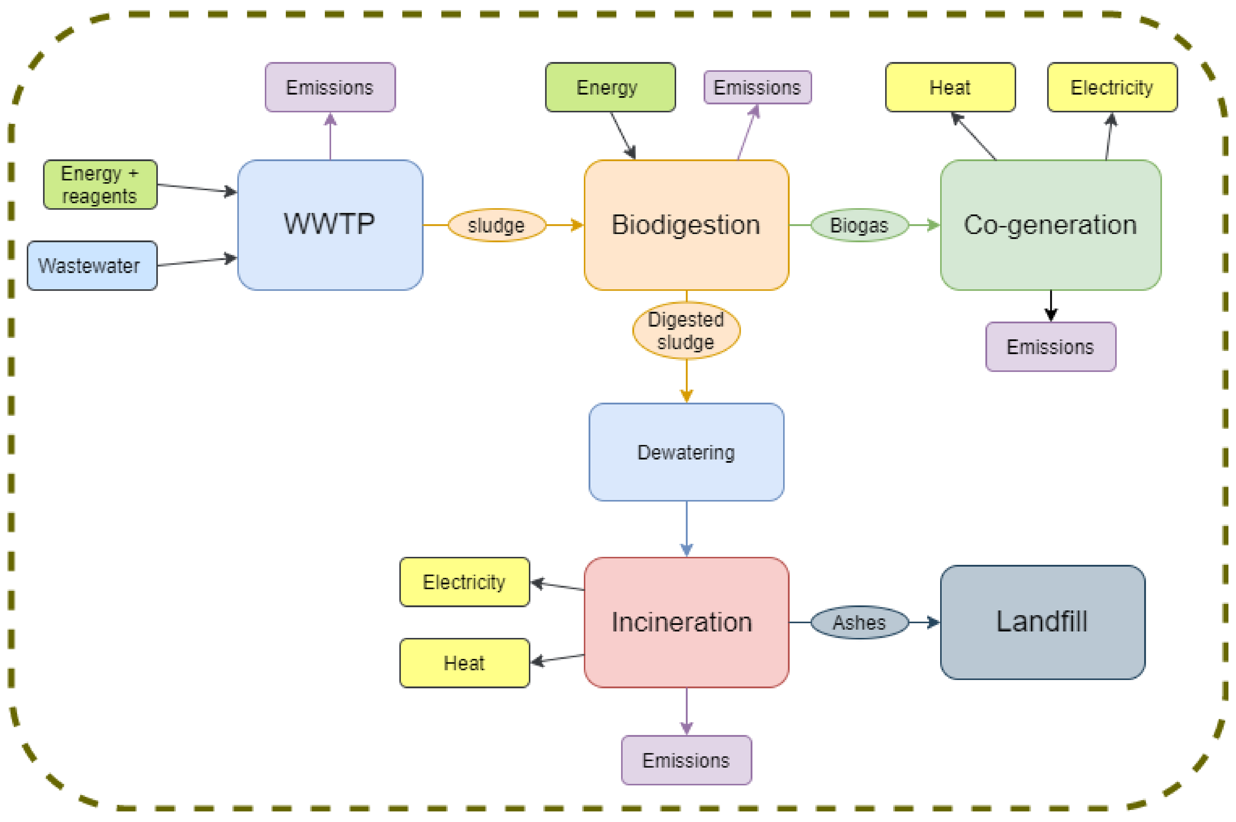

Figure 2: Boundaries of the reference system with the avoided burden methodological approach [1]

3. P-rich product : LCA results

→ Identification of the most impactful stages of each recovery process from an environmental point of view.

- **EuPhoRe®** : Benefit of heat recovery
- **Struvia™**: Detrimental impacts: electricity and polymers
- **Parforce**: Significant impacts: hydrochloric acid, electricity and heat.
- **PULSE**: Significant impact: preliminary drying stage, extraction solvent (use and recycling)

→ Benefits : **Cogeneration** of the **biogas** produced & of the recovery of energy during **incineration**

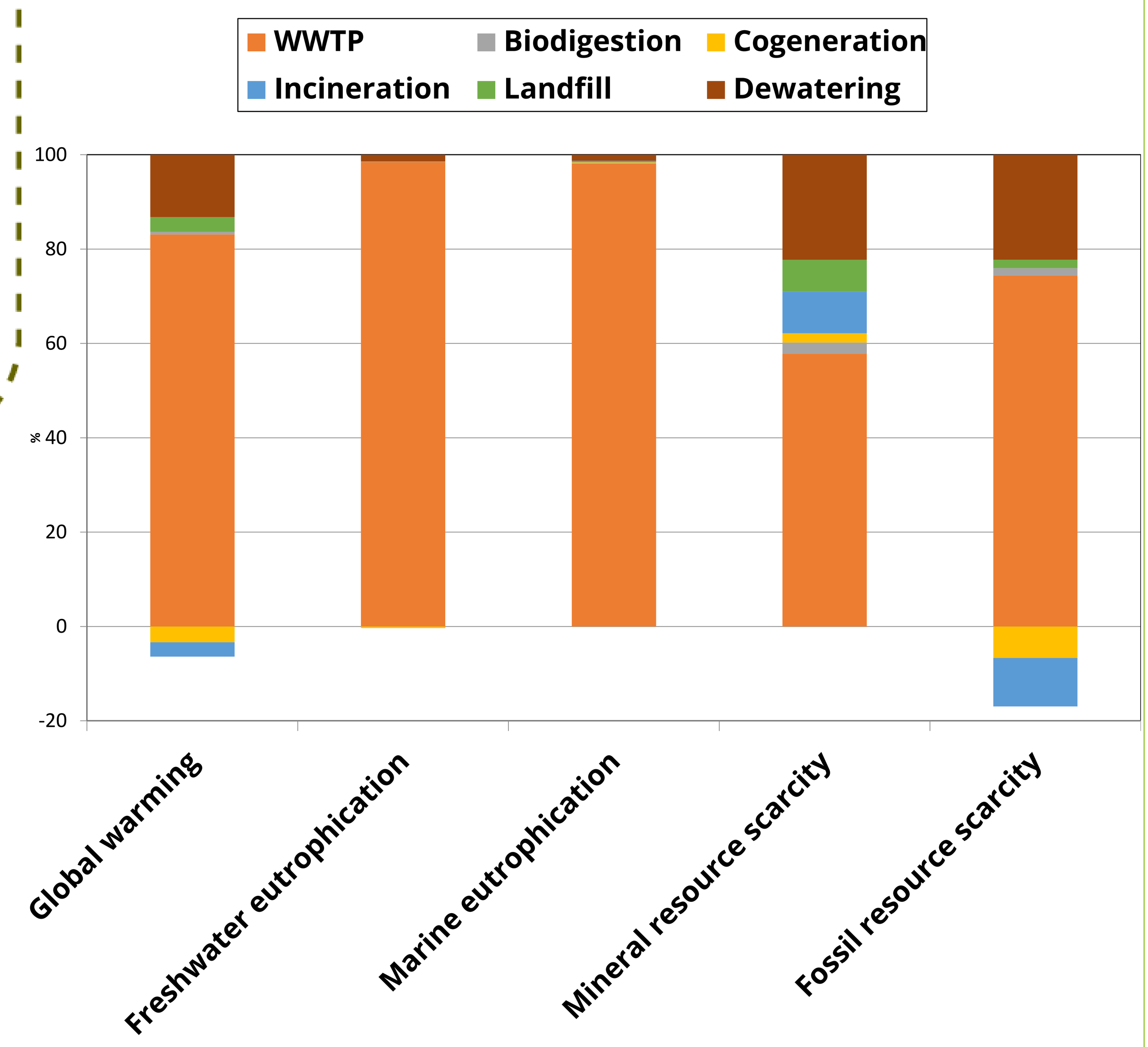

Figure 3: Environmental impacts of the reference system for the methodological approach of avoided burden on the environmental impact categories studied [1]

4. Discussion

For all the technologies studied:

→ Environmental advantage for **mineral resource depletion**.

→ Avoided burden of extraction of phosphate rock, (BAU for production of phosphorus fertilizers)

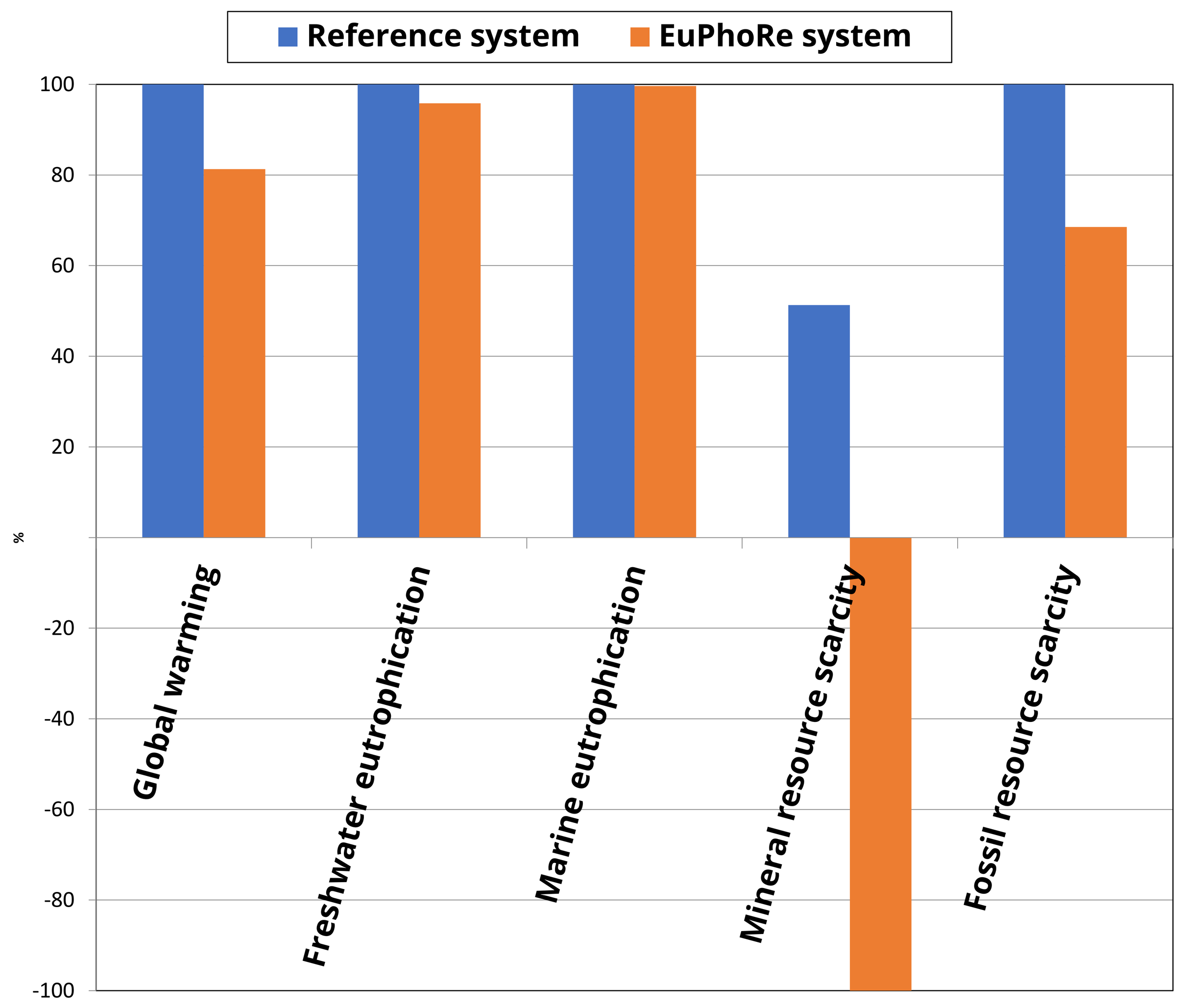

Figure 4: Example of environmental impact comparison for the avoided burden approach (EuPhoRe® system and reference system) [1]

The study of the **environmental performance of recovery technologies** has shown an environmental advantage for:

- EuPhoRe®
- Struvia™

→ Lower environmental impacts than the reference system, especially in the categories.

- Climate change
- Fossil resource scarcity

Two methodological approaches:

- System expansion: extend the system boundaries to include wastewater treatment and P_2O_5 production.
- Avoided burden: subtract the environmental impacts of avoided chemical P_2O_5 production from the impacts of wastewater treatment.

→ Same conclusions

⇨ Validation for robustness

⇨ Consistency of approaches

⇨ Progress in methodology of LCA applied to sludge-based materials

5. Conclusions

In addition to demonstrating the **overall environmental advantage of certain technologies (EuPhoRe® and Struvia™)**, the results of this analysis highlighted the **advantage of all demonstrators on mineral resource depletion.**

This advantage reflects the **possibility of saving the global mineral resources** due to the recycling of **phosphorus**.

The environmental assessment of the recovery processes also permitted the **identification of the most impactful steps** on the environment. This identification was used to propose alternatives from an **eco-design perspective** and to discuss them with the owners of the technologies studied.

References:
[1] Chantrain et alli, „Life Cycle Assessment – Life Cycle Costs works”. In: Ploteau Marie-Edith, Althoff Anke, Nafo Issa, Teichgräber Burkhard, “Technical report of the Phos4You partnership on processes to recover phosphorus from wastewater”, September 2021, edited by LIPPEVERBAND

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