Environmental evaluation of phosphorus recovery processes from wastewater sludge using life cycle assessment

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1. Introduction

In addition to the sanitary aspect of wastewater treatment, another function of wastewater treatment plants (WWTP) is to recover phosphorus from wastewater in order to limit the eutrophication phenomena that can severely damage ecosystems. This extracted phosphorus is mainly concentrated in the wastewater sludge. Nowadays with the ban on land spreading of this sludge, treatment options such as incineration are becoming more and more common. One of the problems with this method of sludge valorisation is that it breaks the cycle of phosphorus, which ends up in the residual ashes, often sent to landfill.

In this context, the Interreg Phos4You (P4Y) project addresses the phosphorus (P) challenge (https://www.nweurope.eu/projects/project-search/phos4you-phosphorus-recovery-from-waste-water-for-your-life/). P is an essential nutrient for all living organisms. Though it is a finite resource on earth, P is largely wasted today. The EU acknowledged this by adding phosphate rock to its list of critical raw materials in 2014. P4Y aims to develop technologies for phosphorus recovery from sludge and wastewater. Various processes are developed and promoted during this project, ranging from thermo-chemical treatments to bio-acidification followed by precipitation directly integrated into the WWTP[2].

2. Materials and methods

A life cycle assessment (LCA) was carried out on four of these phosphorus recovery processes to quantify the environmental impacts of the processes and to identify the most polluting steps within each process, in an eco-design approach.

The particularity of this LCA is to include the wastewater treatment plant in the system boundaries and then not to opt for the zero-burden assumption for the sludge. Sewage sludge is therefore not considered as a waste and has an environmental cost[1]. In order to avoid allocation problems between the water treatment function and the sludge production function of the treatment plant, two options have been studied. The first methodological approach is the extension of the system boundaries to take into account the wastewater treatment plant in addition to the treatment of the sludge produced. The system studied with this option in the framework of the Phos4You project therefore has two functions, wastewater treatment and phosphorus fertiliser production. The second methodological approach used is the avoided burden. This approach studies a system with only the wastewater treatment function and considers the fertilisers produced by recovering phosphorus from the sludge as avoided mineral fertiliser production[2].

The reference scenario includes the wastewater treatment plant, biodigestion of the raw sludge, cogeneration of the biogas produced, dewatering before incineration and landfilling of the residual ashes. This reference scenario is described in Figure 1.

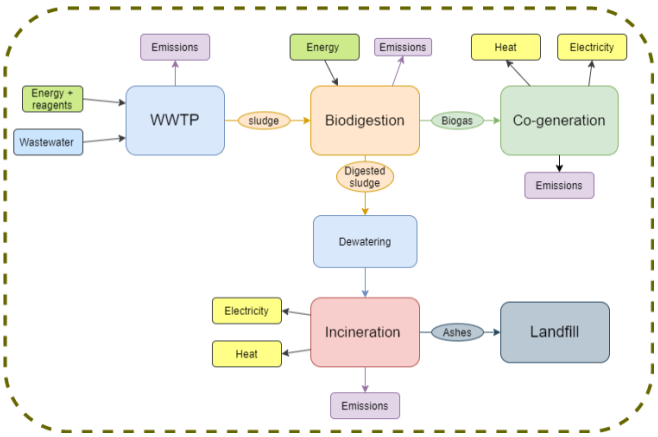

Figure 1 : Boundaries for the reference scenario.

The phosphorus recovery processes studied are a thermo-chemical process to recover ash that can be used directly as fertiliser (EuPhoRe®), a bio-acidification process for raw liquid sludge followed by precipitation (Struvia™), a chemical extraction process directly from the sludge (PULSE) and a phosphoric acid production process based on the ash from sludge incineration (PARFORCE)[2].

The environmental impact assessment focuses on five categories of interest, which are global warming, marine and freshwater eutrophication, and depletion of fossil and mineral resources.

3. Example of results: EuPhoRe® process

As an example, Figure 2 shows the potential environmental impacts of the EuPhoRe® process compared those of the reference system for the selected impact categories.

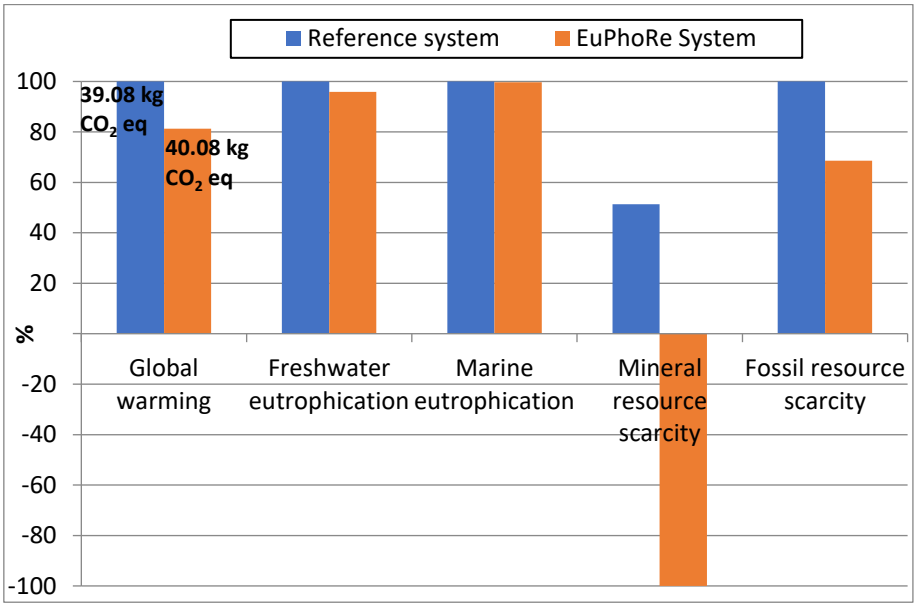

Figure 2 : Comparison of the environmental impacts of the EuPhoRe® system and the reference system.

The detailed reports on the methodology and results are available on the Phos4You project website[2].

4. Conclusions

All phosphorus recovery technologies present an environmental advantage on the category of mineral resource depletion thanks to the local and sustainable production of phosphorus fertiliser based on sewage sludge. Indeed, this fertiliser production makes it possible to limit the exploitation of the mineral resources necessary for the production of phosphorus fertiliser (phosphate rock).
In addition, the environmental study shows that two of the four recovery technologies have a general environmental advantage compare to the baseline scenario of sludge incineration.

5. References

[1] Pradel, Marilys; Aissani, Lynda; Villot, Jonathan; Baudez, Jean-Christophe; Laforest, Valérie (2016): From waste to added value product: towards a paradigm shift in life cycle assessment applied to wastewater sludge – a review. In *Journal of Cleaner Production* 131, pp. 60–75. DOI: 10.1016/j.jclepro.2016.05.076.

[2] 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, DOI n° 10.17185/duepublico/74788, Chapter 5 : Life Cycle Assessment – Life Cycle Costs works, Authors: Gaspard Chantrain Sylvie Groslambert, , Angélique Léonard (ULiège); Anders Nättorp (FHNW)

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