Phosphate recovery from wastewater via reversible adsorption

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Motivation

Phosphorus (mainly present as phosphate, PO_4^{3-}) can either be a nutrient or a pollutant based on its amount and location (Fig 1). The presence of excess phosphorus in water has adverse impacts on the quality of water. At the same time, the global increase in demand for phosphorus as a nutrient makes its recovery essential. Our study thus focuses on the removal of phosphorus as a pollutant and recovering it so that it can be used as a nutrient.

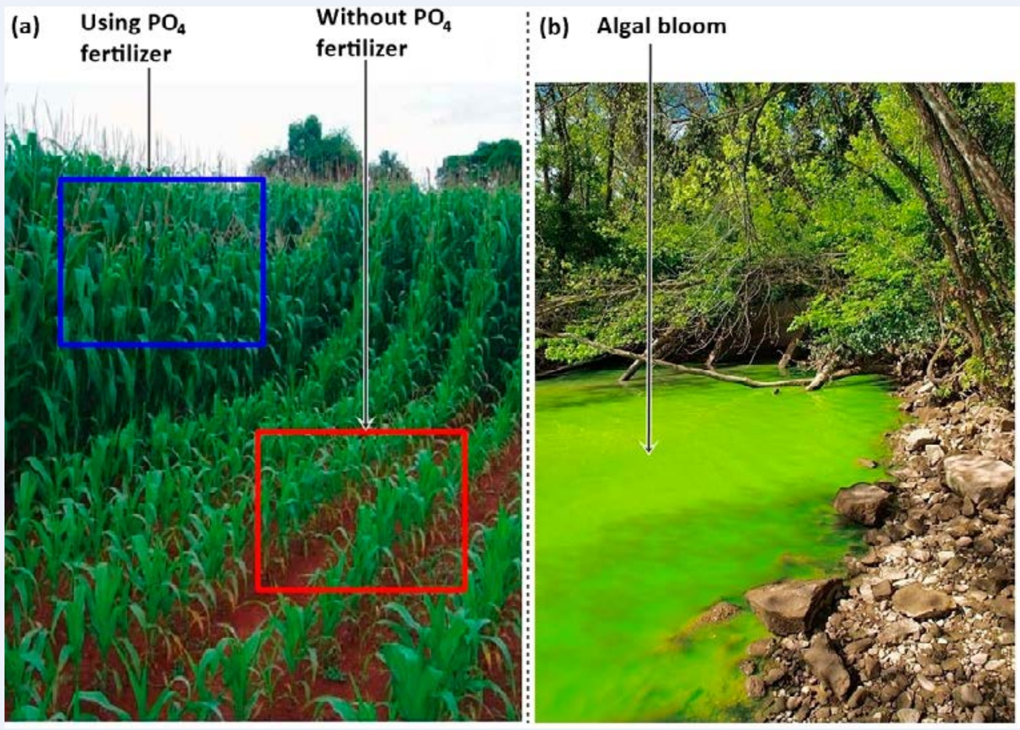

Fig 1:(a) Crops grow better in the presence of phosphate fertilizer[1] (b) Excess phosphate leads to eutrophication

Adsorption is a technique which is more efficient than the conventional technique (precipitation) for removing phosphate at low concentrations. Our first interest is to use adsorption as an effluent polishing step in wastewater treatment. Adsorption could however also potentially eliminate iron dosing for phosphate removal in wastewater treatment provided the economy of the process can be improved, for instance through adsorbent optimization and efficient recovery of the phosphorus. This may open the road to combine energy positive sewage treatment with phoshorus recovery[2]. Selective removal of phosphate could also lead to purer recovery products. Additional possibilities of application could be in lake restoration and as precursor step to prevent membrane bio fouling.

Technological challenge

Adsorption studies often focus mostly on pollutant removal. However, the consequent desorption and regeneration studies are also important especially when the phosphorus needs to be recovered. When engineering an adsorbent, it is necessary to consider different characteristics such as the adsorption capacity, selectivity, kinetics, mechanical strength, operating range and the cost.

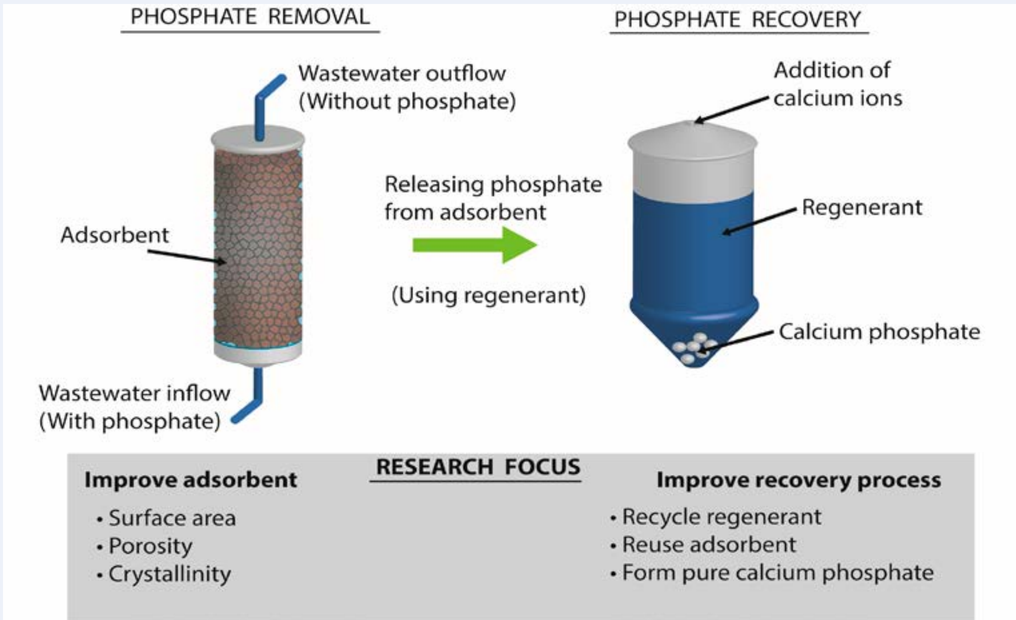

Fig 2: Summary and research areas of the project

Iron oxide and hydroxides are known to have good binding affinity towards phosphate[2]. The project will therefore study the design of an optimum adsorbent based on iron oxides, by modulating the properties such as surface area, pore size distribution and type of iron oxide. The iron oxides will be immobilized as nanoparticles on porous supports (for instance activated carbon) to achieve high adsorption capacities. The recovery process (possibly as calcium phosphate) and the adsorbent reuse will be evaluated. In this way an economic removal and recovery process should be realized. Fig 2 summarizes the research areas in the project.

Research goals

- To develop an optimized adsorbent for successful removal of phosphate from wastewater
- To understand the mechanism of phosphate removal by modeling the capacity and kinetics as a function of adsorbent properties.
- To develop regeneration strategies to recover the adsorbed phosphate and reuse the adsorbent.
- To study the economics of the process and to develop a cost effective process for phosphate removal and recovery.

References

[1] http://its-interesting.com/category/fertilizer/
[2] Wilfert, P.; Kumar, P. S.; Korving, L.; Witkamp, G.-J.; van Loosdrecht, M. C. M., The Relevance of Phosphorus and Iron Chemistry to the Recovery of Phosphorus from Wastewater: A Review. Environmental Science & Technology 2015, 49, (16), 9400-9414.

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