Phopshate recovery from wastewater by adsorption

Dario Frascari[a], Benedetta Martellotti[a], Carla Maggetti[a], Elisa Girometti[a], Davide Pinelli[a], Giacomo Antonioni[a] & Valerio Cozzani[a]

[a] University of Bologna, Department of Civil, Chemical, Environmental & Materials Engineering, Bologna, Italy

E-mail: dario.frascari@unibo.it

Given the current global trend toward stricter regulations on phosphorus concentrations in treated wastewater, the lack of phosphorous reserves in Europe and the growing emphasis on phosphate recovery, the development of cost-effective technologies for phosphate removal and recovery from municipal wastewater (MWW) is increasingly important. This work was aimed at (i) identifying a suitable and robust sorbent for P removal & recovery from MWW, (ii) optimizing the P removal & recovery process, (iii) developing an Aspen Plus-based process simulation, and (iv) conducting a Cost Benefit Analysis (CBA) of the process. A preliminary evaluation of the phosphate adsorption capacities of several sorbents led to the identification calcined pyroaurite—an innovative material made of mixed magnesium and iron oxides—as the most effective. Its performance was further assessed using adsorption isotherms and continuous-flow adsorption/desorption tests with real MWW, demonstrating a high phosphate sorption capacity (12 $mg_P/g_{dry\ resin}$ at typical MWW concentrations), the ability to treat 730 bed volumes before reaching the EU regulatory limit of 1 mg_P/L. Thanks to the use of NaOH 0.5 M as desorption agent, a 93% phosphate recovery rate was achieved. The addition of $Ca(OH)_2$ to the desorbed solution led to the precipitation of calcium phosphate, typically used for the production of P-based fertilizers. The phosphate adsorption/desorption process on pyroaurite was effectively simulated with the Aspen Plus Ion Exchange module. The model resulted capable to predict the effect of variations in empty bed contact time and packed bed height, as well the competition exerted by the other anions present in the tested MWW. The Aspen-based simulation was used to perform the preliminary design of a full-scale plant of phosphate removal, desorption and precipitation implemented to the effluent of an actual wastewater treatment plant located in Northern Italy. The CBA resulted in a final cost equal to 0.10 €/m^3 of treated MWW. The results indicate that phosphate recovery from MWW by ion exchange and subsequent precipitation is a promising process in a circular economy perspective.

Keywords: *phosphate, ion exchange, nutrient recovery, wastewater treatment, process simulation.*

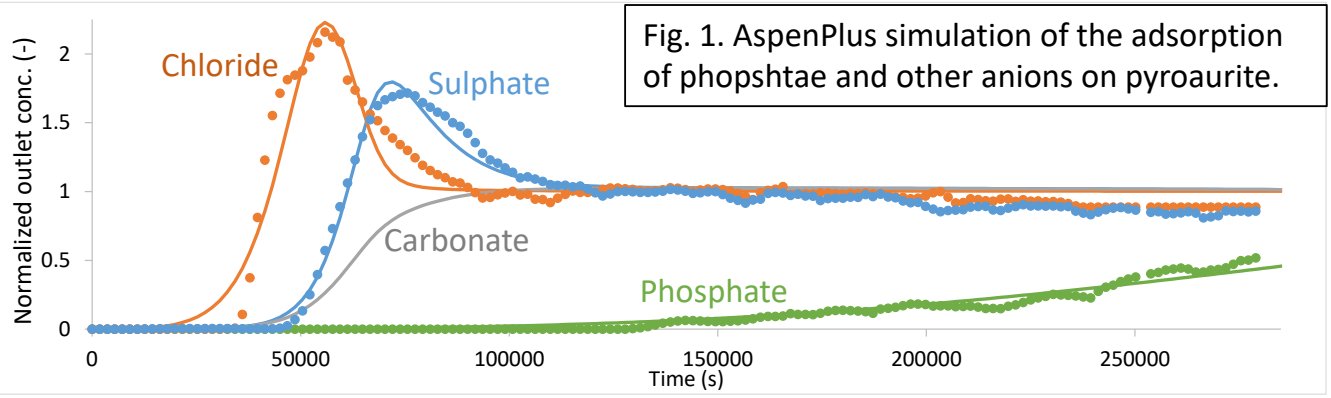

Fig. 1. AspenPlus simulation of the adsorption of phopshtae and other anions on pyroaurite.