Phosphorus recovery on apatite filters: developing a mechanistic model

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Apatite filter, what is it?

Apatite filters are extensive systems for phosphorus (P) removal from wastewater. P retention is based on adsorption/precipitation phenomena leading to the formation of hydroxyapatite (HAP) precipitates onto the apatite's surface.

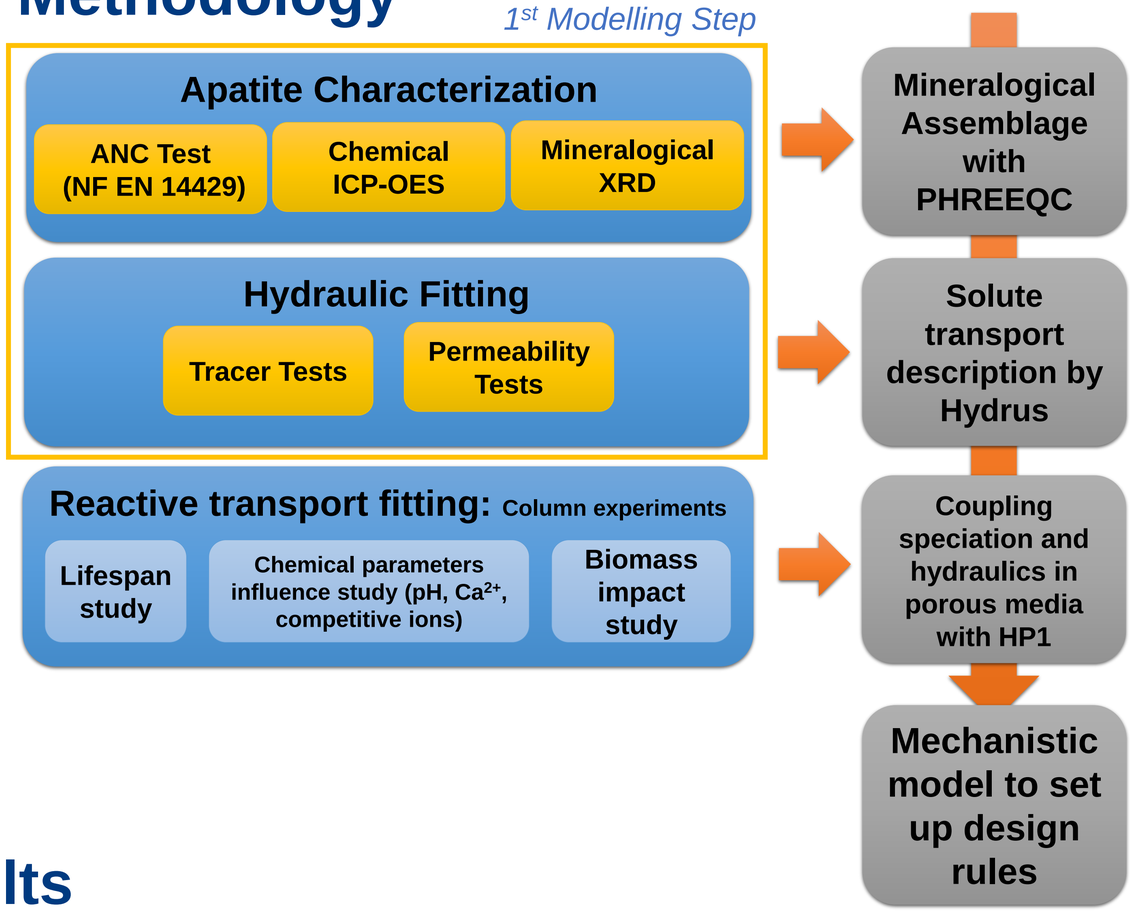
What about P recovery?

As the precipitate and the filtration bed share the same nature, revalorization of the media at the end of the filter's lifespan is possible, e.g. in fertilizer's production.

Aim of the study

To achieve a better understanding of P retention mechanisms and kinetic rates providing a model that will allow to precisely design full scale apatite filters.

Methodology



Results

Apatite Characterization

- Numerical simulation of batch Acid Neutralization Capacity (ANC) tests is performed using PHREEQC, based on the calculation of equilibrium between aqueous solutions and minerals.
- A simplified mineral assemblage is defined on the basis of a mineralogical and chemical characterization (XRD, ICP-OES).
- Acid and base are added to the solid (experiment) and mineral assemblage (model) to obtain pH between 2 and 12. Mineral assemblage is optimized by fitting experimental data with simulation.

ANC batch test conditions:

Liquid/solid ratio = 10L/kg
Room temperature
Contact Time = 48h

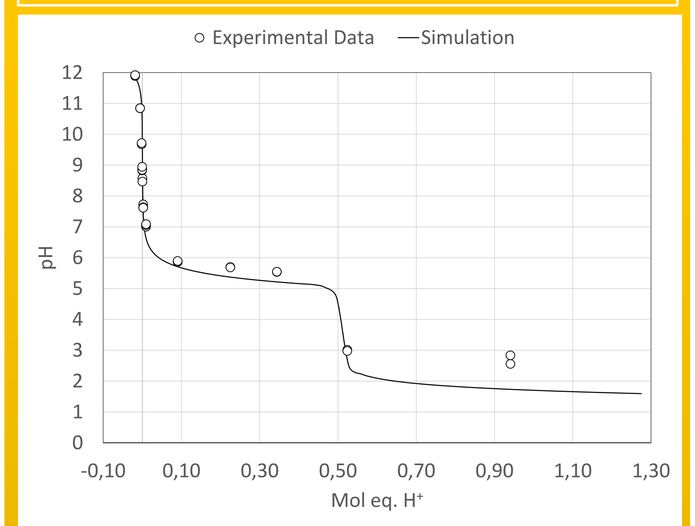


Figure 1. Acid/Alkaline titration curve of apatite sample (top plot)

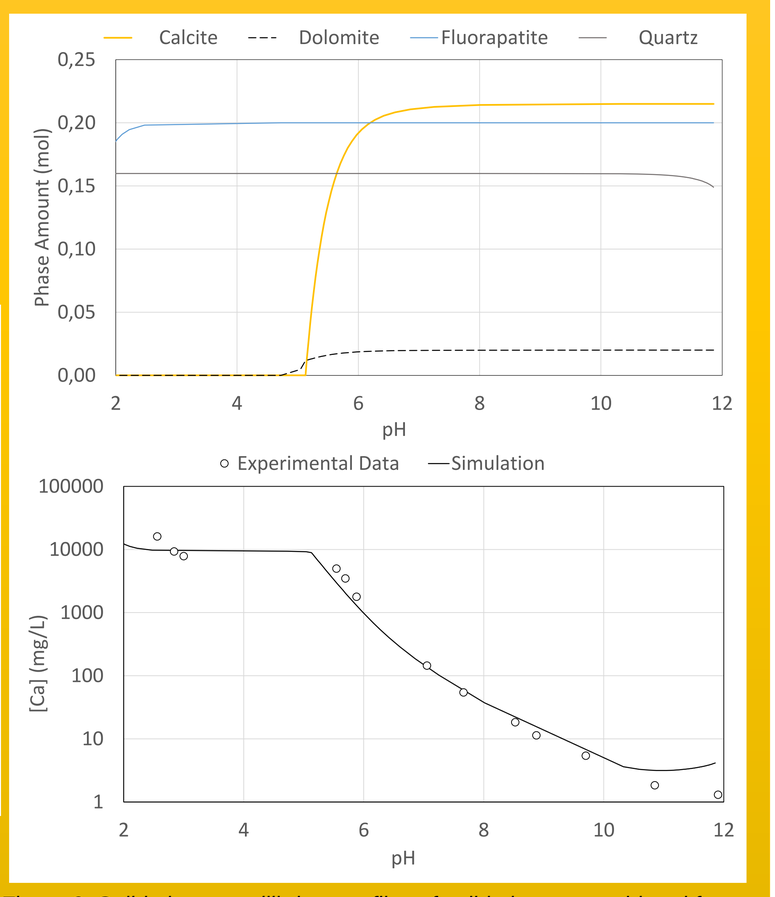


Figure 2. Solid phase equilibrium profiles of solid phases considered for simulation as a function of pH (top plot). Leaching profile of Ca (bottom plot).

Hydraulic Fitting

- Fluorescein tracer tests have been done on pilot columns before and after P retention treatment to determine HRT and solute distribution inside the column.
- This measures may account for hydraulics' evolution with operation time (appearance of dead volumes and /or preferred pathways) of the filter and its eventual chemical or biological clogging.
- One dimensional solute transport in porous media is simulated with Hydrus® software. Fitting is obtained by optimization of the dispersivity parameter (λ [L]).

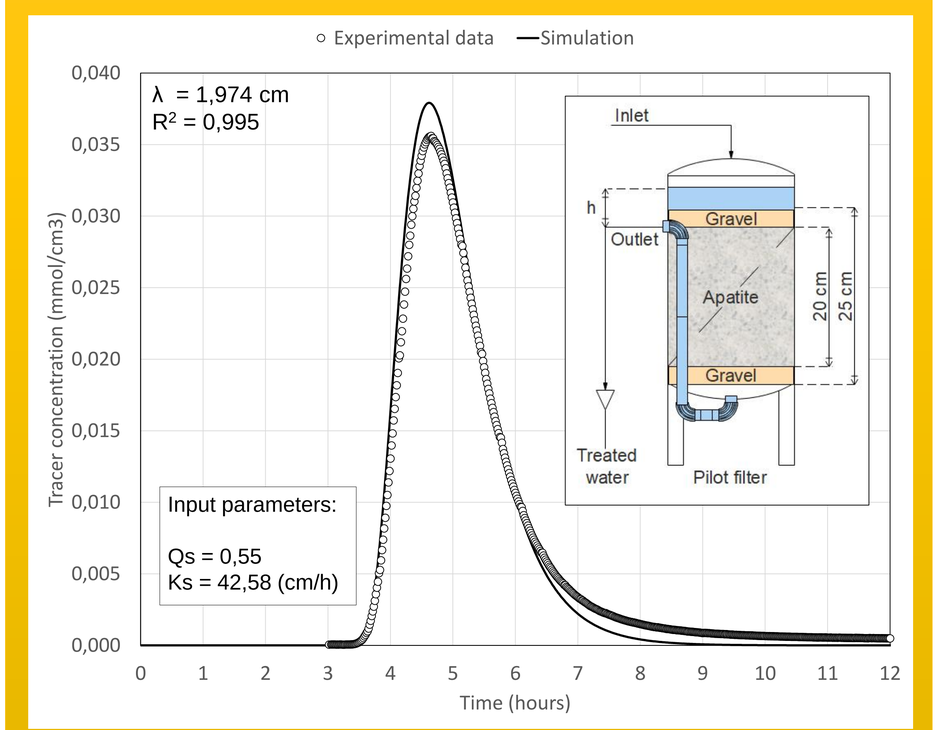


Figure 3. Tracer concentration curve at the outlet of the system: experimental data and simulation (Qs: saturated volumetric water content, Ks: hydraulic conductivity).

Conclusions and perspectives

Results indicate that simulations provide a well fitting in both aspects: filter media characterisation and hydraulics. This multidisciplinary approach allows a full description of the system in geochemical terms as well as on the aspects concerning the flow regime, likely to vary over the operation time.

Research efforts are now focused on the modelling of reactive transport in order to simulate surface interactions of phosphate from wastewaters with apatite media. Experimental data from pilot columns operated for several months will be used for that purpose. A mechanistic model aiming design optimisation of full scale filters will be provided at the end of this study.

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