Sorbents for phosphate removal from agricultural drainage water

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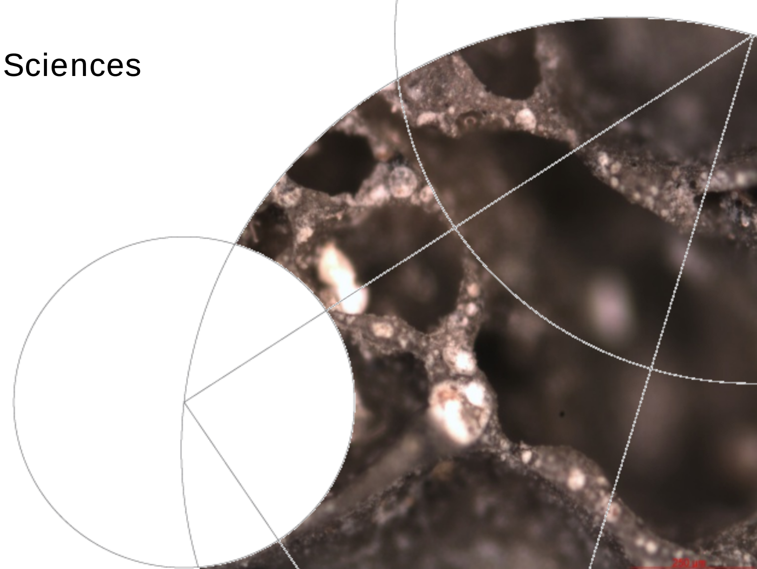


Acknowledgment

This work was done in collaboration between Oklahoma State University and University of Copenhagen

Funded by The Danish Council for Strategic Research (grant no. 09-067280) and University of Copenhagen

The PhD project is a part of the SupremeTech project

Phosphate Sorbing Material (PSM)

Find PSM that can work in an **aerobic environment** with **low and variable phosphate conc.** and **pulse-flows**

PSM need to possess a:

- High phosphate capacity and affinity,
- Reacts fast
- Retain phosphate it has sorped

What affect a PSM:

- Active sorbent (e.g. Al, Fe, Ca and Mg)
- Specific surface area (particle size, shape, porosity, and crystallinity)
- pH
- Inlet P concentration
- Reaction time

Screening

15 materials

- Diatomatic earth (CDE), CFH-12, limestone, Filtralite-P, Shell-sand, seven different LECA etc.

4 fractions

- < 0,5 mm >0,05 mm
- < 1 mm > 0,5 mm
- <2 mm > 1
- < 4 mm >2 mm

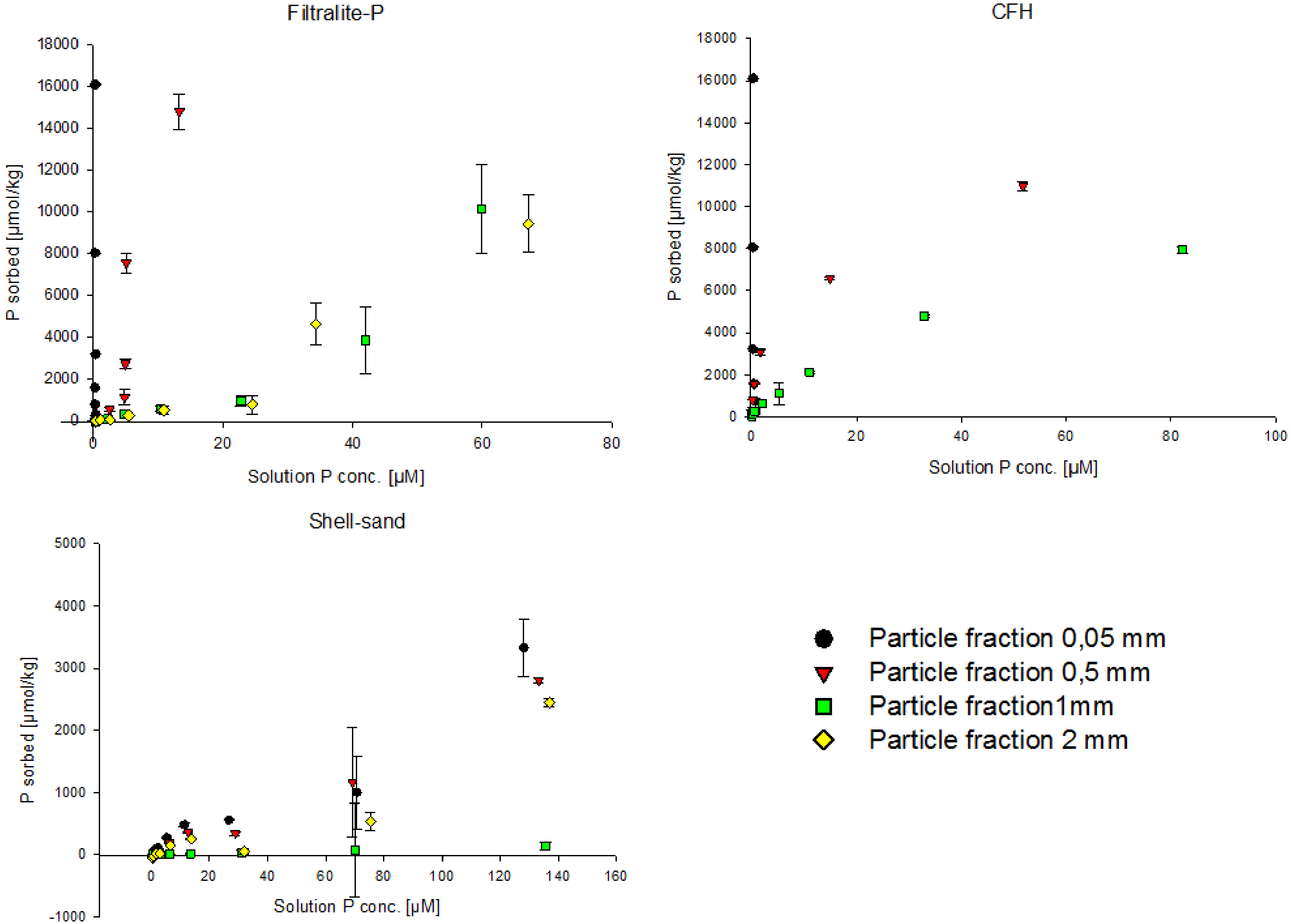
Filter characteristics

- Chemical composition
- Different pools of Fe/Al, Ca/Mg, P
- Specific surface area (BET)
- XRD

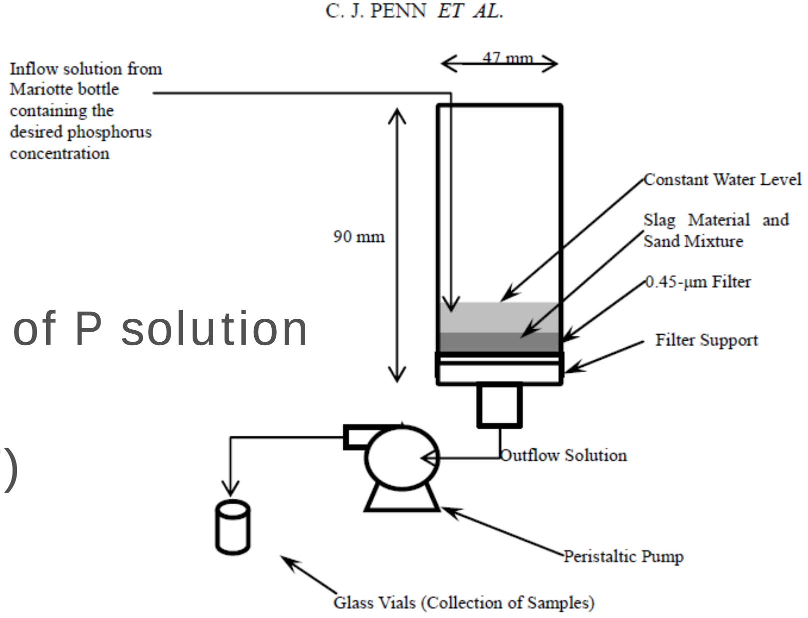
Batch experiments

- Sorption isotherms →P conc. 0-161 µM contact for 24 min
- Kinetics →Contact periods for 1½, 3, 6, 12 and 24 min
- Desorption → four treatments with electrolyte - 15 min each

Isotherms examples



More detailed understanding of two best PSM
Flow-through setting



Flow-through is more suitable because:

i. It can simulate constant application of P solution

ii. Realistic (short) retention times (RT)

The **objective** of this study were to investigate how retention time and P concentration affect P sorption in regard to capacity and affinity

Experimental set up

0.1-2 g material mix with pure quartz sand

Fe-ox based **CFH** (2-1 mm and 1-0.5 mm)
CaO based **Filtralite-P** (4-2 mm, 2-1 mm, and 1-0.5 mm)

4 P inlet concentrations made from KH_2PO_4

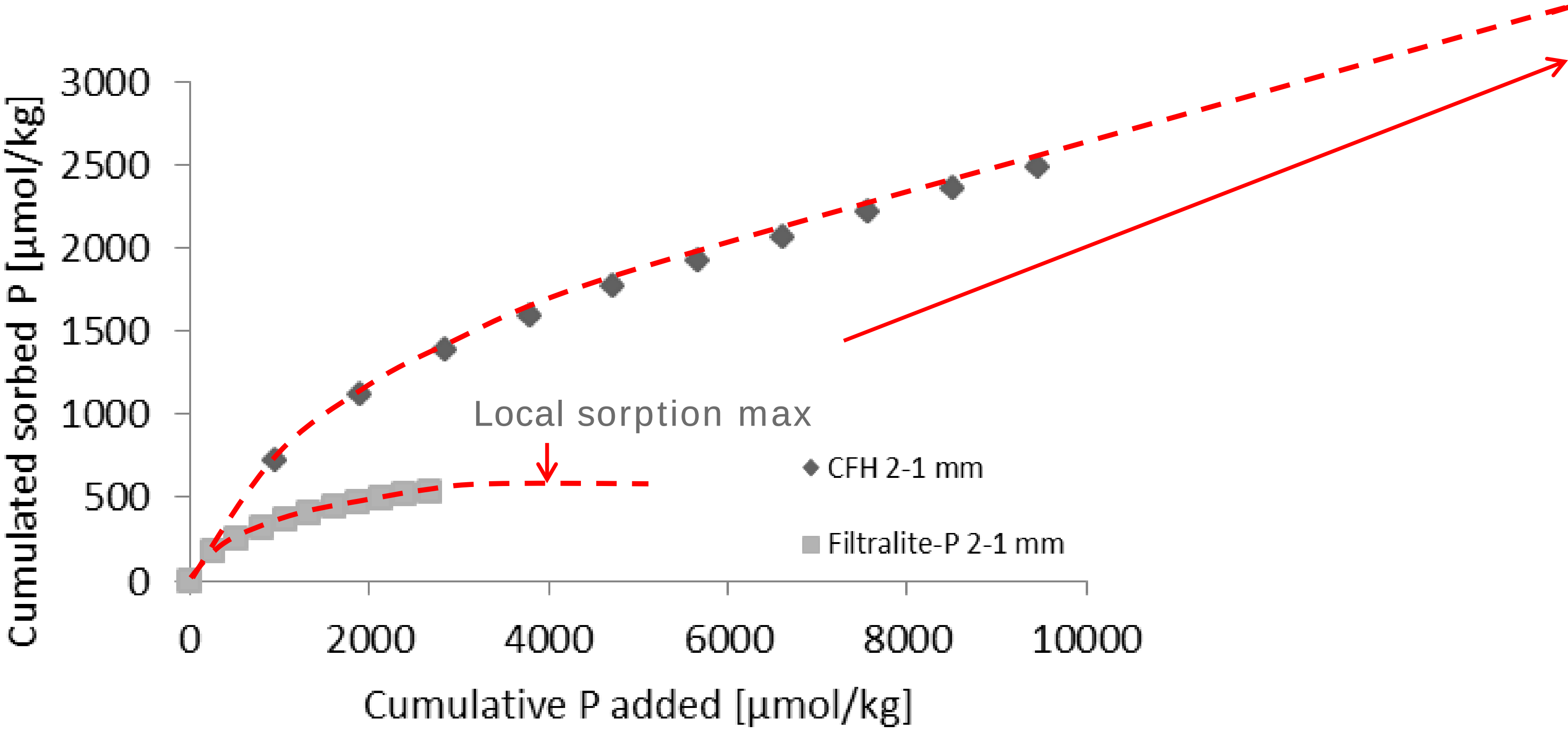
- 1.6 and 3.2 µM– base flow
- 16 and 32 µM – peak flow

6 Retention times (RT)

- ½, 1, 1½, 3, 6, and 9 min

- 5 h flow **sorption** - outflow was sampled every ½ h
- 2 h flow **desorption** with P free solution (6 mM KNO3)
- Outflow solutions were analyzed MR molybdate blue method
- Triplicates - Total of 360 experimental units

Example of flow-through sorption curve - inlet 16 µM, RT 1½ min



If local sorption maximum is not achieved we model

Fitting of flow-through data

Hyperbolae model:

$$Cumulative\ sorbed\ Pi = LSS\,\frac{f \cdot c \cdot t/m}{(K + f \cdot c \cdot t/m)}$$

$f \cdot c \cdot t/m = P\ added$

- f is flow rate (L min^{-1}),
- c is Pi inlet concentration (µmol L^{-1}),
- t is time (min) and
- m is mass (kg)

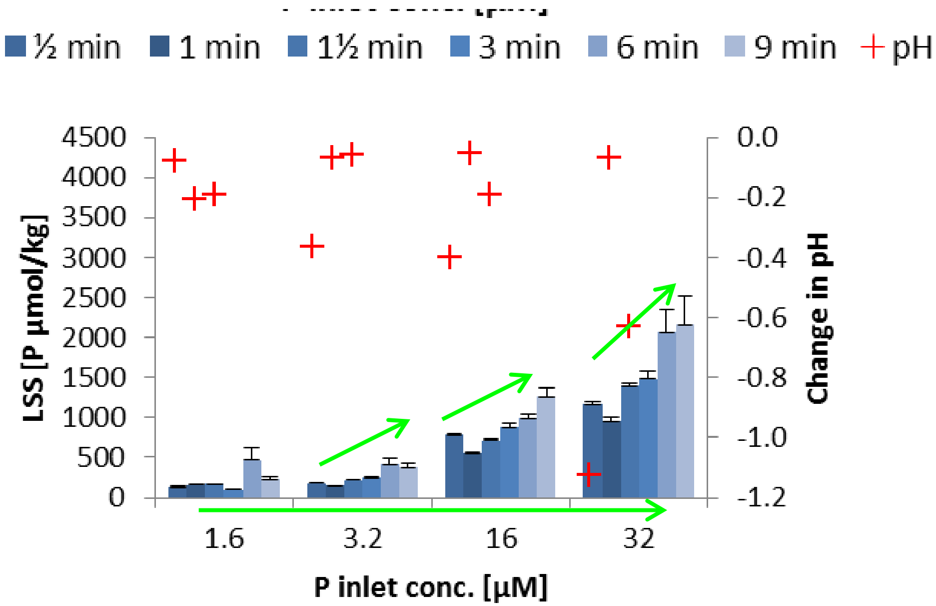
LSS = Local Sorption Saturation (µmol kg^{-1}) inlet = outlet

K =slope curve and is a measure of affinity

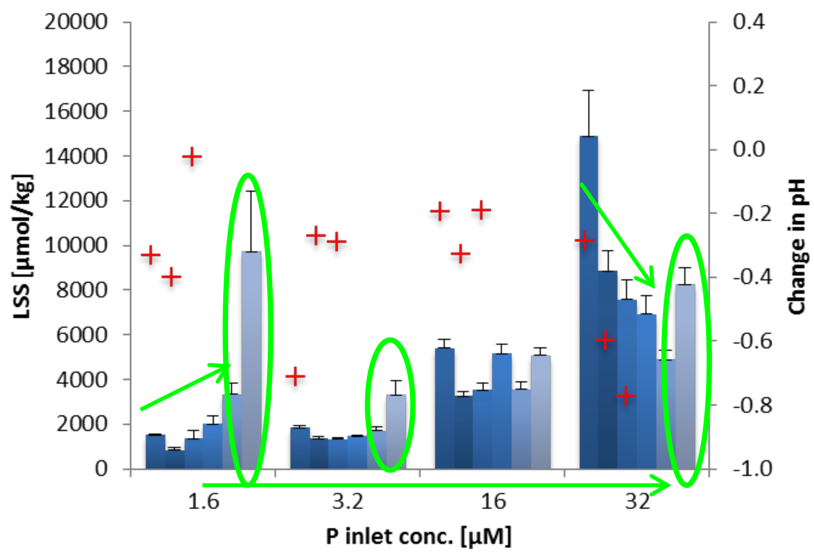
RT and inlet conc. were tested with one-way ANOVA

Sorption 2-1 mm fractions

Filtralite-P



CFH

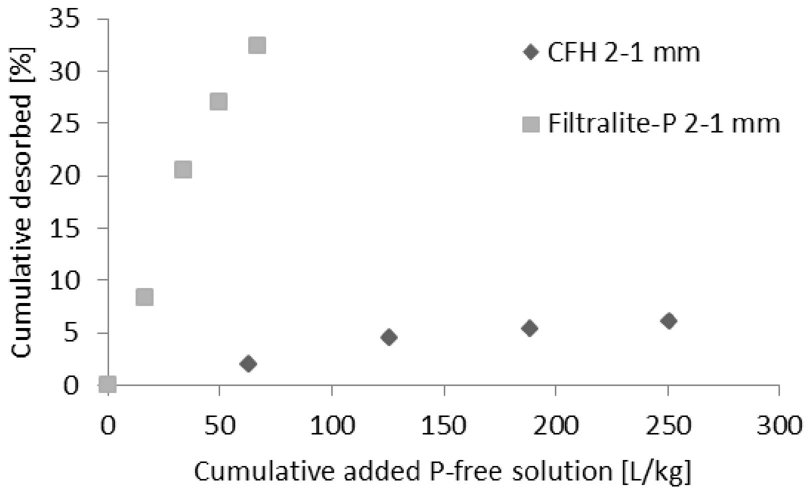


Example of flow-through desorption results

Log modified logistic model:

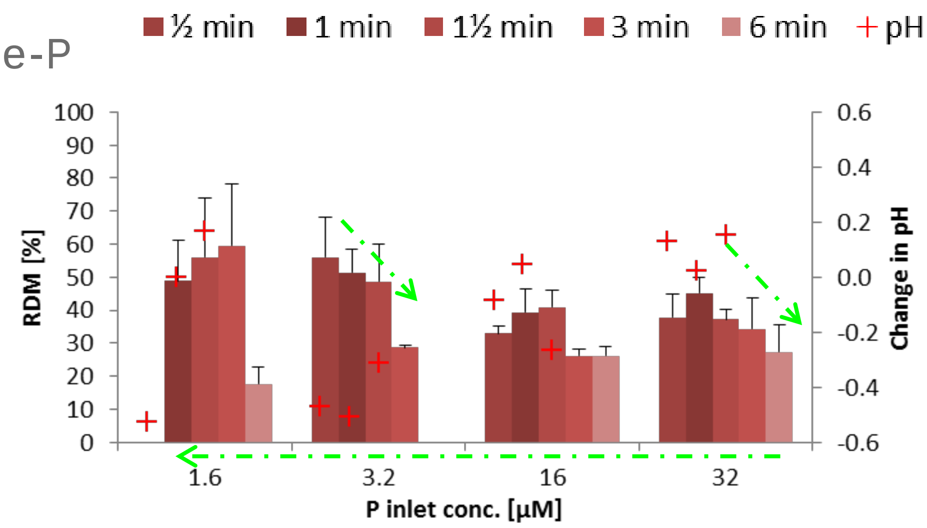
$$Cumulative\ Pi\ desorbed = \frac{RDM}{(1+D\cdot(f\cdot t/m)^{d})}$$

- f·t/m = electrolyte added
- RDM is the Relative local Desorption Maximum (% of the previously sorbed P)
- D is a measure of the lag phase and
- d is the slope of the curve



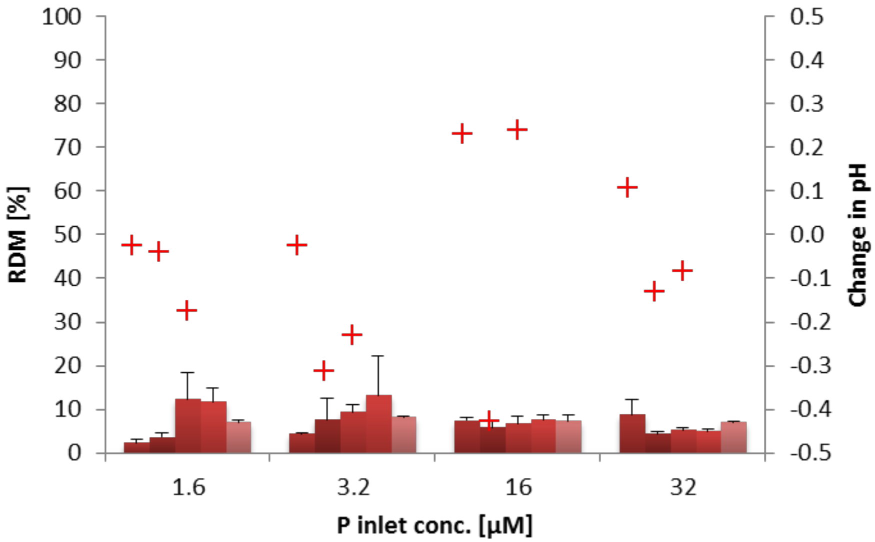
Desorption 2-1 mm fractions

Filtralite-P



RDM higher 35%

CFH



RDM less 10%

Key findings sum-up

In regard to phosphate sorption in an **aerobic environment** with **low P conc.** and **pulse-flows** my results clearly states that a Fe-oxide system would be preferable

i. Higher capacity

ii. Shows highest affinity towards P - also a low P conc.

iii. Sorbs faster than Ca based systems

iv. Sorbs stronger (little desorption)

v. The sorption seem less sensitive to pH and solution composition

Thank you for your attention!