PHOSPHATE REMOVAL FROM AGRICULTURAL WATER USING CALCIUM-RICH MINERALS

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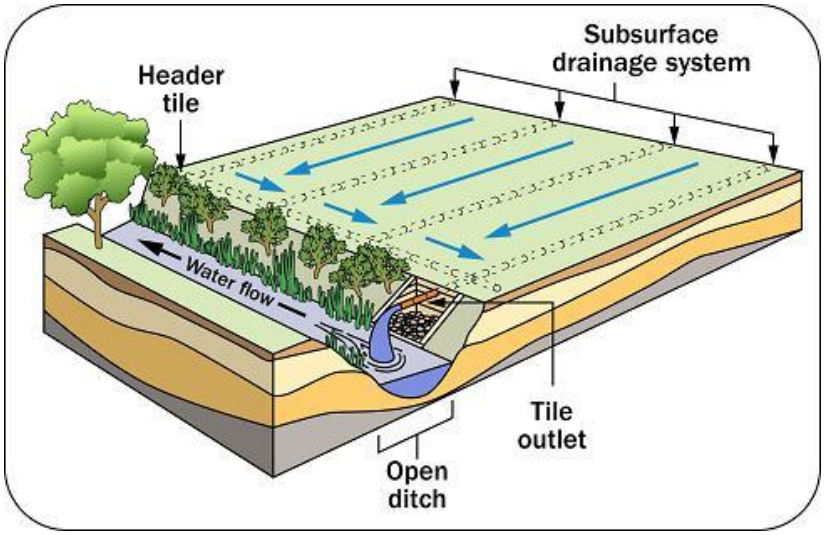
AGRICULTURAL WATER TARGETED AREAS

The purpose of this research is to test materials that can reduce phosphate levels in agricultural wastewater/stormwater and to design an application that can be used in drainage systems

- At this phase of the project, material testing and selection is the current focus



PHOSPHATE ADSORPTION: LIMESTONE ROCKS

- Limestone rocks ($CaCO_3$) were crushed to approximately 1 mm size

- Equilibrium/agitation time of 10 minutes

- Maximum adsorption capacity tested @ 12 mg/L: 0.0254 mg PO_4 adsorbed/g Limestone

LIMESTONE ROCKS IN RIVER WATER

- Locally sourced river water was spiked with phosphate to determine adsorption behaviour in the presence of other ions

- The adsorption capacity of the limestone in river water was reduced by 40%

- Limestone is effective in different water chemistries (water with or without fertilizer and river water from a rural area)

LIMESTONE ROCKS IN WATER WITH COMMERCIAL FERTILIZER AND UREA

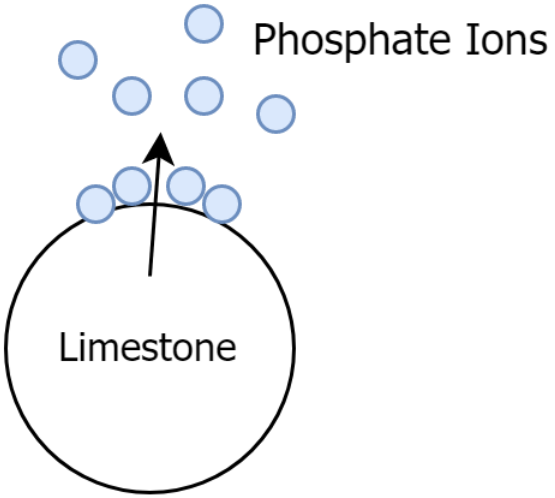
- The adsorption capacity of limestone was unaffected by the commercial fertilizer

- Urea reduced the adsorption capacity of limestone by approximately 10%, likely due to the urea binding to the phosphate (binding between bisurea and bisthiourea)

LIMESTONE ROCKS PHOSPHATE DESORPTION

- Desorption of saturated limestone rocks at several pH levels in deionized water

pH of Soln.	Desorption
4	50%
7	22%
11	11%



LIMESTONE ROCKS

- At a grain size of 1 mm, limestone rocks had an adsorption capacity on the lower end but had low equilibrium times and high desorption, which could be advantageous in certain applications

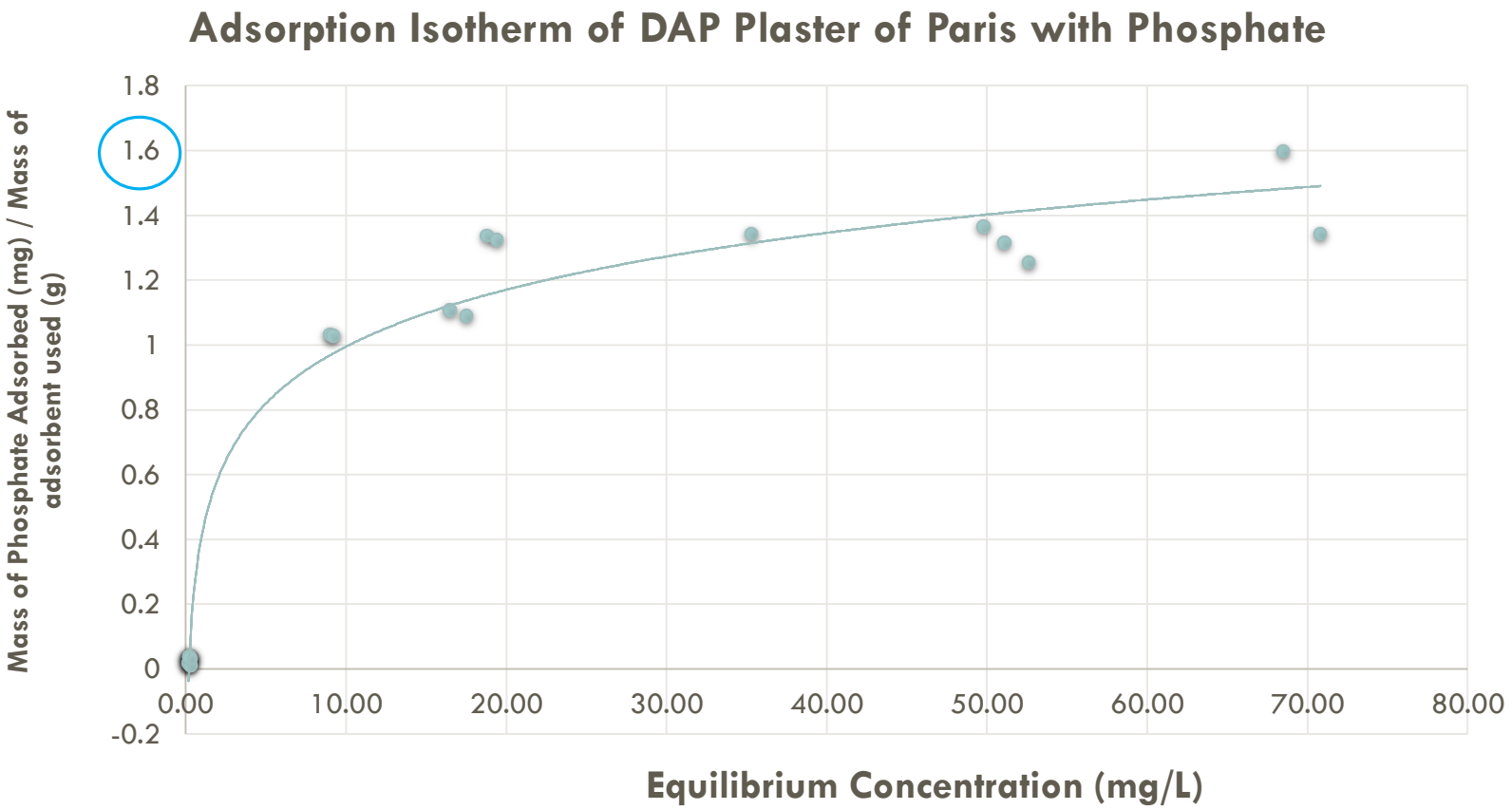
- Limestone rocks could be used as an intermediate before using other materials to further reduce phosphate concentrations

GYPSUM

- Professional-grade DAP Plaster of Paris was used with no additional treatment
  - DAP Plaster of Paris is approximately 10-30% $CaCO_3$ and 60-80% $CaSO_4$
- In a 20 mL solution an equilibrium time of 10-15 minutes was found using Plaster of Paris
- Removal efficiency was 68%

GYPSUM: ADSORPTION ISOTHERM (PH=5.5)

The material appears to follow the Freundlich isotherm model (logarithmic)

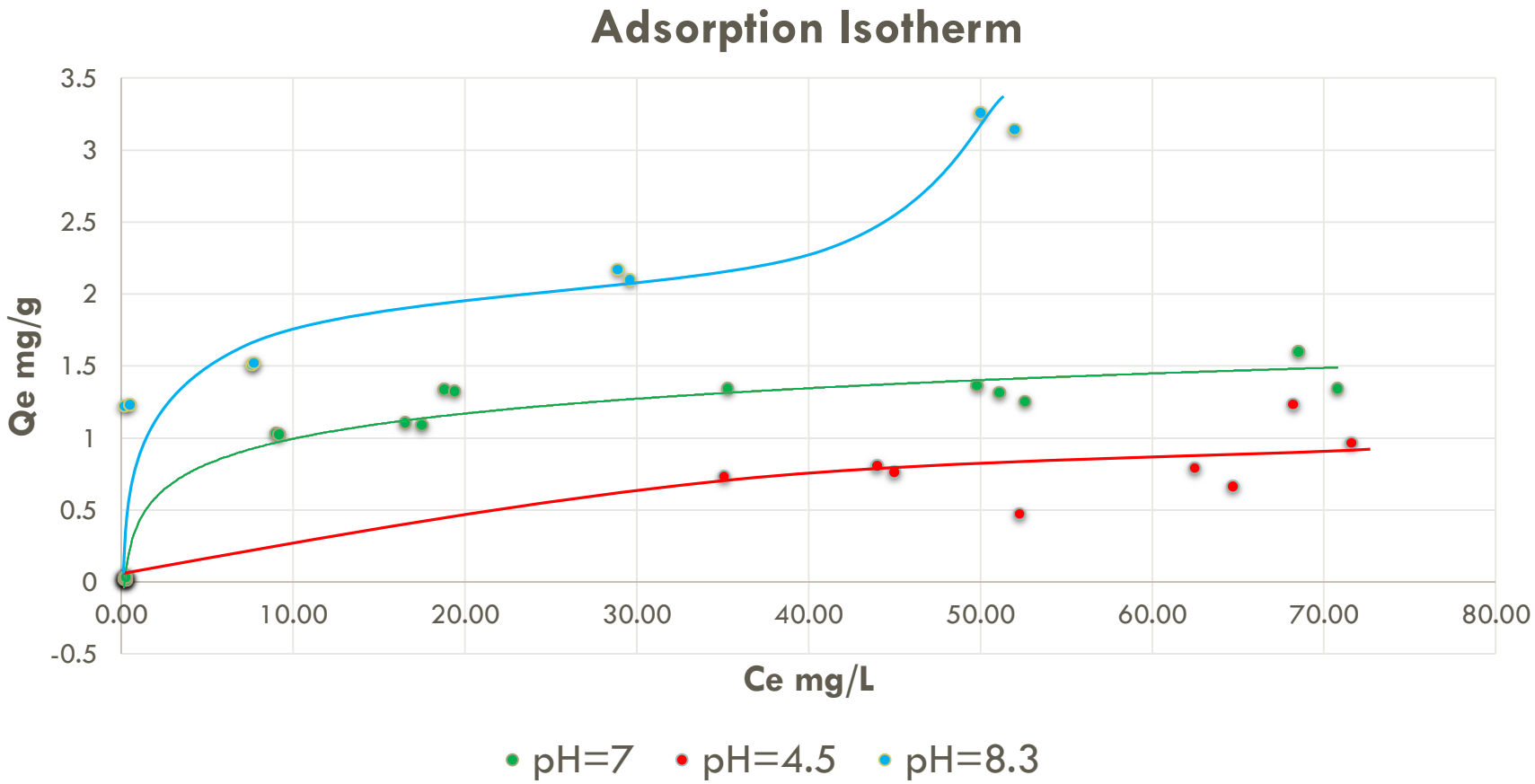


GYPSUM: ISOTHERM

- From the isotherm, the maximum adsorption capacity at pH=5.5 and at the concentration ranges tested is ~1.6 mg PO_4 adsorbed/g Plaster of Paris

- A high maximum capacity reflects a better capability of reducing phosphate levels to very low concentrations (ppb level)

GYPSUM IN SOLUTIONS OF DIFFERENT pH



pH was adjusted using 0.1 M KOH and 1 M HCl

EXTRACTING GYPSUM

- If we plan to apply Plaster of Paris in a powdered form, some method of extraction is necessary

- Sodium alginate was tested as a flocculant for the Plaster of Paris so that the powder can be collected in flocs

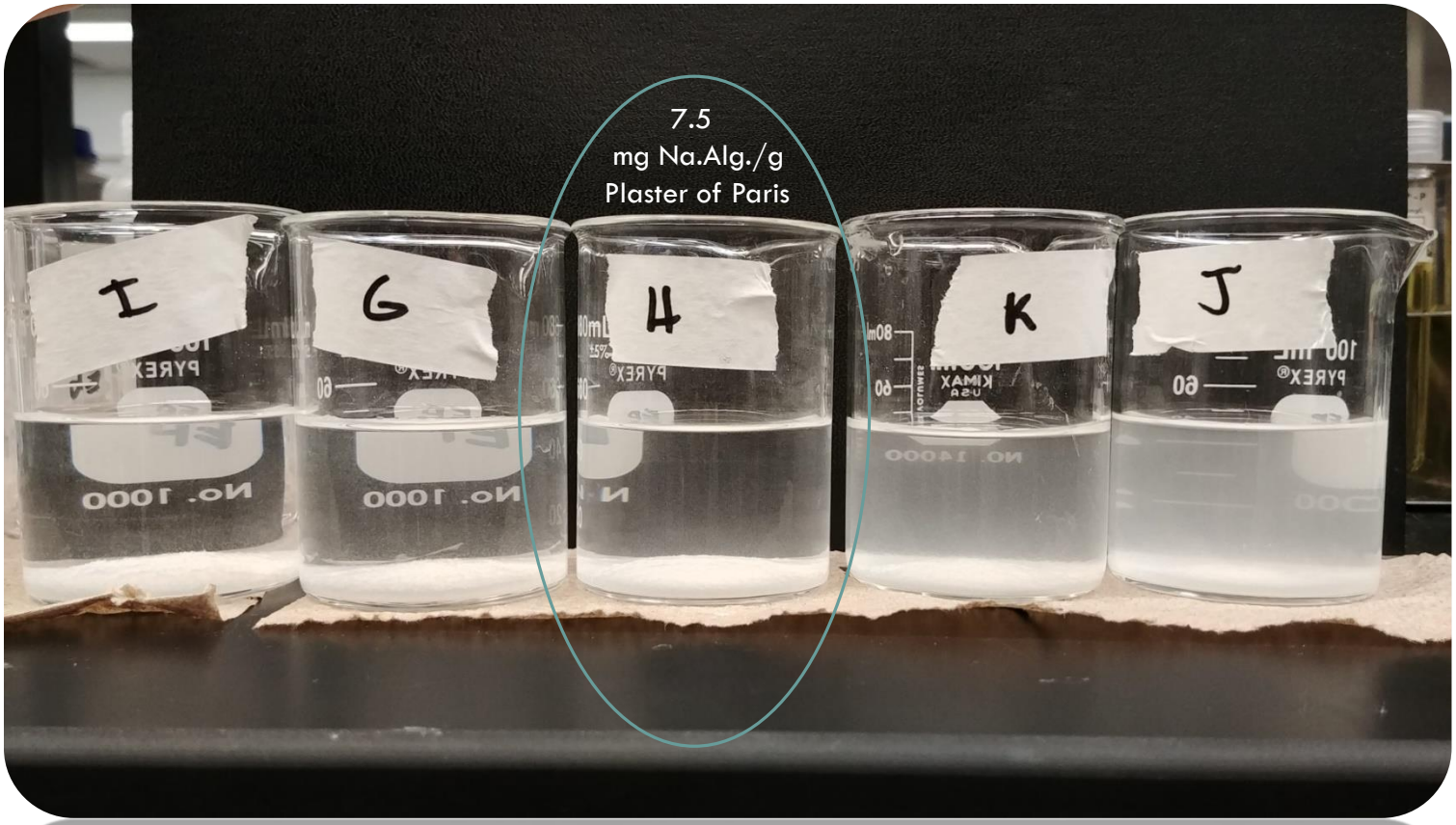
EXTRACTING GYPSUM: THE EFFECT OF ALGINATE ON ADSORPTION

- Sodium alginate was tested in conjunction with the Plaster of Paris to adsorb phosphate

- At low concentrations of Plaster of Paris, the flocculant slightly increased the equilibrium time required

- The sodium alginate did not affect the total adsorption capacity of the Plaster of Paris at a significant level

OPTIMIZING THE RATIO OF ALGINATE AND PLASTER OF PARIS



PLASTER OF PARIS DESORPTION

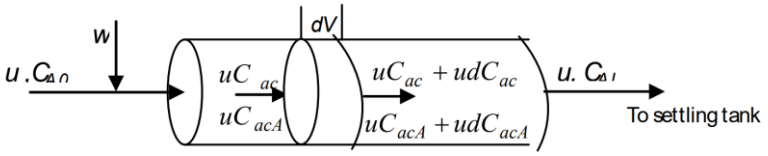
Plaster of Paris desorption results:

- Significant desorption occurred at very low pH levels

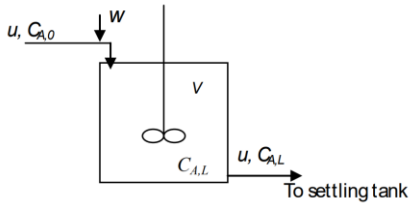
pH	% Desorbed
1.60	53%
2.33	27%
7.00	23%
11.63	15%

While this means that the material will not leach phosphate back into "cleaner" waters, a very low pH is required to reclaim and reuse phosphate

NEXT STEPS



- Test filters treated with Plaster of Paris, explore uses in PFR systems (drainage pipe) and drainage systems that could reflect CSTR systems (pond or lake)



- Test calcium silicate which has been reported to have a very high capacity and can reduce PO_4 to 5 ppb and below

- Test calcium silicate & gypsum as a mixture to selectively target concentration ranges