Legacy phosphorus characterization and desorption of U.S. Mid-Atlantic agricultural soils

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BACKGROUND

Chicken manure contains phosphorus which is a vital nutrient in plant growth and crop production.

The repeated addition of phosphorus leads to build up of the nutrient.

Due to leaching, erosion, and runoff, phosphorus can enter water systems causing eutrophication.

Over nourishment of phosphorus promotes algae growth which may cause anoxic conditions leading to fish kills.

What phosphorus species are in the soil and what is their mobility?

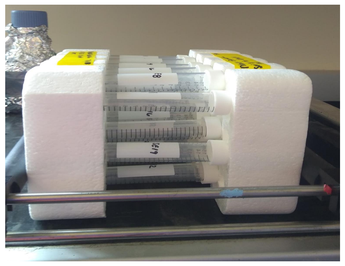
OBJECTIVES

1. Determine the physicochemical characteristics of high legacy P soils from throughout Delmarva.
2. Determine the rate of P loss in soil through desorption experiments.
3. Determine the strengths of P bound to soil compounds by comparing desorption curves collected from different desorbing agents.

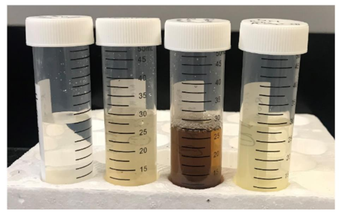
METHODS

Soil samples were sieved through a 2 mm sieve and sent to the soil testing lab to determine:

- Mehlich 3-routine analysis (agronomic need P)
- Microwave acid digestion (total P)
- Particle size analysis



DI $NaHCO_3$ NaOH HCl



Hedley sequential extraction experiments were completed by placing 500 mg of soil with 30 ml of extraction solution.

- DI water: easily extractable P
- NaHCO3: easily extractable P
- NaOH: Fe- & Al- P (ligand exchange)
- HCl: Ca- bound P
- Digest: tightest held, mineral P

Desorption experiments were completed by placing 200 mg of soil with 10 ml of desorption agents. These were then placed on the shaker at 200 rpm.

- Pore water (0.01M KCl)
- Acid rain (0.1M HNO_3)
- Ligand exchange mechanisms (0.1mM Na_2SiO_3 and 1.0mM Na_2SiO_3)
- Sea level raise (1.0mM K_2SO_4)

Samples were taken at 0.5hr, 1hr, 2hr, 3hr, 6hr, 12hr, 24hr, 48hr, and 72hr intervals

RESULTS

Sample ID	Textural Class	M3-P (mg/kg)	Total P (mg/kg)	M3-Ca (mg/kg)	Total Ca (mg/kg)	M3-Al (mg/kg)	Total Al (mg/kg)	M3-Fe (mg/kg)	Total Fe (mg/kg)
EFT	Loam	303	726	1063	1298	669	8807	410	4840
CGAp	Silt Loam	198	937	773	1099	982	14342	272	16430
Manure Shed	Silt Loam	1121	2004	2061	3380	737	12544	407	4500
Tingle 19-20	Loamy Sand	356	974	819	1264	1321	5655	273	2061

Figure 1: Soil texture and composition of each soil sample with respect to their separates. The concentrations of the elements of interest in each soil following Mehlich III extraction and EPA3051 (specific acid digestion method).

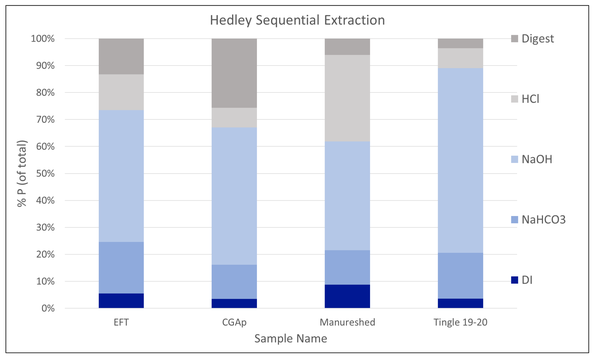


Figure 2: The Hedley sequential extraction solution ICP-OES P contribution from different extractions as percentages of the total P.

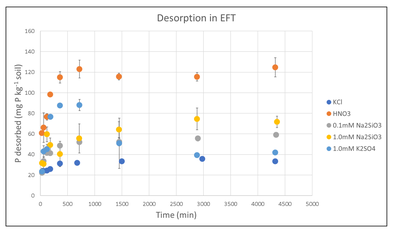


Figure 3: Average values of the concentration of P in all samples of EFT collected at each time interval and each desorption agent.

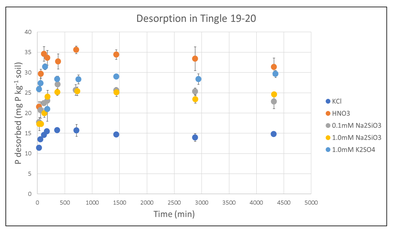


Figure 4: Average values of the concentration of P in all samples of Tingle 19-20 collected at each time interval and each desorption agent.

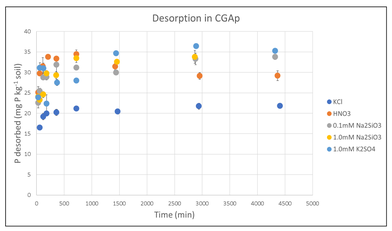


Figure 5: Average values of the concentration of P in all samples of CGAp collected at each time interval and each desorption agent.

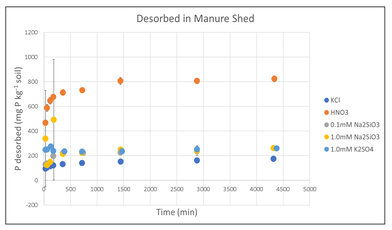


Figure 6: Average values of the concentration of P in all samples of Manure Shed collected at each time interval and each desorption agent.

DISCUSSION

- EFT has a large amount of labile P.
  - Had the highest percent of P extracted from DI water plus $NaHCO_3$ which tend to extract loosely held P.
  - Has generally lower amount of Ca, Al, and Fe, all of which form stronger bonds with P.
- CGAp likely has the most tightly held soil P.
  - Had the lowest percent of Mehlich III extractable P at 21%
  - Had highest percentage of P extracted in the Hedley digest
  - Had the highest amount of total Fe and Al, which could indicate them forming strong bonds with P
- Results for manure shed indicate a lot of loosely held P that is highly susceptible to transport off the field.
  - Had the greatest portion of DI extractable P
  - At 56%, a large portion of the total P was extracted with Mehlich III.
  - Had the highest percentage of P extracted using HCl, suggesting that it has a high amount of Ca- bound P
  - Had a high amount of P desorbed using HNO3 during the kinetic desorption experiment, and HNO3 is known to dissolve calcium phosphates.
  - Had the highest amount of M3-Ca, supporting the that it has a lot of calcium phosphates.
- Tingle 19-20 is likely dominated by large amount of P associated through inner sphere complexes
  - Had the highest percent P desorbed when using NaOH
  - This soil has the highest amount of Al that was extracted during Mehlich III
- The desorption experiments completed using HNO_3 at pH 4 also desorbed more P than other desorbing agents, especially for soils with high Ca.
  - Manure shed had the highest Ca and desorbed the most HNO_3 P by far. This may indicate preferential P desorption from the dissolution of calcium phosphate minerals (like fluorapatite).
  - CGAp had the lowest Ca, and desorbed the least HNO_3 P.

Ongoing and Future Work

- Future extracting agent: A higher concentration of sulfate (to mimic some effects of sea level rise)
- We will fit the desorption data to curves and do statistical analysis to test significance.

Acknowledgements

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