PHOSPHORUS SORPTION BY SOILS OF THE EVERGLADES AGRICULTURAL AREA

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ABSTRACT

The Everglades Agricultural Area (EAA), downstream and south of Lake Okeechobee in south Florida and once part of the vast Everglades, has been drained in the early 20th century for agriculture and flood protection. As a result of organic matter oxidation in these Histosols, soils are becoming shallower; soil pH and $CaCO_3$ content are increasing. Our objective was to determine the phosphorus sorption capacity of the organic soils in the EAA and to determine if P sorption is increased in shallower soils due to increased pH. We sampled three soil series, based on their depth to bedrock varying from less than 51 cm to less than 130 cm. Sorption isotherms experiments were conducted and the isotherms fitted to Langmuir to determine P sorption maxima. The sorption maxima were measured using both field moist and air-dried soil samples. Iron oxide, Aluminum oxide and calcium carbonate content were determined along with bulk density, soil organic matter (SOM) content and soil pH. Soil organic matter content ranged from 71% to 87% of the soil. There was an increase in pH and decrease in SOM as soils became shallower. The sorption maxima ranged from 1286 to 5260 mg Kg^{-1} when moist soil samples were used and it was significantly greater than air-dried soil samples. We found that the P sorption capacity of these soils varied among the three soil series, but could not be correlated with soil depth alone. The P sorption capacities were higher than mineral soils and were correlated significantly and positively to oxalate extractable Fe & Al, and pH and negatively correlated to extractable P, and SOM in the surface 20 cm of soil.

INTRODUCTION

- The EAA is a small portion of historic Everglades region, consisting of an artificially drained area of approximately 283, 000 ha of organic soils. Most soils in the EAA are Histosols and are classified taxonomically into soil series based on their depth of soil profile over the limestone bedrock (Fig 1).
- Development in Everglades for agriculture, in 1850, has lead to a change in hydrology and quality of water.
- The most critical and prevalent water quality issue is related to P eutrophication in the downstream Everglades.
- Drainage and development also lead to cultivation of the organic soils and this resulted in organic matter oxidation and subsidence (Fig 2).
- Subsidence has resulted in changes in soil properties like increase in mineral matter content, increase in pH and decrease in organic matter content.
- Changes in the soil properties due to subsidence and changes in hydrology may have changed the P sorption capacity of soils. Thus it is important to study the P sorption capacity of the organic soils of the EAA.

Fig 1. Map of the EAA in Florida.

Fig 2. Subsidence post at Everglades REC.

OBJECTIVES

- To study the P sorption capacity of selected organic soils in the EAA.
- To determine the P sorption capacity of surface and subsurface layers.
- To investigate soil physcio-chemical properties that impact soil P sorption in these organic soils.

METHODS

Soil samples investigated were from Dania (shallowest soil profile <51 cm), Lauderhill [intermediate soil depth 51-90 cm], Pahokee [deepest soil profile 90-130 cm]) from farms in the EAA. (Fig 3).

- Nine sites were sampled, with two samples from each of these sites.
- Soil samples were divided into two cores, 0-20 and 20-40cm.
- Phosphorus sorption experiments were conducted with 6 P concentrations and a control using field moist samples.
- Linear Langmuir isotherm plots were constructed and sorption maxima (Smax) and sorption constant (k) parameters were calculated for all the three soil series at 0-20 and 20-40 cm from the linear Langmuir isotherm equation:

(C/S = 1/[k S_{max}]+ C/S_{max}), where C is equilibrium solution P concentration (mg L^{-1}) and S is P adsorbed (mg Kg^{-1}) .

- SOM, pH, total P, acetic acid extractable P (Pa), water extractable P (Pw), extractable Fe, Al, Ca and Mg content and $CaCO_3$ content of the soil were determined.

Fig 3. Map of EAA with sampling sites.

RESULTS

1) P sorption capacity

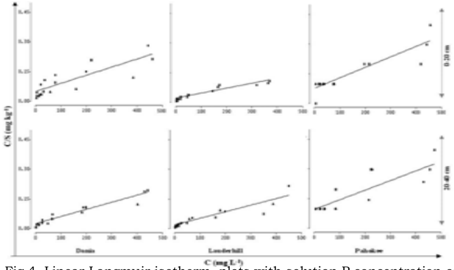

Fig 4. Linear Langmuir isotherm plots with solution P concentration on X-axis and amount of P sorbed over solution P concentration on Y axis.

Table 1. Sorption maximum and other soil properties.

Soil Series	Depth (cm)	pH	SOM (%)	S_{max} (mg kg^{-1})	
Dania	46	7.3	81	2548	a
Lauderhill	73	7.4	75	4089	b
Pahokee	101	6.6	83	2098	a

Means with the same letter are not statistically different at the 0.05 level.

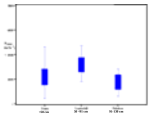

Fig 5. Smax of the three soil series.

- The sorption maxima for the samples from Dania, Lauderhill, and Pahokee vary significantly from each other and all have a high P sorption capacity (Table 1). Tillage and cultivation may have played a role in the increased sorption in these soils by increasing the surface area for sorption.
- The sorption at surface 0-20 cm is not significantly different than at subsurface 20-40 cm of the soil profile for all the three soil series.
- Though P sorption capacity varies with soil series, the difference was not related to soil depth alone, as predicted. Dania, the shallowest soil had an intermediate sorption and not the highest (Fig 5 and Table 1).

2) Soil characteristics impacting soil P sorption.

Table 1. Selected physcio-chemical properties.

Series	TP	Pa	Pw	Fe	Al	Ca	Mg	$CaCO_3$
	mg kg^{-1}							
Dania	1272	111	9	8364	1924	10132	1960	2398
Lauderhill	1933	112	5	12873	2040	9861	1890	2828
Pahokee	1593	131	16	4658	970	9407	1356	879

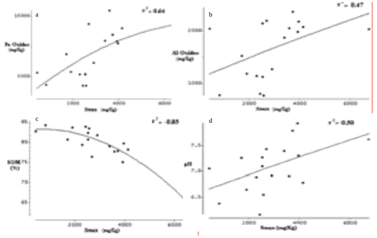

Fig 6. Relationship between sorption maxima and extractable amorphous Fe and Al oxides (a&b), SOM (c), and pH (d).

- Fig 6. Soil P sorption significantly and positively correlated with:
  - Amorphous Fe and Al oxides
  - pH
- Soil P sorption correlated Negatively with:
  - SOM
  - water extractable P
- Correlations were significant only at surface 0-20 cm depth. Hence only the surface 20 cm of the samples were considered while discussing the results.
- Soil P sorption did not correlate with total $CaCO_3$

CONCLUSIONS

- Though P sorption in these organic soils varied with soil series they did not vary with respect to their depth to bedrock as expected. The shallowest soil did not have the highest sorption capacity.
- Total $CaCO_3$ content of these soil did not influence the P sorption capacity.
- Amorphous Fe content of these organic soils played a major role in their capacity to sorb P.
- Soil pH and water extractable P also influenced their P sorption.
- Phosphorus sorption estimated from surface 20 cm of the soil and subsurface 20-40 cm of the soil were not different.