

Effects of soil calcification on phosphorus transformations and availability to c...



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1. Introduction.

The Everglades Agricultural Area (EAA) encompasses approximately 280000 hectares, extending from Lake Okeechobee south to the Broward County line. Most of the soils in this area are Histosols (soils that are composed mainly of organic materials). The principal crops are sugarcane and winter vegetables. Sod and rice are grown on a smaller scale, but sod production is gaining in importance (Snyder, 2005).

The organics soils of the Everglades Agricultural Area formed when the flooded conditions limited soil oxygen levels and organic matter production exceeded organic matter decomposition. Subsequently, drainage of the EAA was the leading cause of loss of the soil and a lowering of the surface elevation formerly known as subsidence. Furthermore, when these soils were drained, the rate of organic matter (OM) decomposition exceeded accumulation (Tate, 1980).

Drainage systems for agricultural practices and the use of P fertilizers for optimal crop production are common. Nonetheless, over-application of fertilizers contributed to excess P in run-off from the EAA into adjacent canals and wetlands. In addition, strategies for minimizing phosphorus inputs for crop production need to be developed.

Phosphorus adsorption in soils is highly dependant on pH and calcium carbonate levels. Moreover, increases in soil pH resulting from soil subsidence and incorporation of bedrock limestone into soil by tillage may have altered soil phosphorus dynamics and increased P fertilizer applications necessary to maintain crop yields.

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2. Objectives.

2. 1. Main objective.

The objectives of this study were to estimate potential effects of future subsidence and increasing soil Ca concentrations on soil P transformations and availability. Likewise, effects of calcium concentrations on soil microbial activity and organic matter decomposition rates will be assessed for different phosphorus applications rates.

2. 2. Secondary objectives.

- Predict how soil subsidence and resulting changes in soils chemistry influence the behavior of phosphorus in soils.
- Develop statistical models.

3. Materials and methods

3. 1. Site description The samples were collected from 47-CD-105 from the Everglades Agricultural Research and Education Center (EREC). Four replicates were taken each called S1, S2, S3 and S4. Calcium carbonate was added to soil to simulate potential Ca levels in soils undergoing subsidence in the future. Soils were adjusted from their residual 2% Ca levels to levels of 5, 10, and 20%. This range encompasses current and future predicted soil Ca levels in the organic soils of the EAA. Of major concern is the fate of applied P fertilizers in subsiding soils of the EAA, and impacts of projected increases in soil CaCO₃ levels of the fate of P fertilizes in soil. Soil P fertilizers were applied to Ca-amended soil at a wide range of P rates (0, 25, 100, 300 lb

P₂O₅/ac) typical for crop production in the EAA. The fate of applied P into various P pools from labile to recalcitrant were followed up to 21 d after application. Moreover, plant-available P forms were measured during this time frame to determine how future subsidence impacts P availability to crops. Results of the study will be used to predict effects of calcification of soil on P availability to crops and to develop relevant P recommendations for the changing soils of the EAA.

3. 2. Soil sampling Samples were collected on January 22nd. Four different sites were sampled to 6 in. depth. Samples were stored in paper bags and dried at 70°C.

3. 3. Methods Sixty four samples were analyzed in order to determine water-holding capacity (WHC), bulk density (BD), Loss on Ignition (LOI), soil pH, water-extractable phosphorus (P_w), TKN, TKP, P fractionation, NH₄-N, NO₃-N, microbial respiration, and soil extracellular enzyme activity.

3. 3. 1. Water Holding Capacity To determine WHC, 5 g of oven dry soil were placed on filter papers (Whatman #42) set in plastic funnels. The soil was saturated and drained by gravity. After 50 min, the soil was weighed again. (%) WHC = (wet soil- initial dry soil/ initial dry soil).

3. 3. 2. Bulk density Bulk density is a measure of the weight of the soil per unit volume (g cm⁻³), usually given on an oven-dry basis. Variation in bulk density is attributable to the relative proportion and specific gravity of solid organic and inorganic particles and to the porosity of the soil. The sites were sampled with a soil corer of a known volume (120. 6 cm³). Then, the

samples were weighed to get the fresh weight and then dried at 105°C for 24 hours. Soil bulk density = oven-dry wt/total volume of core

3. 3. 3 Loss on Ignition The soil organic matter content is expressed as the loss on ignition (LOI). To determine LOI, 10 g of dry soil were placed in glass beakers (known weight) and into a muffle furnace at 550°C for 6 hours. Then, samples were placed in a desiccator to allow them to cool while avoiding moisture. The remainder of the samples after burning in the muffle furnace is called the ash content (mineral matter). (%) LOI = (initial dry wt. - ash wt.) / initial dry wt.

3. 3. 4. Determination of the pH 3 g of dry soil were placed in a 50 mL plastic cup with 30 mL of distilled water (Ratio = 1 g soil: 3 mL water). The samples were placed in the mechanical shaker for 10 min and then the samples sat for 1 hour. The pH was measured using a pH Meter (UF/EREC Soil Testing Laboratory Procedures and Protocols, 2001).

3. 3. 5. Chemical analysis To do the chemical analysis and to prepare for the incubation of the soil samples, the oven-dried soil was passed through 2 mm sieve. To determine water extractable phosphorus (P_w), 1.5 g of soil was placed in 40 mL centrifuge tubes. 30 mL of DI water was added to the each tube (1 g soil: 20 mL water). Samples stood overnight (20 hours approximately) then placed on a mechanical shaker for 50 minutes. Then, the samples were centrifuged for 10 min at 6000 rpm. The supernatant was filtered (through # 42 Whatman filter paper) and stored at 4 °C for P determination.

3. 3. 6. P fractionation P fractionation was done with an initial weight of 1 g of oven dry soil. The next table shows the volume of reagents used for each extraction, times for mechanical shaker and centrifuge steps and specifications to filter and collect the extract.

3. 3. 7. Total phosphorus To determine Total Phosphorus (TP) by ashing, 0.5 g of oven dry soil was placed in 50 mL glass beakers. The samples were placed in the muffle furnace at 550°C for 6 hours. The ash was moistened with distilled water and 20 mL of 6 M HCL were added to each sample. Then, samples were placed on hot plates at 100 - 120 °C until dried. Then, samples were moistened with 3 mL of distilled water plus 2.25 mL of 6 M HCl and put back on the hot plates until a near boiling point. Beaker contents were transferred to 50 mL volumetric flasks and brought up to volume using distilled water. Samples were stored at 4°C until colorimetric analysis (Anderson, 1976; U. S. EPA., 1993).

3. 3. 8. Microbial respiration rate To determine the microbial respiration rate, it is necessary to grind the soil and pass it through a 2-mm sieve. One gram soil was weighed and placed into the tubes. Water was added to soil to reach 50% of water-holding capacity and placed into jars. Ten ml. of 1 M KOH were added. The samples were placed into an incubator at 25°C for seven days. After seven days, soil was removed from mason jars and 25 mL of 2 M KCl were dispensed and contents shaken for 1 hour. The samples were centrifuged for 10 minutes at 6000 rpm. Extracts were filtered through Whatman # 42 filter paper into labeled bottles.

3. 3. 9. Soil enzyme activity Enzymes are catalysts, that is, they are substances that without undergoing permanent alteration cause chemical reactions to proceed at faster rates. Accumulated enzymes in soils are regarded as enzymes present and active in a soil in which no microbial proliferation occurs (Kiss et al., 1975). Enzyme activities in soils are derived from free or extracellular enzymes. Besides, proliferating microorganisms produce enzymes that are released to the soil. Free enzymes in soils are adsorbed on organic and mineral constituents.

3. 3. 9. 1. Sulfatase activity The principles of the method described is based on colorimetric determination of p-nitrophenol released by arylsulfatase activity when soil is incubated with buffered (pH= 5. 8), potassium p-nitrophenyl sulfate solution, and toluene.

3. 3. 9. 2 Phosphatase activity Of the various methods available for assay of phosphatase activity in soils, the method developed by Tabatabai and Bremner is the most precise. It involves colorimetric estimation of the p-nitrophenol released when soil is incubated with buffered sodium p-nitrophenyl phosphate solution and toluene.

3. 3. 9. 3. Glucosidase activity The principles of the method described for assay of B-glucosidase activity are similar to those of the assay of phosphodiesterase. The method is based on colorimetric determination of the p-nitrophenol released by B-glucosidase when soil is incubated with buffered PNG solution and toluene.