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Mass Balance of Phosphorus in the Drainfield of Onsite Wastewater Treatment System

Sara Mechtensimer, Yun-Ya Yang, and Gurpal S. Toor

Soil & Water Quality Laboratory, Gulf Coast Research and Education Center, University of Florida, Wimauma, FL, USA. E-mail: smechten@ufl.edu

INTRODUCTION

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- Onsite Wastewater Treatment Systems (OWTS) are also known as a septic systems and consist of a septic tank and a drainfield or mound which treats effluent by dispersing it in unsaturated soil.
- Main concern with phosphorus (P) in OWTS is that if the septic tank effluent (STE) is not properly treated in the drainfield, P can move to shallow groundwater and nearby surface waters.
- In Florida, OWTS discharge an estimated 426 million gallons of effluent per day from approximately 2.6 million septic systems to subsurface soil.
- Residential wastewater contains 6-12 mg of total P per liter, with 59% coming from toilet waste, 37% coming from use of personal care products, soaps and detergents, and 4% from garbage disposal waste.
- About 85% of P in effluent is present as orthophosphate or dissolved reactive P (DRP).

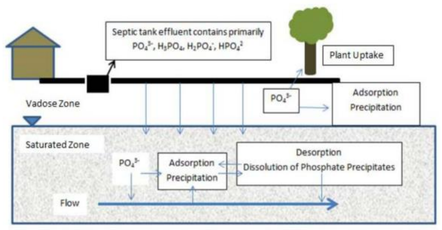


Fig. 1. Fate and Transport of Phosphorus in a Septic System.

Fate of Phosphorus in Septic Systems

- Possible transformation of phosphorus (P) in the drainfield (Fig. 1) include the following:

➢ **Inorganic P:** As polyphosphates are broken down to orthophosphate in water, most of P that enters drainfield is present as orthophosphate. Orthophosphate is sorbed by soil components such as organic matter, calcium, iron and aluminum thereby reducing the amount of P leaching. Further, some P is precipitated with iron, aluminum, and manganese compounds in acidic soils and as calcium and magnesium compounds in alkaline soils.

➢ **Organic P:** Part of the organic P fraction is converted to orthophosphate via mineralization. This process is most rapid when soils are warm and moist but well drained. Organic P may also sorb directly onto soil surfaces.

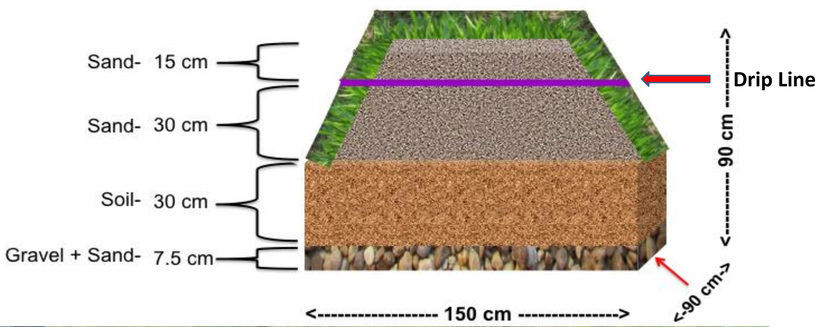
OBJECTIVE AND HYPOTHESIS

- **Objective:** Determine the mass balance of P in the drainfield of a conventional OWTS.
- **Hypotheses:**
  - H1: Most of the applied P in septic tank effluent will be retained in the drainfield (unsaturated soil) because of sorption/precipitation reactions.
  - H2: Organic P may leach from the drainfield .

METHODS

- Conventional drainfields (hereafter, referred to as mounds) were constructed, in triplicate, using pressure treated wood (1.5-m length x 0.9-m width x 0.9-m height) with 1:1 side slope (**Fig. 2**). A hole was drilled at the bottom of each mound to collect leachate.
- Mounds were packed as shown in **Fig. 2**. A drip line with 3 emitters (30 cm apart) was placed on top of the sand layer and dispersed 9 L/day of STE (equal to the maximum allowable rate of 3 L/ft²/day for Florida's sandy soils).
- Natural soil collected from the surrounding area (0-30 cm) was used to construct the mounds along with sand and pea gravel.
- Mounds were instrumented with CS650 Campbell sensors to measure volumetric water content, temperature, and electricity conductivity. These were located beneath the drip line (6 probes, 3 in each layer) and sides (4 probes, 2 in each layer).
- Effluent and leachate was analyzed for dissolved reactive P (DRP) and total P (TP) by the molybdenum blue colorimetric method using a Seal AA3 auto analyzer.
- Data are reported for 61 leaching events that occurred during Jan-Sept 2013.

Fig. 2. Construction of Septic Mounds.

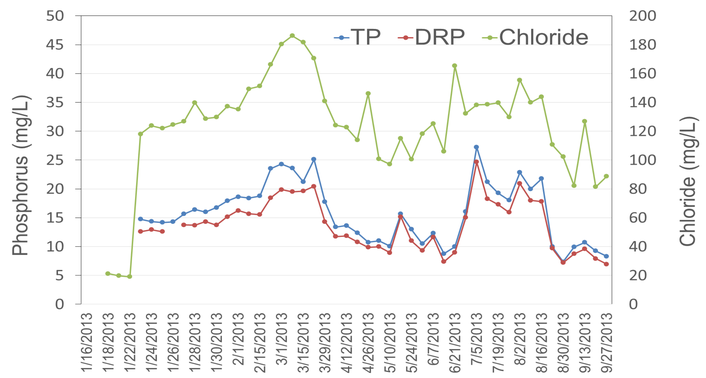


DISCUSSION AND CONCLUSIONS

Concentration of Phosphorus in STE and Leachate

- Median concentrations of chloride in STE were 127 mg/L, but showed tremendous variability during Jan-Sept 2013 (Fig. 3).
- Median concentrations of total P and DRP in STE were 15.7 and 13.7 mg/L, respectively. The proportion of DRP in STE was 85% of total P.
- Less than 1% of added P with septic tank effluent was recovered in leachate (DRP: 0.5%, other P: 0.5%).
- Mean concentrations of total P and DRP leachate during Jan-Sept 2013 were 0.072 mg/L and 0.036 mg/L, respectively. This suggests rapid sorption and precipitation of P in the drainfield.

Fig. 3. Concentrations of Chloride, DRP, and Total P in Septic Tank Effluent during Jan-Sept 2013.

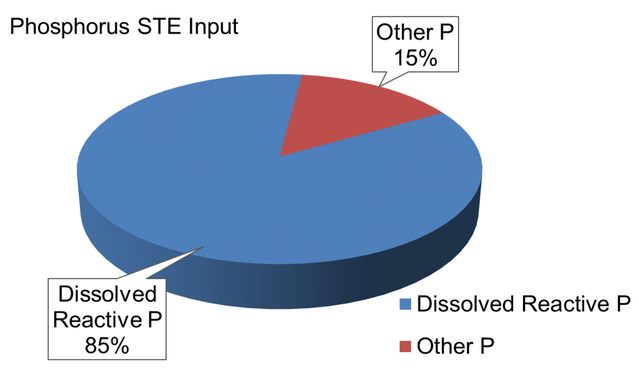


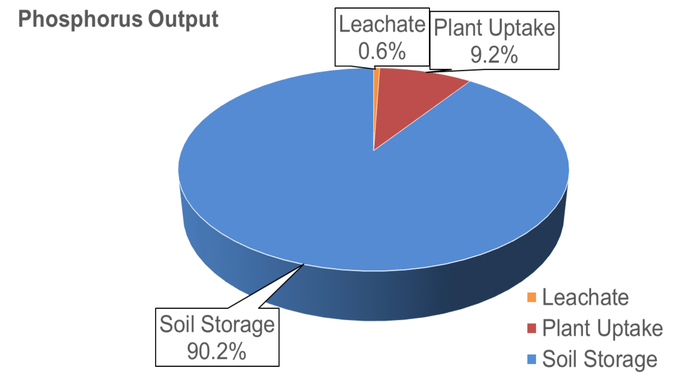
Mass Balance of Phosphorus

- Total P added with STE from Jan-Sept 2013 was 32.6 g.
- Out of which, less than 0.2 g was recovered in leachate (0.6% of total) and 3 g was taken up by plants (9.2% of total). This suggests that >90.2% of the added total P was stored (fixed) in the soil (Fig. 4).

Fig. 4. Inputs and Outputs of Phosphorus in Drainfield.

Total P Input = STE
Total P Output = Leachate + Plant uptake
Soil Storage = Total Input - Total Output





ONGOING RESEARCH

- As most of the P was fixed in the soil, our ongoing work includes speciating P forms in the soil by using a combination of chemical extractions and spectroscopic techniques.
- We will use XANES (X-ray Near Edge Structure Spectroscopy) to identify P minerals in soils and solution state NMR (Nuclear Magnetic Resonance) to identify organic P forms in soil. This will provide information about P attenuation mechanisms and long-term fate of P in the drainfield.

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