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Soil and Water Science
Research Brief

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A MODEL FOR LONG-TERM P LEACHING IN SANDY SOIL

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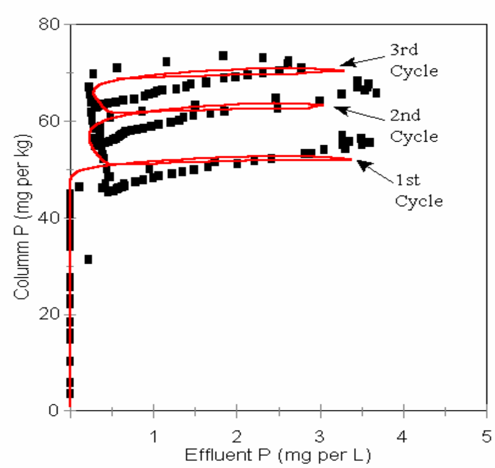
Leaching in acid, sandy soils is recognized as an important transport mechanism for P. Accurate estimates of P retention capacity are required to efficiently utilize land for waste disposal while protecting water quality. Measuring P retention capacity of soil is complicated by the fact that both the adsorption and desorption of P are slow reactions that can take months or years to reach equilibrium. This long-term sorption/ desorption behavior must be understood if predictions of P loading capacity under field conditions are to be attempted.

A model has been developed to describe P leaching that is based on the following assumptions: 1) P adsorption and desorption are reversible processes but can occur at different rates; 2) the effects of sorption/desorption kinetics are negligible for the time periods considered, i.e., years; and 3) Freundlich parameters controlling sorption/desorption of P can be estimated from a single-point isotherm which we call the Relative Phosphorus Adsorption (RPA).

In its simplest form, the model assumes that the soil consists of a single horizon with a uniform bulk density and water content, through which water flows under unsaturated, steady-state conditions. The column length is divided into an arbitrary number of segments and P leaching is simulated as a two-step process: 1) the displacement of the pore water in each segment by that from the overlying segment, and 2) partitioning of P between solid and solution phases. The P concentration in the input solution can be changed periodically to simulate cycles of P application, resulting in both adsorption and desorption occurring at different points within the column at the same time.

The amount of P retained by a sample from the C horizon of an Astatula fine sand *vs*. the concentration of P in the leachate when exposed to 3 cycles of a 5 mg/L P solution is shown below. The solid line is the model simulation; the squares are actual data for this column. Each P cycle occurred over a period of about one year.

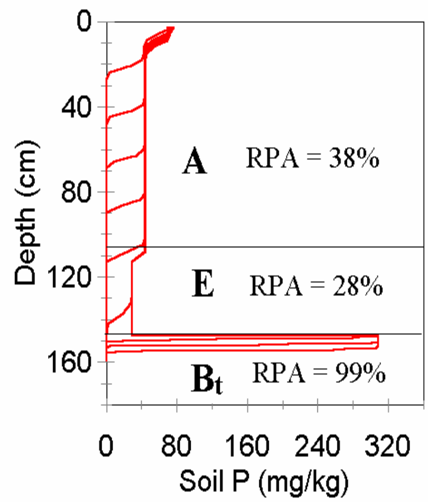


Notice that the amount of P retained in the column was still increasing after three cycles and that the model did a good job of describing the increased P retention over time.

Our goal is to predict P leaching in soils to which manure or lagoon effluent is added. To demonstrate how the model can be used to simulate P leaching at the field scale, we will assume that we have a soil that consists of three horizons, an A, E, and Bt. For this simulation, actual soil characterization data for a Millhopper fine sand were used.

The RPA for each horizon was estimated using clay content and the water content of each horizon was taken to be the field moisture percentage. Other inputs to the model included the depth of each horizon, the amount and phosphorus concentration in the effluent being loaded into the soil, and an estimate of the net amount of water available for deep percolation through the profile, i.e., net water = rainfall + effluent – evapotranspiration.

The diagram below shows the simulated movement of P down the profile with time (each line represents one year). The model predicts that after 6 years, P will have traveled 150 cm down the profile and will begin entering the Bt horizon. Notice the drop off in soil P in the E horizon that has the lowest P retention capacity, and the sharp boundary of P accumulation in the upper layer of the Bt horizon. A total of about 1500 kg P/ha was applied during the simulation that covered a period of 11 years, the last five of which consisted entirely of P loading of the Bt horizon.



The much slower movement of P in the Bt horizon is a consequence of its higher clay content and greater P sorption capacity. It should be cautioned that this is only a simulation and not actual data for P leaching. Current research on P leaching in sandy soils of the Suwannee River Basin should provide an opportunity to validate the model and to indicate how accurate such simulations are for predicting long-term P leaching. In the meantime, these simulations can show, at least qualitatively, how soil properties and management practices can impact P leaching.

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