



Soil and Water Science

Research Brief

University of Florida

Institute of Food and Agricultural Sciences

LABORATORY VALIDATION OF SOIL PHOSPHORUS STORAGE CAPACITY PREDICTIONS

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Well-drained sandy soils receiving high application rates of manure are particularly prone to phosphorus (P) leaching due to limited P retention capacity. Soil test P (STP), and degree of phosphorus saturation (DPS) or P saturation ratio (PSR), which relates the amount of P already adsorbed to the soil P sorption capacity (Al and Fe), are parameters used to make environmental risk assessments. The parameters identify present day problems, but fail to identify risks of future P additions. For example, the STP of a native Florida Spodosol is typically very low, but the environmental risk of applying additional P could be very high because of the soil's negligible P retention capacity.

The soil phosphorus storage capacity (SPSC) concept was recently proposed by Nair and Harris (2004). SPSC corresponds to the amount of P that can be safely added to a specific volume or mass of soil before the P becomes an environmental concern. Determining the storage capacity of a soil can be critical in nutrient management to indicate how long P could be safely applied to the soil under specific loading conditions. Calculations for PSR and SPSC are as follows:

$$PSR = \frac{\text{Oxalate P}}{31} \div \left[\frac{\text{Oxalate Fe}}{56} + \frac{\text{Oxalate Al}}{27} \right]$$

$$SPSC = (0.15 - \text{Soil PSR}) * \left[\frac{\text{Oxalate Fe}}{56} + \frac{\text{Oxalate Al}}{27} \right] * 31$$

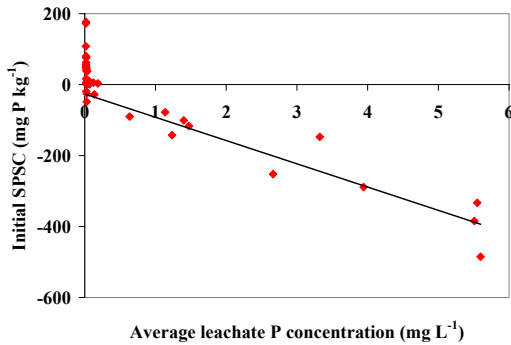
All the elements (expressed in mg kg⁻¹) are divided by the respective atomic weights to convert to mmoles and to standardize the calculations. In the SPSC calculations, a multiplication by 31 (P atomic weight) is necessary to convert the result into mg P kg⁻¹. According to Nair et al. (2004), a PSR value of 0.15 best approximates an environmental threshold for Florida sandy soils. When PSR exceeds 0.15, P concentrations in the soil solution increase rapidly, signaling increased potential for P loss to the environment. Soil Test P, Fe and Al can also be used to calculate PSR and SPSC if calibrated against similar oxalate values.

Data from a column leaching experiment (Rhue et al., 2006) of soils minimally, and highly P-impacted with dairy and poultry manures were used to validate the SPSC concept. The soil columns received various concentrations of P for approximately 30 months.



We calculated initial SPSC values before beginning the column study. The following figure shows little or no P in the leachate when initial SPSC values were positive (soil was a P sink when PSR < 0.15), whereas P leachate concentrations increased linearly

when SPSC values were negative (soil was a P source when PSR > 0.15).



Comparison of initial SPSC and average leachate P concentration

At the end of the study, the soils were again analyzed for oxalate extractable P, Al, and Fe, and PSR and SPSC recalculated. The final SPSC is referred to as the observed SPSC. The total P gained or lost during the column experiment was added to the initial oxalate extractable P value to determine a new oxalate P. Using this new P concentration, we calculated a new PSR according to the formula below. The predicted SPSC was calculated using this new PSR.

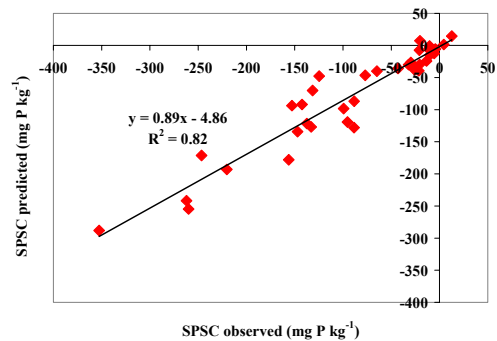
$$NewPSR = \frac{Initial\ oxalate\ P + P\ gained\ or\ lost}{Final\ oxalate\ [Fe + Al]}$$

$$SPSC_{predicted} = (0.15 - new\ PSR) * Final\ oxalate\ [Fe + Al]$$

When all the soils (minimally and highly impacted) were considered, we found a conservative SPSC prediction, approximately 90% of the observed values. The high percentage and the strong correlation suggest that SPSC is capable of integrating the risks associated with previous loadings while taking into account the P release capability of the soil.

A comparison between observed and predicted values for only the minimally impacted dairy- and poultry-amended soils yielded slightly better absolute predictions. The results suggest that SPSC can closely

estimate the amount of P that can be added to sandy soils before environmental problems would occur.



SPSC predicted versus SPSC observed for all soils in the column study

The information is particularly critical in manure application scenarios, where nutrient loading is based on crop N requirements that result in excess P in the soil.

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Nair, V.D., K.M. Portier, D.A. Graetz, and M.L. Walker. 2004. An environmental threshold for degree of phosphorus saturation in sandy soils. J. Environ. Qual. 33:107-113.

Rhue, R.D., W.G. Harris, and V.D. Nair. 2006. A retardation-based model for phosphorus transport in sandy soil. Soil Sci. 171:293-04.

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