New Tools to Identify Phosphorus Hotspots and Predict Phosphorus Loss Risk from Manure Impacted Soils

D. Chakraborty[2] and R. Prasad[1,2]

2. dzc0003@auburn.edu 1,2 rzp0050@auburn.edu

[1]Alabama Cooperative Extension System, [2]Dept. of Crop, Soil, and Environmental Sciences, Auburn University, AL, 36849

Introduction

- Poultry industry in Alabama is the second largest agricultural industry and generates an estimated 1.5 million tons of poultry litter (PL) containing approximately 19,350 tons of phosphorus (P) (Booth, 2002).
- Poultry litter is bulky which limits their economical long distance transportation.
- Repeated application of PL on farmland often result in buildup of P in soil over time leading to creation of "**P hotspots**".
- Phosphorus transported from agricultural fields during rainfall events can trigger eutrophication of aquatic systems and cause ecological and economic degradation.
- Lake Wedowee watershed in Alabama is of prime importance mainly due to expansion of poultry operations in the area.
- Phosphorus Index or Soil test P (STP) are the two most common tools used to indicate the potential for P loss risk from farmlands to environment.
- Effectiveness of these tools to predict P loss risk is not clear for Alabama soils.
- P saturation ratio (PSR) and soil P storage capacity (SPSC) are two potential tools that can be used for environmental risk of P loss from Alabama soils.
- Soil phosphorus storage capacity is defined as the amount of P that can be added to a given volume or mass of soil before the soil becomes an environmental concern.
- A soil PSR (change point) of 0.10 and above has been established as an indicator of greater risks of P loss from Florida soils (Nair et al., 2004).

Hypothesis

- Soil test P originally developed for agronomic purposes is not a true indicator of environmental P loss risk.

Objectives

- To estimate the PSR and SPSC of soils under different management practices in Lake Wedowee watershed.
- To compare if SPSC and PSR are better approaches for environmental P loss risk assessment than STP.

Materials and Methods

- Soil samples were collected from pasture lands, row crop and hay fields in the Wedowee watershed.
- Samples were collected to a depth of 60 cm (0-5, 5-15, 15-30 and 30-60 cm) at multiple locations within a field.
- Samples for respective depths were air-dried, grinded and sieved.
- Water Soluble P (WSP) was determined using 1:10 soil:solution ratio
- Mehlich-1 (M1), Mehlich -3 (M3) and Oxalate (Ox) – extractable P, Fe and Al were determined using standard procedures (Chakraborty et al, 2012)

Calculations

- Phosphorus saturation ratio (PSR): molar ratio of P to {Al +Fe} based on oxalate extraction.
- SPSC was determined from oxalate extractant considering a threshold PSR of 0.15 for Alabama soils

SPSC = (0.15 - PSR)*Extractable (Fe+Al)*31(mg P kg^{-1})

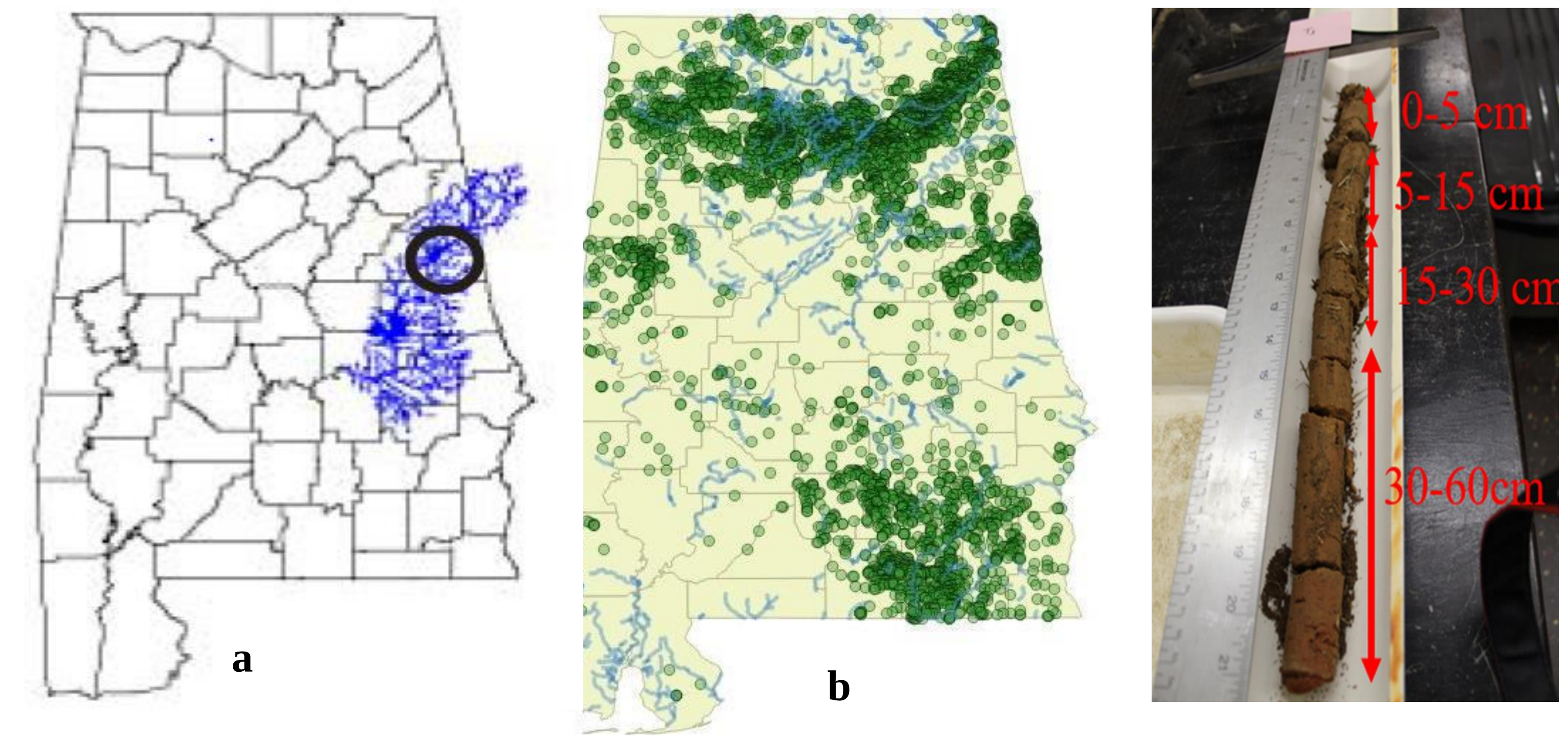

Figure 1: (a) The Tallapoosa River Basin in Alabama and Georgia with the Lake Wedowee region circled; (b) distribution of broiler production in Alabama (c) Soil cores taken from sampling farms.

Results and Discussion

Table 1. Selected chemical characteristics of two soil sample with same Mehlich 1 (M1)-P

Sample	Field Information	Soil horizon	P source	M1-P	M1-Al	M1-Fe	WSP	PSR	SPSC
				-----------mg kg^{-1} -----------					mgkg^{-1}
1	Pasture	5-15 cm	Chicken litter	24	398	54	0	0.10	78
2	Corn Field	0-5 cm	Chicken litter	24	101	49	3	0.16	-21

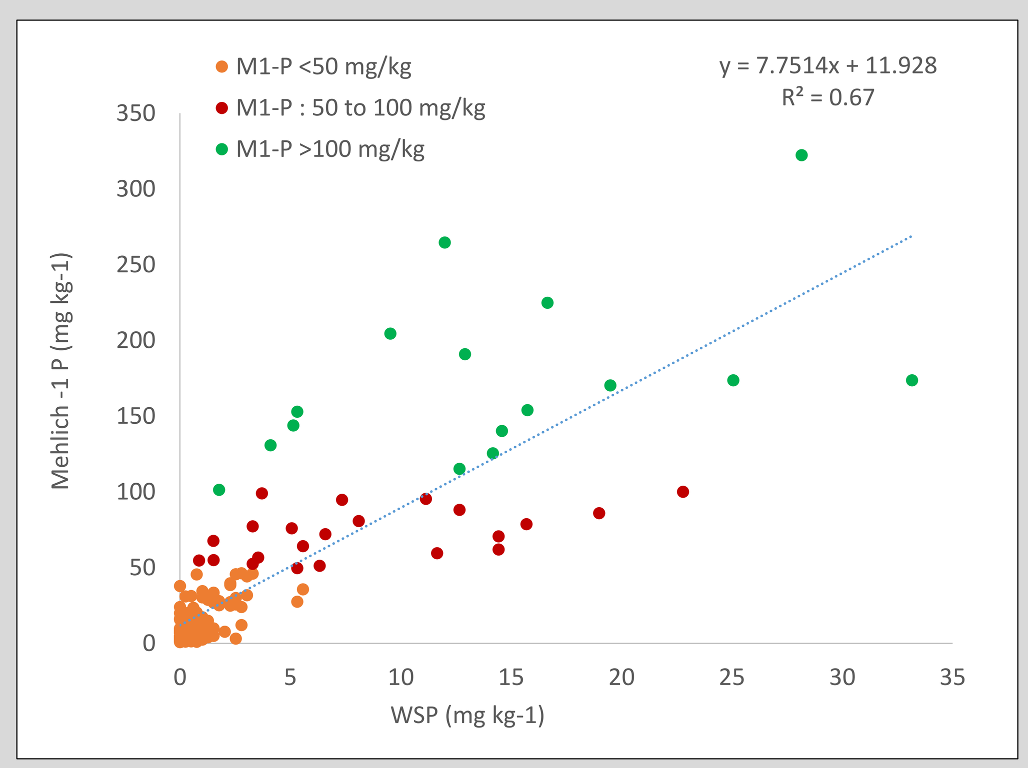

Figure 1: Relationship between Mehlich -1 P (mg kg^{-1}) and WSP (mg kg^{-1}) for soils from Lake Wedowee watershed.

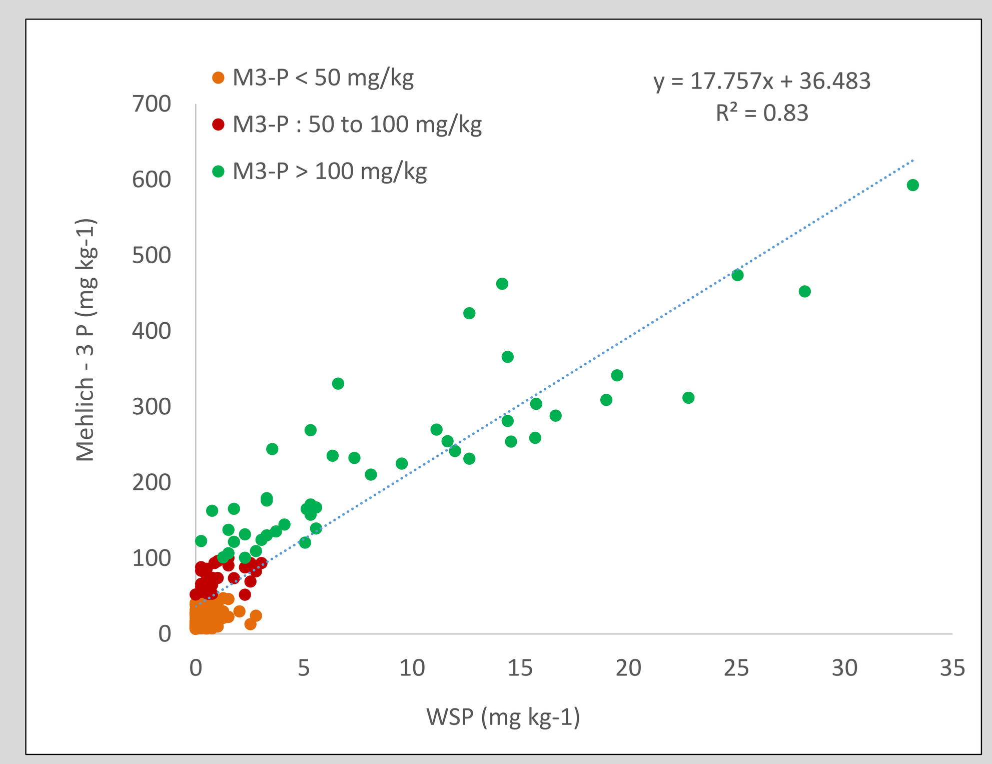

Figure 2: Relationship between Mehlich -3 P (mg kg^{-1}) and WSP (mg kg^{-1}) for soils from Lake Wedowee watershed.

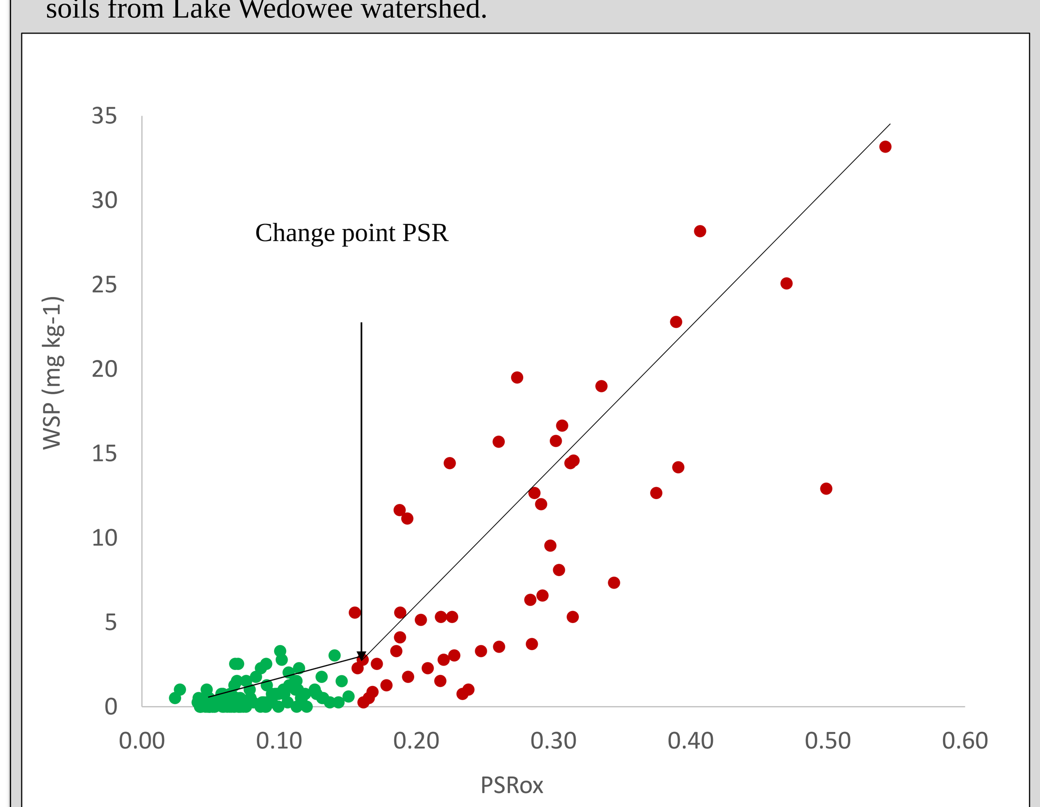

Figure 3: Relationship between water soluble P (WSP; mg kg^{-1}) and P saturation ratio using oxalate extractant (PSR_{ox}) for Alabama soils.

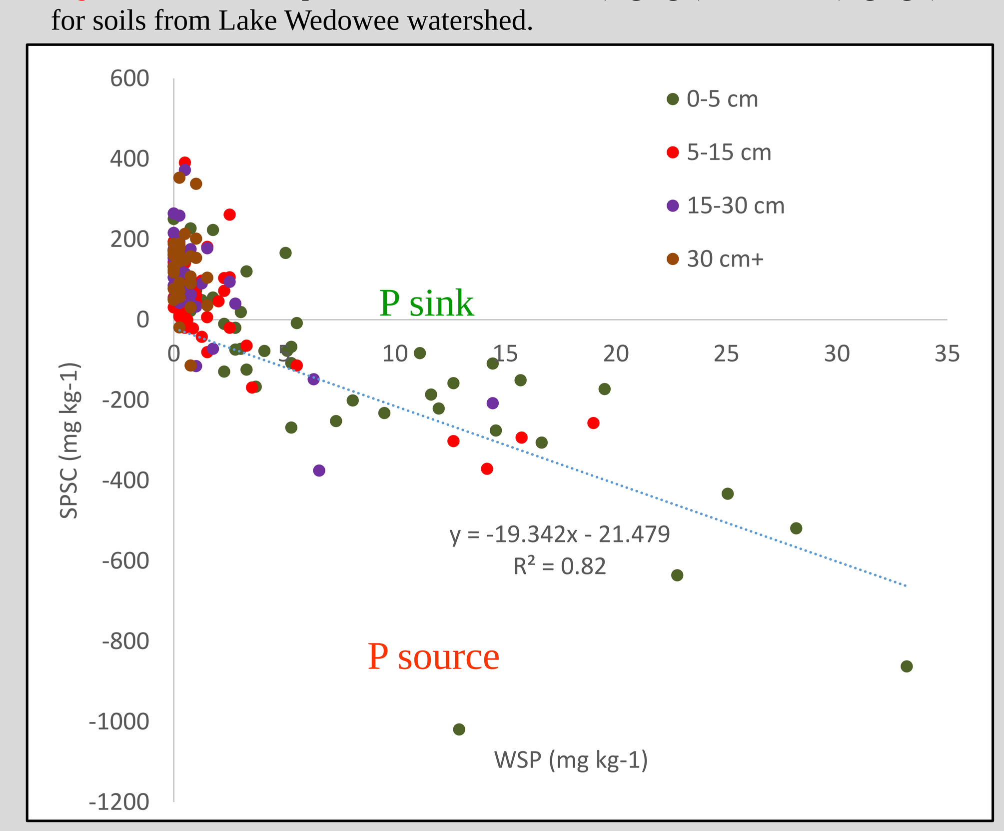

Figure 4: Relationship between SPSC (mg kg^{-1}) and WSP (mg kg^{-1}) for soils from Lake Wedowee watershed.

- Relationship between M1-P and WSP (Fig. 1) indicates that when M1-P is < 50 mg kg^{-1} environmental P loss risk is less and the risk increases as M1-P value exceeds 50 mg kg^{-1}.
- Water soluble P has a greater correlation with M3-P (Fig. 2) compared to M1-P (Fig.1). Further research is needed to confirm this finding for Alabama soils.
- Although STP (M1-P) can be used as indicator for P loss risk, however Table 1 shows the drawbacks of using M1-P. Two soils with same M1-P have different P retentive capacity.
- The "change point" PSR for Alabama soils is 0.15 (Fig. 3). Further research is needed to confirm the change point PSR for Alabama soils.
- SPSC calculated using oxalate extractant has a better relationship with WSP (Fig. 4) and is a better indicator for P loss as it accounts the actual P retentive capacity of the soil.
- Most of the surface 0-5 cm soil have negative SPSC and act as a P source. However most of the subsurface horizons (30 cm +) have capacity to retain P.

References

- Booth, L. 2002. Animal Waste Products used in Crop and Forage Production. Alabama Cooperative Extension System. Publication no. CRD-67-A.
- 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

Acknowledgement

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