NC STATE UNIVERSITY

Phosphorus Leaching as Affected by Fertilizer Sources

DEPARTMENT of SOIL SCIENCE

J. Kang, A. Amoozegar, D. Hesterberg, and D. Osmond

Introduction

Although phosphorus (P) leaches through soils slowly, matrix components of different P sources can potentially enhance P leaching. Leaching of P proceeds via two consecutive steps: a loading step and a translocation step. In the loading step, P is "loaded" through its release from the source (e.g., land-applied animal wastes) into infiltrating water. In the translocation step, P moves through the soil with infiltrated water at different rates depending on P mineralization, travel distance, P sorption capacity of the soil, and the presence of preferential flow. This research focused on the loading step affected by a variety of P-source materials and the subsequent translocation step through a sandy soil.

Research Objectives

- To evaluate the water extractable P in P-source materials as a predictor of P leaching loss
- To characterize concurrent transport of dissolved reactive P and dissolved organic C through soil columns amended with a range of P-source materials
- To compare model prediction of P transport using equilibrium convective-dispersion equation with measured P leaching data through soil columns

Materials and Methods

Soil columns and P source treatments

- Repacked soil columns (6.35-cm-diameter, 10-cm-length) using an Autryville sandy loam (Loamy, siliceous, subactive, thermic Arenic Paleudults).
- Surface-applied one of seven P-source materials as a pulse to the top of soil columns (Fig. 1).
- Analyzed column leachates for dissolved reactive P and dissolved organic C with 23 pore volumes of water throughput.

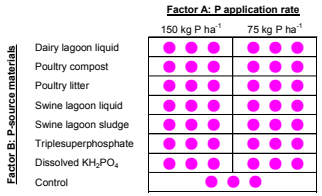

Fig. 1. Phosphorus source treatment following two way factorial arrangements on a completely randomized design. Note that each closed circle symbolizes a soil column.

P sorption and transport parameters

- Estimated dispersion coefficient and column Peclet number through a Br tracer test (Fig.3).
- Determined the Langmuir P sorption isotherm and calculated the partition coefficient of P in liquid P sources (dissolved KH_2PO_4, dairy lagoon liquid, and swine lagoon liquid) corresponding to their water extractable P concentration.
- Calculated the retardation factor of P for each of liquid P sources.
- Simulated equilibrium transport of P according to the convective-dispersion equation via CXTFIT program (Measured data vs modeled CDE transport).

Fig. 2. Soil columns instrumented with leachate collection system

Results and Discussion

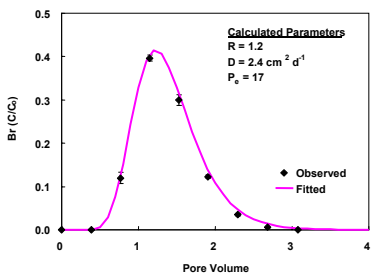

Fig. 3. Bromide (Br) breakthrough curve fitted to the convective-dispersion equation by the CXTFIT. Bars indicate standard errors of the mean Br concentration in the leachate from all 45 columns. C_o, input concentration; C, output concentration; R, retardation factor, D, dispersion coefficient; P_e, column Peclet number.

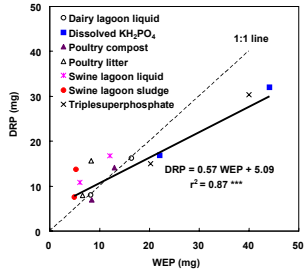

Fig. 4. Relationship between the amounts of water extractable P (WEP) and the cumulative amounts of dissolved reactive P (DRP) leached from surface-applied P-source materials. ***Significant at the 0.001 probability level.

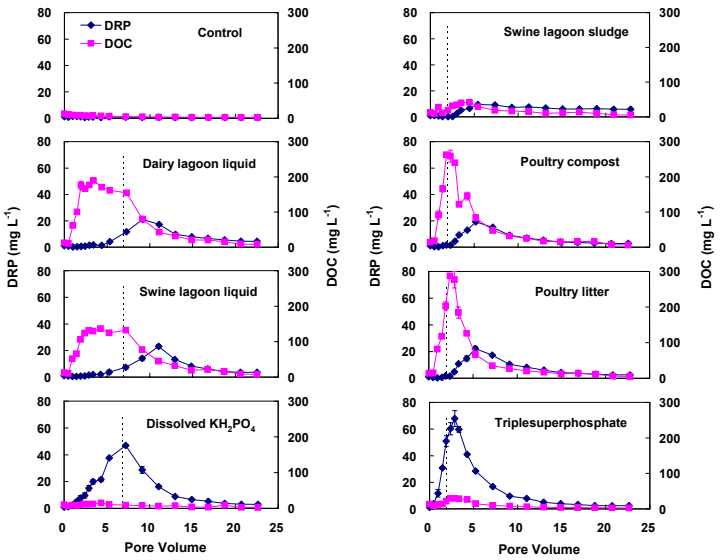

Fig. 5. Concurrent transport of dissolved reactive P (DRP) and dissolved organic carbon (DOC) through the soil amended with a range of P sources at a rate of 150 kg total P ha^{-1}. Dashed lines show pore volume at which P source mixtures were switched to deionized water (i.e., end of P application pulse). Error bars indicate one standard error of the mean concentrations of DRP and DOC.

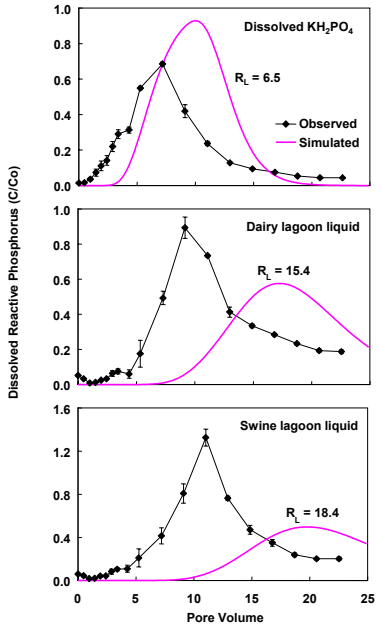

Fig. 6. Comparison of CDE-simulated P breakthrough curves to the measured P data in column leachates for dissolved KH_2PO_4, dairy lagoon liquid, and swine lagoon liquid. Error bars indicate one standard error of the mean relative concentrations of dissolved reactive P (C/C_o). C_o, input concentration; C, output concentration; R_L, retardation factor using the Langmuir sorption parameters.

Summary and Conclusions

- Minimal adsorption or preferential transport of bromide, displaying small variability and matching the equilibrium CDE using CXTFIT (Fig. 3)
- Significant effects of P application rate ($p < 0.001$), P source types ($p < 0.001$), and their interaction ($p < 0.001$) on the amount of dissolved reactive P leached
  - Linear relationship between the amount of dissolved reactive P leached and water extractable P in P-source materials (Fig. 4)
  - Greater P recovery in column leachates amended with organic P sources (126 ± 15%) compared with inorganic P sources (66 ± 2%) (Fig. 4)
- More retarded dissolved reactive P transport than dissolved organic C due to a higher affinity of P to sorption sites
- Enhanced P transport relative to the CDE model prediction due to a combination of the mineralization of solid-phase P remaining on the soil surface and competitive sorption between DOC and P (Fig. 6).
- Land application of liquid wastes need to consider not only the water extractable P of source materials but mineralization of organic residues when devising environmentally sound P fertilizer recommendations.