FORMS OF PHOSPHORUS IN MANURE AND IMPACTS ON RUNOFF LOSSES

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Phosphorus (P) is removed from fields in runoff either as dissolved P or as a component of soil particles carried by runoff water. The focus of our work concerns the potential for P to dissolve in water from dairy manure or poultry litter applied to soil. The objectives of our research were to quantify P released from manure-amended soils with different antecedent soil test P levels and to elucidate manure P chemical properties controlling P loss to runoff water. For this research, we used water-extractable P in raw manures and manure-amended soils with water as an indicator of the relative susceptibility of P in these materials in the field to dissolution and removal by runoff water.

The P in raw poultry litter is very different from that in dairy manure. Poultry litters can be more than ten times more concentrated in P than semi-solid dairy manures on a per ton wet weight basis. For example, in one of our experiments, a 3 ton/acre application of raw poultry litter contained the same amount of total P as a 25 ton/acre application of dairy manure. However, a greater percent of the P in most dairy manures is water-soluble. We found that from 17 to 66% of the P in semi-solid dairy manure (n=8) was extracted with water, while for poultry litters (n=7) only 14 to 22 % was extracted with the same procedure. The poultry litters we examined came from broiler houses in northwest Wisconsin, and they were similar in total P and other minerals and in water-extractable P. These poultry litters contain mineral forms of calcium-magnesium phosphate that is sparingly soluble but more soluble than rock phosphate (apatite; Cooperband and Good, 2002). In contrast, we have not been able to identify discrete phosphate mineral particles in dairy manure.

In one long-term laboratory experiment, we mixed dairy manure or poultry litter with Plano silt loam surface soil at a total P rate equivalent to 25 wet ton/acre of the dairy manure. We used soil with two different Bray 1 P levels (11 and 30 ppm). Immediately after application, water-extractable P in manure-amended soil reflected the relative amount of water-extractable P in the raw dairy manure or poultry litter, with concentrations for both dairy manure amended treatments twice as high as those for the poultry litter treatments. Within 2 weeks, however, water-extractable P concentrations in the manure-amended soils were dramatically reduced but still significantly higher than background levels. After 2 weeks, these concentrations remained comparatively stable for the remainder of the 36-week experiment. The dairy manure-amended, “high soil test P” soil had significantly higher water-extractable P concentrations than both poultry litter-amended treatments and the dairy manure amended “low soil test P” soil.

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For a second experiment, we designed a procedure that allowed for repeated water-extraction of manure-amended soil with minimal physical disturbance of the soil. This minimal-disturbance water extraction procedure also allowed us to assess P susceptible to removal by water during periods of short-term saturation, similar to those that lead to runoff. Dairy manure or poultry litter were applied at the same P rate to Plano silty clay loam surface soils with three antecedent Bray-1 P concentrations (33, 76, and 85 ppm), and the resulting manure-amended soils were extracted with water weekly for 24 weeks. The soils were collected from the same research field, and the different soil test P concentrations were produced from applications of different amounts of dairy manure applied over a 6-year period (1994-99). In the first 2 to 4 weeks of the incubation experiment, P removed in saturation water was greater with poultry manure treatments than with dairy manure treatments. Water extraction concentrations decreased over the course of the incubation for poultry litter-amended soils. In contrast, for dairy manure-amended soils they increased to concentrations twice as high as those for poultry litter after 12 weeks. Water-extractable P from the soils with the two higher Bray1-P concentrations was significantly higher than those for the lower P soil regardless of amendment type.

The results of our second experiment indicate that where manure applications are made, particularly multiple annual dairy manure applications, P concentrations are likely to be unacceptably high in runoff water for periods extending over years. Ambient water quality criteria for P in the study area are 0.033 mg P L^{-1} for rivers and streams and 0.01475 mg P L^{-1} for lakes (US Environmental Protection Agency, 2000a, b). In contrast, the concentrations of P in the extraction water were greater than 1.0 mg P L^{-1} where dairy manure or poultry litter were added to soils that had received prior dairy manure applications. With the dairy manure-amended soil treatments, these concentrations remained above 1 mg P L^{-1} even after 14 weeks of weekly extraction. The likelihood of high P concentrations in runoff water from manure-amended cropland indicates the need for strategies that increase infiltration of runoff water in the field and thus reduce total P loads to surface water bodies.

References

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