"Predicting bioavailable phosphorus release from animal manures"

In our research, we used water-extractable P in raw manures and manure-amended soils as an indicator of the relative availability of P in these materials to dissolution in runoff water. When we amended a Plano silt loam soil at two different soil test P levels (11 and 30 ppm Bray1 P) with poultry litter, there was no statistical difference in the water-extractable P in the soils regardless of original soil test P. We examined several poultry litters from NW Wisconsin directly using scanning electron microscopy and energy dispersive x-ray spectroscopy and found that they contain discrete, calcium-magnesium phosphate mineral particles. We believe that the phosphate minerals in the poultry litter were controlling water-extractable P concentrations in these soils.

We also observed that dairy manure does not contain the same sort of phosphate mineral particles as poultry litter. Additionally, the proportion of the total P in dairy manure that is water-soluble varies with dilution rate and among manures. On average, more than 50% of the P in 10 different dairy manures was dissolved in water with dilutions of 1 part manure to 1000 parts water. From a rather small data set of two liquid manures and five solid daily-haul type manures, it appears that liquid manures are more concentrated in total P. There also may be a difference in the predominant forms of P in liquid versus solid dairy manures. We found a positive relationship between water-extractable P and water-extractable ammonium in dairy manures, suggesting that some of the P may be in the form of ammonium phosphates like struvite.

Following manure amendments to soils in incubation experiments, water-extractable P in soil was buffered at elevated concentrations. Initially, when either poultry litter or dairy manure was applied to soils in our experiments, there was a significant reduction in water-extractable P (in most cases during the first two weeks following amendment). Subsequently, water-extractable P remained comparatively stable at concentrations higher than those of unamended soil for the duration of the experiment (24 or 36 weeks).

We designed a manure-soil incubation procedure to simulate weekly P extraction by precipitation/runoff in surface soils without disturbance of soil aggregates. In dairy-manure amended soils, the concentrations in weekly minimal-disturbance extractions were approximately three times higher than those for poultry litter treatments with the same soil and same amendment P rate. In contrast, there were no statistical differences in the water-extractable P concentrations using a standard extraction procedure of shaking a fixed weight of soil with a fixed volume of water (i.e. with aggregate disruption). Differences in the soil physical and chemical properties with the different manure amendments led to differences in extraction efficiency from the aggregated soil.

Our research has shown that livestock species have a large influence on the amounts and patterns of soluble P and that these differences can lead to differences in P losses from manure-amended soil. Manure management recommendations should be developed to consider the differences in P solubility from different manures. We have also shown that there is potential for unacceptable soluble P losses from silt loam soils amended with manure, and dairy manure in particular, and that these losses can persist for a considerable period of time following manure application. This indicates a need to promote infiltration to reduce total runoff volumes from fields that have received multiple annual dairy manure applications.

Papers published

Cooperband, L.R. and L. Ward Good. 2002. Biogenic phosphate minerals in manure: implications for phosphorus loss to surface waters. Env. Sci. Tech. 36:5075-5082.