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ISEQ Work Summary as of December 2005

My research is focused on reducing water quality problems associated with dissolved and particulate P losses to surface waters from soils that have been amended with organic P sources. Organic P sources, including animal manures and municipal biosolids, have historically been applied to soils at rates designed to meet crop N needs resulting in the buildup of soil P. This buildup of soil P to concentrations that exceed crop requirements has been linked to increased P loss and ultimately to water quality problems in the Mid-Atlantic region of the U.S.A. Phosphorus solubility in organic P sources varies widely due to the source (i.e., animal, municipal) and chemical or biological treatment (i.e., addition of metal salts, composting) of the material. Consequently organic P sources will have different relative risks of P loss when applied to soil. Therefore, several states, including DE, MD, and PA are incorporating weighting factors, or P source coefficients (PSCs) into their risk assessment tools (the P Site Index) to account for differences in risk of P loss from organic P sources and inorganic fertilizer. Phosphorus source coefficients are designed to assess the potential for dissolved P losses from organic P sources and are assigned to sources based on their relative P solubility with respect to fertilizer P. In addition to the influence of the species of P in the organic sources, the species and concentrations of P in the soils that will receive these soils will also have an impact on the solubility and bioavailability of P in organically amended soils.

My research project incorporates laboratory and microscopic scale research to determine how the speciation of P differs between organic P sources, and how these differences will affect P solubility and bioavailability when they are incorporated into the soil. A laboratory study was conducted to assess the effects of organic P source incorporation on soil P in eight Mid-Atlantic soils. Differences in chemical forms of P in biosolids (Fe-treated, Fe & lime, Al & lime, biological P removal, and anaerobically digested) and animal manures were evaluated using a sequential fractionation technique. Organic P sources and inorganic P fertilizer were then incorporated into acid soils from the Mid-Atlantic to determine the solubility of P at 2-, 30-, and 180-d after incorporation. I also investigated the effects of changing redox conditions and pH on dissolved P loss from selected incubation study soils. Under reducing (anoxic) conditions, soils amended with organic P sources have the potential to release P that would exist in an insoluble form under oxidized conditions due to the reductive dissolution of other elements, such as Fe, in the system. Soils receiving Fe-rich organic P sources, such as $FeCl_3$-treated biosolids, may ultimately become a source of dissolved P if they become submerged or if fine-textured P-rich particles are eroded into fresh water systems where anaerobic conditions may develop. Selected incubation samples were equilibrated with a weak salt solution under an N_2 atmosphere for several weeks, allowing for reducing conditions to develop. Redox potential (Eh) and pH were measured weekly and samples were analyzed for dissolved Al, Fe, P, and Ca initially (under oxidized conditions) and once stable reducing conditions had been established to determine the effects of changing redox conditions. This experiment will allow us to gain more knowledge about how properties of organic P sources and soils affect pH and thus iron and P release.

In addition to batch incubation studies, I will be examining the forms of P in biosolids and manures using X-ray absorption near edge spectroscopy (XANES). Direct characterization of P using XANES will aid in our understanding of how land application of these organic P sources will affect soil P. Unlike the chemical fractionation techniques, which use chemical extractants that are destructive and may change the chemical and physical composition of the sample, XANES can be used to study samples in their natural state allowing better understanding of real world systems. Also, it is possible to characterize poorly crystalline and amorphous materials in addition to crystalline materials and organic species using XANES. The use of XANES will provide useful information regarding the speciation of the solid phases of P in manures and municipal biosolids, which cannot be obtained by any other direct characterization method that is currently available. The XANES data will be compared to chemical fractionation data. Ultimately, all the data collected will allow us to better understand the mechanisms of P release and sorption when organic P sources are added to the soils. Understanding the forms of P in organic P sources, and how changing physical and chemical conditions effect the changes in soil P when these material are added to the soil will allow us to further develop PSCs for use in risk assessment tools.