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ISEQ Work Summary as of December 2004

Recent nutrient management-based investigations have focused on understanding the role of agronomic point-source nutrient pollution, such as confined animal feeding operations (i.e., poultry production facilities), in the decreased water quality of the Mid-Atlantic Region of the United States. Because of intensive poultry production on the Delmarva Peninsula, manure management policies are being implemented and enforced. These laws require comprehensive nutrient budgets for farms which land-apply animal waste to meet crop nutrient needs. As best management practices (BMPs) are becoming incorporated into environmental legislation, an understanding of animal manure chemistry will ensure the preservation and improvement of environmental quality.

In poultry litter (PL), water-soluble phosphorus (P) concentrations can be as high as 34,000 mg kg^{-1}; therefore, manure management focuses on reducing environmental impacts from concentrated land application of this P-rich material. The use of alum (aluminum sulfate, $Al_2(SO_4)_3$), as a PL amendment, has shown promise as a BMP by reducing the quantity of soluble P released from the amended material by up to 75% (when compared to unamended PL). So, P concentrations in runoff from pastures, which received broadcast applications of alum amended PL, were significantly lower than with unamended PL. In addition, decreases in dissolved reactive P and increases in nitrogen (N) content (by decreasing gaseous ammonia volatilization in the poultry houses) make the litter a more valuable and environmentally sound nutrient source for small grain crops adjacent to poultry operations. The economic costs of alum application are comparable to those of other manure amendments, and are offset by decreased ventilation costs due to lower ammonia concentrations within the houses. However, the reactivity and stability of P in this dynamic system needs to be investigated.

A fundamental understanding of P reactivity in amended PL is necessary to maximize the benefits of this BMP and determine the environmental impact of large-scale land application. To address these issues, my research objectives are three-fold. The first objective is to differentiate the forms of phosphate in PL, based on routine sequential extractions. Fast and inexpensive, sequential extractions are useful for manure analyses required in nutrient management plans. However, we need to understand the chemistry of the extraction process to determine its accuracy for assessing the chemical composition of animal wastes as a source of crop nutrients. I have employed cutting-edge XANES (X-ray absorption near edge structure) spectroscopy, at the National Synchrotron Light Source at Brookhaven National Laboratory, to analyze and determine P speciation in sequentially extracted PL. Synchrotron research is time consuming, highly regulated, and only possible at government facilities. Therefore it could not be used for routine analysis of animal manures However, if we can use this technique to decipher the inorganic and organic P speciation in PL, we can relate this to widely-used, simple sequential extractions. In addition to giving chemical meaning to these procedures, the efficiency and accuracy of manure and soil P testing will improve.

The second objective is to understand the adsorption of phosphate onto aluminum surfaces, similar to those found in alum amended poultry litter, under varying pH conditions. Because the litter pH decreases in response to alum addition, the nature of P-Al chemistry will also change. These reactions are even more complex due to the presence of organic acids in the waste. Therefore, the third objective of this study is to focus on the role that organics, which are readily present in PL, play in P stability. In addition to traditional approaches (batch sorption isotherms), the use of Attenuated Total Reflectance Fourier Transform Infrared (ATR-FTIR) spectroscopy will be used to investigate P and organic acid interactions on aluminum oxides. To analyze the ATR-FTIR data, we are using quantum mechanical modeling. This is a new approach which allows one to determine the types of sorption complexes that occur in a system. These sorption reactions are directly related to the ability of aluminum surfaces, present in alum amended PL, to retain phosphorus against leaching and erosion.

Overall, the aim of my research is to combine molecular-scale tools with routine laboratory analyses to understand P sorption and desorption in alum amended PL. Relating these scientific approaches will enhance our interpretations of widely-used characterization techniques and enable better predictions and monitoring of phosphate transport in agronomic settings. From an economic, agronomic and environmental standpoint, the results from this research will provide support for the use of PL, as an inexpensive, abundant fertilizer, in a manner that benefits the crops without extensive environmental impacts.