Concentration and Extraction of Phosphorous from Swine Manure Slurries (as Struvite)

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Summary and Implications

Excessive loading of phosphorus (P) onto agricultural lands has been recognized as a threat to surface water quality. Forced precipitation of struvite ($MgNH_4PO_4 \cdot 6H_2O$) from animal waste slurries prior to land application can reduce dissolved reactive P levels in manure slurries. It also offers the potential to recover excess phosphorus from manures and move it to cropping areas that require phosphorus fertilizer inputs. Past work indicates that ~90% of the soluble phosphorus can be concentrated into a precipitate following chemical amendment.

This study will provide important information regarding the feasibility of phosphorus recovery as a means of balancing swine manure nutrient content with crop needs. Given the expanding regulations regarding phosphorus management, it is important to develop and test phosphorus management strategies. The sustainability of many animal operations in their current locations will depend upon their ability to meet new regulations requiring phosphorus management as well as nitrogen management.

Introduction

The long-term goal of this project is to develop a manure management technology that allows animal feeding operations to successfully implement P based nutrient management plans on their existing land base. This long-term goal is supported by the following specific project objectives: **1)** Optimize existing phosphorus concentration and extraction processes for field-scale use with swine manure slurries, **2)** Develop a pilot-scale swine manure phosphorus recovery system, **3)** Determine the agronomic value of the recovered fertilizer precipitate using agronomic trials and **4)** Conduct economic analyses to determine the cost-effectiveness of the technology as a swine manure management option.

Supporting these goals are the following four research hypotheses to be tested:

Hypothesis 1: Phosphorus can be concentrated and extracted from swine manure slurries as a valuable slow release fertilizer that is easily transported.

Hypothesis 2: Phosphorus can be recovered through concentration and extraction from swine manure slurries on a farm-scale under field conditions.

Hypothesis 3: The phosphorus based precipitate recovered from swine manure slurries has agronomic value comparable to commercial fertilizers.

Hypothesis 4: Recovery and transport of a phosphate precipitate for use as a fertilizer is a cost-effective swine manure management option.

Materials and Methods

To form struvite, magnesium, ammonium and phosphate must be available for reaction. Magnesium is generally the limiting nutrient and must be supplemented for the solubility reaction. Animal waste slurries often contain high organic and solids concentrations, therefore magnesium additions exceeding stoichiometric rate are required. Before a pilot scale system can be designed there are two items that need to be identified, an efficient, economical method for pH adjustment and a method to determine Magnesium additions.

Current research is focused on developing a bench-scale continuous flow reactor (CFR) to force struvite from manure slurries. Sensors and an automated control system are being designed to optimize Mg injection and pH adjustment in the CFR. The control system will allow for real-time adjustments based on manure composition, eliminating the need for multiple laboratory tests. Methods for the separation of the phosphorus precipitate from the manure slurry will be tested for performance and application feasibility.

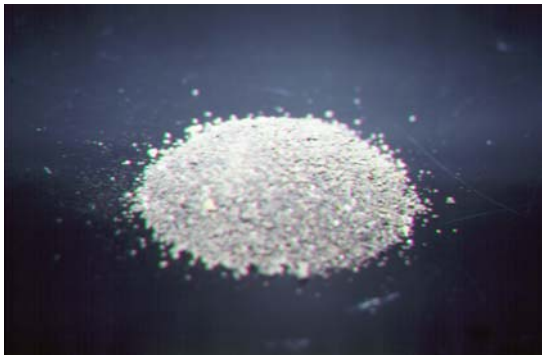

Figure 1. Precipitate recovered during lab tests.

Since struvite is twice as dense as most of the organic matter in animal waste, the precipitate can be recovered using separation methods that take advantage of density differences. A grit removal screw or hydro-cyclone could be used as precipitate removal devices. A grit-removal screw designed to work with animal manure has been developed to separate sand from manure slurry (Wedel, 1999). The McLanahan Corporation (Holidaysburg, PA) currently

manufactures this unit. The unit separates individual components from a mixture of materials having different sizes and densities.

We plan to test this device or a similar unit as our removal mechanism. If we find any operational difficulties with this approach we will use readily available hydro-cyclone technology to recover the precipitate from the waste stream. In a hydro-cyclone, slurry enters the cyclone at the top of cone at an angle. It travels around the circumference of cyclone in a circular path. Centrifugal forces cause the more dense material to travel down the cone, while the less dense fraction exits out the top of the device.

Results and Discussion

This project is still in progress and final results are not yet known. The next step in the development of this technology is designing and building a pilot-scale, mobile continuous flow reactor (MCFR). The MCFR will allow us to perform multiple tests on farms across the state to determine the efficiency, performance, and quality of the phosphorus removal and recovery or the system.

Struvite recovered from on-farm trails with the MCFR will be assessed for agronomic value and quality. The economic feasibility and cost effectiveness of this method as a manure management option will then be determined.

Figure 2. The conceptual schematic of the proposed phosphorus recovery process.