Report

Community Manure Management Feasibility Study

Dane County, WI

February 2008

Report for

Dane County, Wisconsin

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APPENDIX B
UW PLATTEVILLE SUMMARY REPORT

Dane County Study Observations and Recommendations

End of project report submitted to Strand Associates, Oct 2nd, 2007.

This report serves as a summary of the findings carried out by UW-Platteville faculty for a preliminary study on the removal of phosphorus from manure samples via chemical means. The samples studied were collected from three different dairy farms with two different types of digesters (mesophilic and thermophilic). The following salts were tested for the chemical removal of phosphorus: $FeSO_4$, $Fe_3(SO_4)_2$, $MgSO_4$, and $Al_3(SO_4)_2$.

Samples of approximately 200 ml of manure were placed in 600 ml beakers, to which the chemical solution was added. To a varying degree, frothing of the samples occurred after chemical addition. Samples were continuously mixed for three days, a relatively long period, to aid in the dissipation of the frothing. Then the samples were allowed to settle for two days. After settling, the supernatant was decanted for analysis. The remaining sample was centrifuged at 15,000 rpm (or 17,640 rcf) for 15 minutes, with analyses performed on the centrate.

Removal by Iron (III) Sulfate

The most significant tests were carried out using three samples collected at Quantum Dairy in Weyauwega, WI. This dairy farm uses a mesophilic digester installed by GHD Engineering based in Chilton, WI. The samples were analyzed or treated within a week of collection and stored at 4 °C before use. The three samples were untreated manure, digested manure, and the liquid fraction of digested manure. Removal efficiencies at Fe:P molar ratios on the order of 3:1-4:1 are summarized in Table 1.

Table 1. Removal Efficiencies Using Iron (III) Sulfate

Type of Manure	Separation Method	% Total P	% Soluble P	% TKN	% Total Solids	% Volatile Solids
Raw Manure	Decant	75	97	61	67	88
	Centrifuged	64	96	61	67	83
Digested Total Manure	Decant	57	96	47	55	68
	Centrifuge	82	98	49	62	76
Digested Liquid Portion	Decant	79	98	47	33	51
	Centrifuge	86	99	49	40	67

Soluble P removal efficiencies are very high, greater than 95% in all cases. However, total P removal efficiencies were in some cases much lower, ranging from 57% to 86%. This less efficient removal is attributed to colloidal P, which for the digested manures, was increasingly removed by centrifugation. With the exception of total P, removal efficiencies were similar for both methods of separation, as would be expected for constituents that are dissolved (unaffected by centrifugation) or associated with larger (noncolloidal) particulates that readily settle. Note that total solids analyses include both suspended and dissolved solids and the relatively low removal efficiencies result from dissolved solids remaining in solution. The manure:iron salt mixtures exhibited excellent settleability, the supernatant had very low turbidity (transparent). However, some particulates did remain in solution and some additional particulates were resuspended during the decanting procedure.

Centrifugation is more efficient at particulate removal, with less resuspension occurring during decanting.

Removal by Iron (II) Sulfate or Magnesium Sulfate

For these initial tests excessive metal addition occurred as a result of miscalculation, with Fe:P molar ratios of up to 38. Removal efficiencies were relatively high for both chemicals (Fe or Mg), however settling was less effective due to colloidal formation for the magnesium. The magnesium solution remained cloudy even after the two day settling period. For Fe^{+2}, an intermittent layer (white in color) between the supernatant and the settled solids that formed could be iron carbonate. This layer was not analyzed for P content or present in the other test solutions.

Frothing

In some of these samples excessive frothing occurs and forms a layer of ~ 3 times the size in solution; a 200 ml solution would make a 600 ml layer of froth (needed a larger beaker for these samples). This frothing occurs when aluminum sulfate or iron (III) sulfate is added in liquid or solid form. The frothing does not occur when magnesium sulfate, iron (II) sulfate or acid (tested as a control) is added. At this time, the gas released that is responsible for the frothing is assumed to be carbon dioxide. The gas is odorless and is not flammable.

Transferability of results

The removal efficiencies presented serve as a preliminary indicator of the effectiveness of iron (III) as a coagulant. Actual removal efficiencies would be expected to vary depending on specific farm practices, such as, but not limited to: type of livestock, feed ration, bedding type, manure collection system, and post-collection treatment/storage.

Conclusion

The addition of iron salts is shown to be an effective way to remove phosphorus, nitrogen and volatile (organic) solids from both untreated and digested dairy manure. Total phosphorus was removed at an average of 75% using a 3:1 Fe^{+3}:P molar ratio. This same ratio removed 97% of the soluble P as well as over 50% of the volatile solids and TKN (organic N and ammonia). This suggests the potential for using removed solids as a nutrient source for off-site use. However, several potential issues remain unanswered:

- Is the phosphorus removed by iron salts bioavailable?
- What are the costs of slurry versus dried solids?
- Do markets exist for the removed solids?