MANURE PROCESSING

for Farm Sustainability

Extension
UNIVERSITY OF WISCONSIN–MADISON

RESEARCH OUTPUT PROVIDED BY

Joe Harrison
Emeritus Professor,
Washington State University

Keith Bowers
Ostara Nutrient Recovery Technologies

Steve Norberg
Agriculture Extension Regional Specialist,
Washington State University

FACT SHEET DEVELOPMENT

Rebecca A. Larson
Associate Professor,
Nelson Institute for Environmental Studies,
University of Wisconsin–Madison

Horacio Aguirre-Villegas
Scientist III,
Nelson Institute for Environmental Studies,
University of Wisconsin–Madison

Manure Processing Fact Sheet Series

Struvite Recovery from Manure

Introduction

Phosphorus is an important mineral added to animals' diets and is critical to their development and growth. However, much of the phosphorus is excreted and ends up in manure. For many crops, if manure is applied at the rate needed for nitrogen, too much phosphorus is applied, which may lead to buildup of excess phosphorus in soils. Phosphorus buildup can lead to increased phosphorus loss and the resulting environmental consequences (Andraski and Bundy 2003; Jokela et al. 2012). If manure is applied to meet crop phosphorus needs, supplemental nitrogen application is required. Struvite recovery systems can capture and concentrate manure phosphorus in an easy-to-handle slow-release phosphorus fertilizer. Struvite is captured in the form of magnesium-ammonium-phosphate [$MgNH_4PO_4 \cdot 6(H_2O)$] particles (**Figure 1**) that can be transported more cost–effectively than that of manure for use on fields that have a phosphorus demand, thus increasing nutrient use efficiency and reducing environmental impacts associated with over-application.

Figure 1. Recovered struvite.

Technology Basics

A struvite recovery system uses a fluidized bed system to produce struvite (magnesium-ammonium-phosphate). In the struvite recovery system tested in Washington on livestock manure, the fluidized bed is a cone system (**Figure 2**), where manure enters the system through the bottom of the cone. The manure is circulated around the cone to create the fluidized bed conditions in which manure particles can collide to form struvite. The pH in the system is lowered to 5.5 to allow the manure phosphorus to disassociate from calcium (a step that is not required with low calcium content manure such as swine manure), and then raised to 7.5 (using ammonia) to promote the formation of struvite. Once the struvite is formed, it is

Figure 2. Cone fluidized bed system for struvite recovery.

Figure 3. Struvite recovery point from the cone fluidized bed system.

captured and removed from the reactor (**Figure 3**). The recovered struvite product can then be applied to fields at agronomic rates as a fertilizer (**Figure 4**).

Performance and End Use

Phosphorus removal and recovery were measured in the system shown above. For total phosphorus, the average reduction over 28 runs was 30% (with a range from 2 to 72%). The average removal of ortho-phosphorus was slightly higher at 32%. Based on the level of ortho-phosphorus in the manure, approximately 2.6 pounds of struvite could be recovered for every 10,000 gallons of manure processed.

Figure 4. Struvite land application.

Once recovered, struvite can be land applied as a fertilizer. Field trials indicated that corn and alfalfa yields were maintained or improved after incorporating struvite with the commercial fertilizer monoammonium phosphate (MAP) (Hilt et al. 2016). Application of struvite had similar or improved yields than that of MAP used alone when applied to acidic soils, but reduced performance when applied to alkaline soils (struvite dissolves faster in acidic conditions). More recent field trials confirmed that struvite added to MAP can improve or maintain crop yields when compared MAP only (**Figure 5**). Studies suggested mixing struvite to MAP at rates of 50-75% (e.g., struvite to MAP of 50:50 or 25:75) increases yields (Norberg et al. 2018).

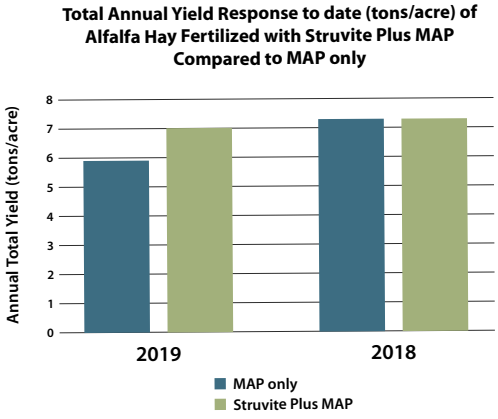

Figure 5. Total annual yield response of alfalfa hay fertilized with struvite plus MAP compared to MAP only.

Cost

The cost to install a struvite recovery system designed to handle 60,000 gallons of manure per day in Washington is approximately $75 to $125 per cow. The operating costs are $80 to $140 per cow per year ($0.22 to $0.39 per cow per day or $0.003 to $0.006 per liter of manure). When the struvite system is integrated within a manure system that has a digester, operating costs are on the lower end of the reported range while recovering struvite from undigested manure is at the higher end (increased chemical costs without a digester).

Limitations

Use of this technology is limited to liquid manure. Therefore, some manure systems may require preprocessing to lower the solids content of the manure (e.g., solid liquid separation). To form struvite, phosphorus must dissociate from calcium to then bind with magnesium and ammonium. Cattle manure has a relatively high level of calcium, and therefore requires the pH to be lowered to facilitate the dissociation of phosphorus from calcium. Swine manure has relatively lower level of calcium, and therefore this process is not needed for struvite recovery. Lowering the pH is most easily accomplished using acids, among which sulfuric acid has been found to be the most effective.

References

Andraski, T. W., and L. G. Bundy. 2003. Relationships between phosphorus levels in soil and in runoff from corn production systems. *Journal of Environmental Quality*, 32:310–316. https://doi.org/10.2134/jeq2003.3100

Hilt, K., J. Harrison, K. Bowers, R. Stevens, A. Bary, and K. Harrison. 2016. "Agronomic Response of Crops Fertilized with Struvite Derived from Dairy Manure." *Water Air Soil Pollut* 227, 388. https://doi.org/10.1007/s11270-016-3093-7

Jokela, W. E., W. K. Coblentz, and P. C. Hoffman. 2012. "Dairy Heifer Manure Management, Dietary Phosphorus, and Soil Test P Effects on Runoff Phosphorus." *Journal of Environmental Quality*, 41(5):1600-1611. https://doi.org/10.2134/jeq2012.0046

Norberg, S., E. Mackey, S. Fransen, J. Harrison, D. Llewellyn, and L. Whitefield. 2018. "Developing practical phosphorus and potassium tissue test recommendations and utilizing struvite in modern alfalfa systems." National Alfalfa and Forage Alliance Final Project Report 2018 Grant. https://www.alfalfa.org/pdf/researchArticels/18Norberg-USAFRI-Final.pdf

This fact sheet was developed with information presented at the 2021 Midwest Manure Summit.

Members of the Manure Summit Steering Committee, all affiliated with the University of Wisconsin-Madison:

Tina Kohlman, Regional Dairy Agent, Fond du Lac/Sheboygan/Ozaukee/Washington Counties, Division of Extension

Rebecca A. Larson, Associate Professor, Nelson Institute for Environmental Studies

Jamie Patton, Outreach Specialist, Nutrient and Pest Management Program, Department of Horticulture

Stephanie Plaster, Farm Management Outreach Specialist, Division of Extension

Amber O'Brien, Former Agriculture Educator, Calumet County, Division of Extension

Heather Schlesser, Agriculture Agent, Marathon County, Division of Extension

Lyssa Seefeldt, Agriculture Educator, Eau Claire County, Division of Extension

Chelsea Zegler, Agriculture and Water Quality Outreach Specialist, Division of Extension

Extension
UNIVERSITY OF WISCONSIN–MADISON

Division of Extension publications are subject to peer review.

Reviewers: Zong Liu is an Assistant Professor for the Biological and Agricultural Engineering Department at Texas A&M, Jackie McCarville is the Agricultural Educator for Green County, and Evan Henthorne is the Program and Agricultural Educator for Adams County, both at the University of Wisconsin–Madison Division of Extension.

This publication is available from your county Extension office (counties.extension.wisc.edu) or from Division of Extension Publishing at learningstore.extension.wisc.edu.

Struvite Recovery from Manure (A4192-007) I-05-2022