Compost Bedded Pack Dairy Barn Nutrient Availability

Leslie Hammond [1], Mark Coyne[1], and Joseph Taraba[2],
epartment of Plant & Soil Sciences[1]; Department of Biosystems and Agricultural Engineering[2] , University of Kentucky

Introduction

Animal feeding operations generate considerable waste, which results in nutrient management challenges to dairy producers in relation to P and N. Compost Bedded Pack Barns (CBP) are a relatively new, cost effective, and ecologically- conscious strategy to capture the full value of waste as a solid nutrient input to cropping and pasture systems. Native soils can exhibit high and low soil test P (STP) as a result of mineralogy. Producers are subject to a 'P-index' when managing nutrients, which is in part determined by STP. Our goal was to observe P dynamics of land-applied CBP product and raw dairy manure in low and high STP environments to determine the potential consequences of land-applied CBP for P fertility use.

System Overview

The use of compost bedded pack dairy barns in the US began around 2006 as an alternative housing and waste management system promoting animal welfare, reducing management costs, and converting waste into a mobile asset. The loafing area consists of sawdust or wood chips. During milking, a tillage device mixes the loafing area to facilitate composting. Barns are cleaned out in Spring or Fall, and the product is land-applied as a supplemental fertilizer, which also helps build soil organic matter and reduce fertilizer inputs.

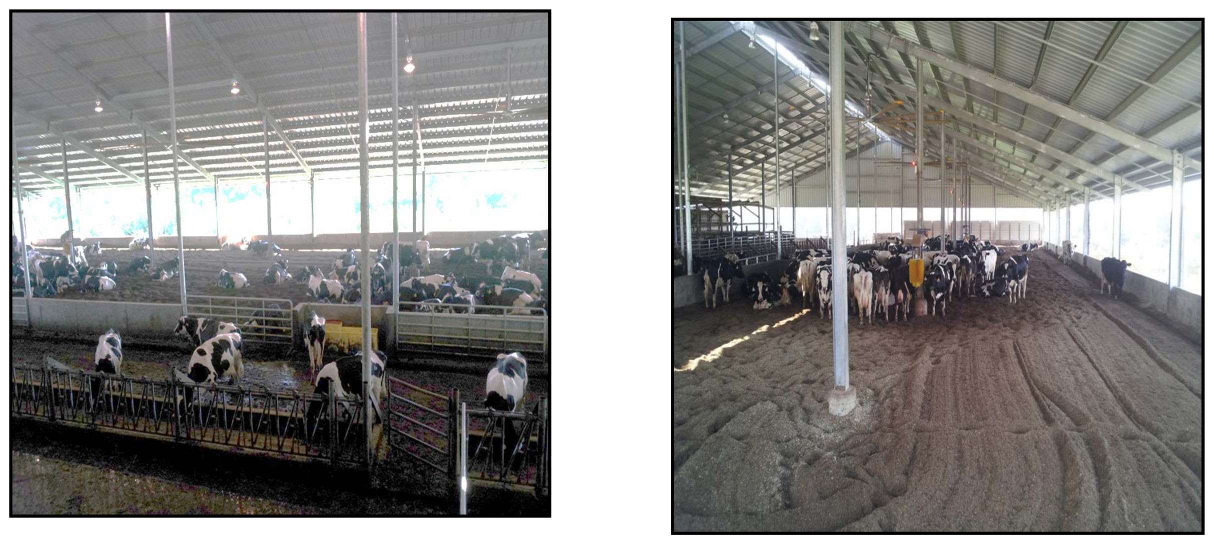

Figure 1. Typical design and occupancy of a compost bedded pack dairy barn.

Objectives

The applicability of CBP wastes to nutrient management is little known. This study provided the following information:

1. Compared P availability of raw manure and CBP product with time.
2. Showed the effect of STP on P availability of CBP amendments.
3. Developed and utilized a simple P-fractionation scheme to quantify plant-available P.

Methods – Sampling and Incubation

1. Soils were collected from two cooperators' farms. Both soils are a Faywood silt loam, one soil (pH 6.0) exhibited native high STP (178 mg kg^{-1}), and the other (pH 6.6) is low STP (15 mg kg^{-1}). Soils were air dried, and sieved to <2mm.
2. Nine core samples were collected from various positions in a "well-managed"CBP barn and mixed to form a composite. Raw manure was collected from the feed alley.
3. Total P of raw manure and CBP product was determined by Kjeldahl digestion.
4. Soils were amended with 0, 52, 112, 224 kg total P ha^{-1} of CBP product or raw manure.
5. After 30 days aerobic incubation in replicate plastic bags at 25^{0} C, water extractable PO_4-P and organic P were determined.

Methods – P Fractionation

1. Water soluble PO_4-P (P_i) and Organic-P (P_o) were determined colorimetrically after mixing 1 g of amended soil in 100 mL H_2O for four hours and centrifuging the resulting supernatant at 3700 rpm for 27 min to approximate filtration through a 0.45 µm filter.
2. Inorganic P was determined by Malachite green reaction. Organic-P was decomposed by exposure to UV light for one hour (6W, 254nm) and quantified as the difference between UV-treated and untreated supernatant samples.
3. The P fractionation technique was calibrated to 2013 NAPT soil standards and shown to have an R^2 of 0.92 when correlated to Olsen P (data not shown.)

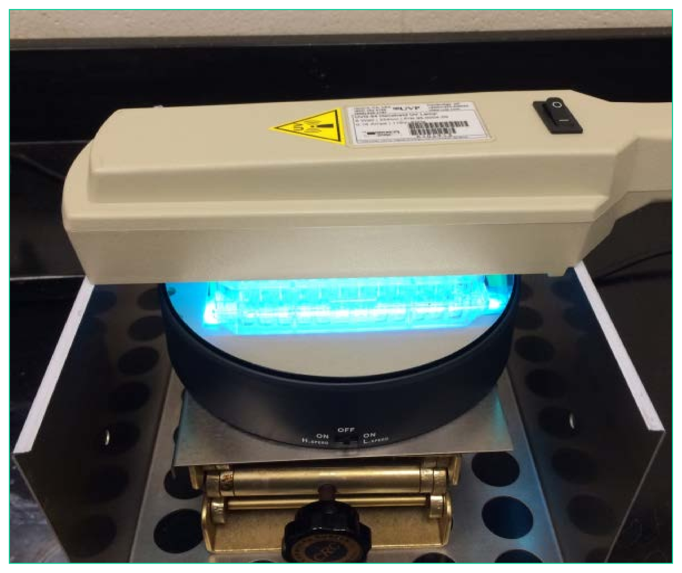

Figure 2. Design for in-plate UV oxidation of organic P in water soluble extracts.

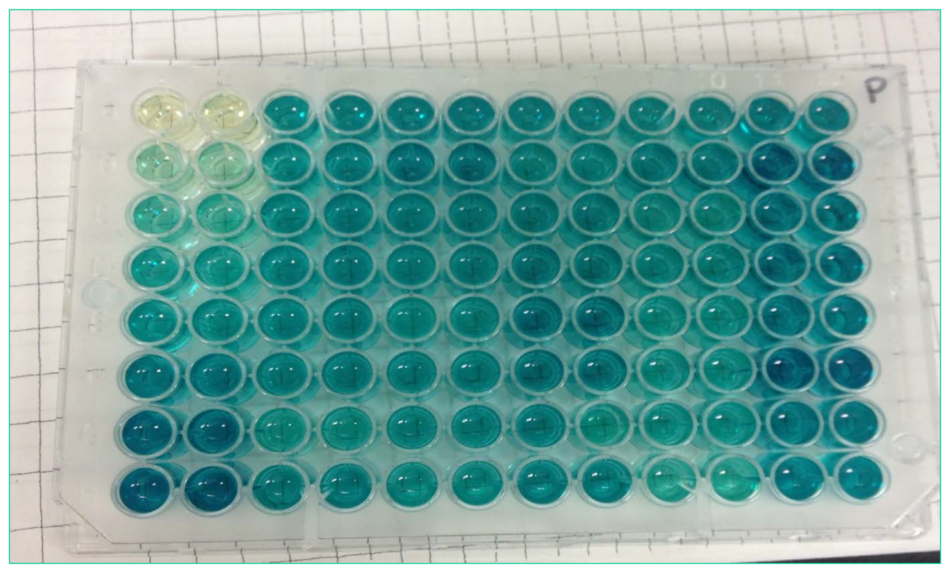

Figure 3. Example of a typical colorimetric microplate for P determination. Standards are in the two left-most columns

Results

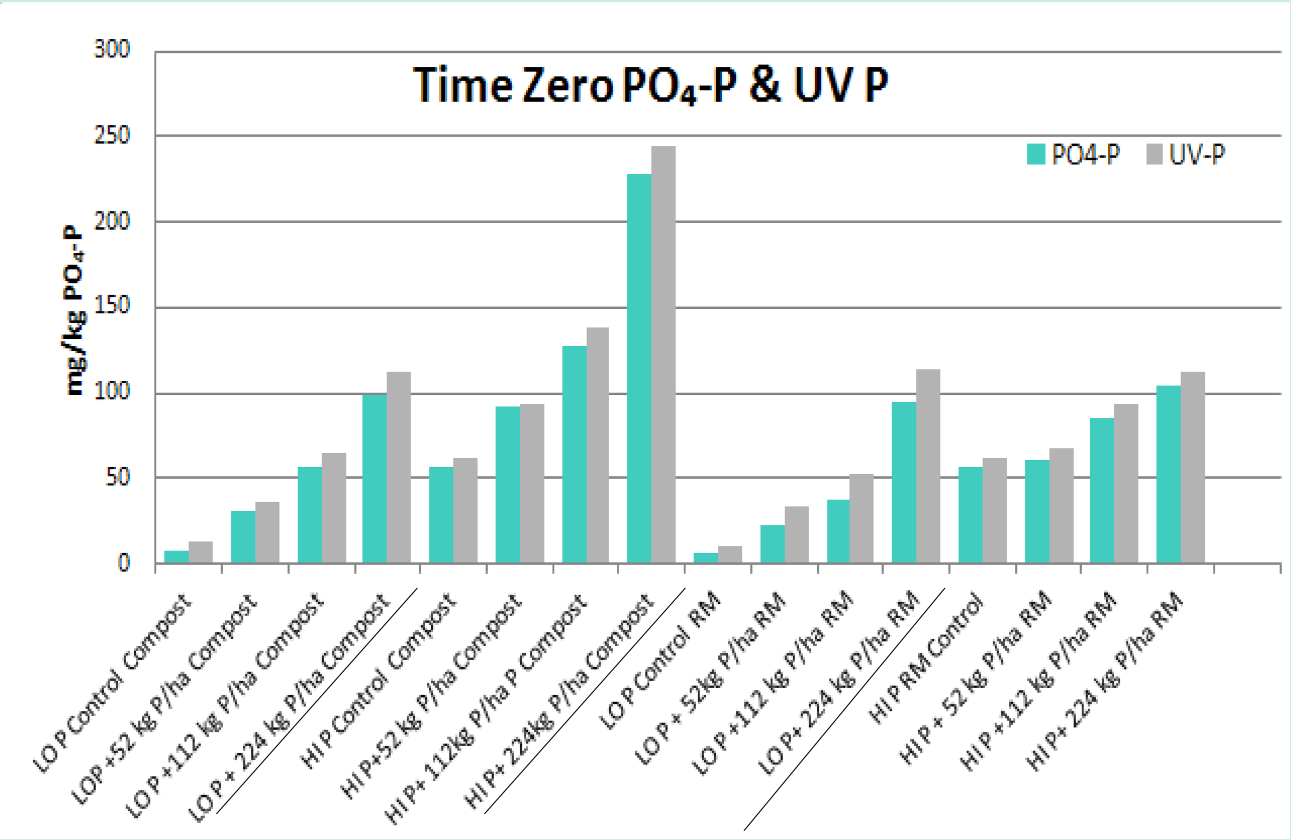

Figure 4. Bioavailable P increases with rate and is generally higher in High (STP) soils. LO P = low STP soil; HI P = high STP soil; RM = raw manure.

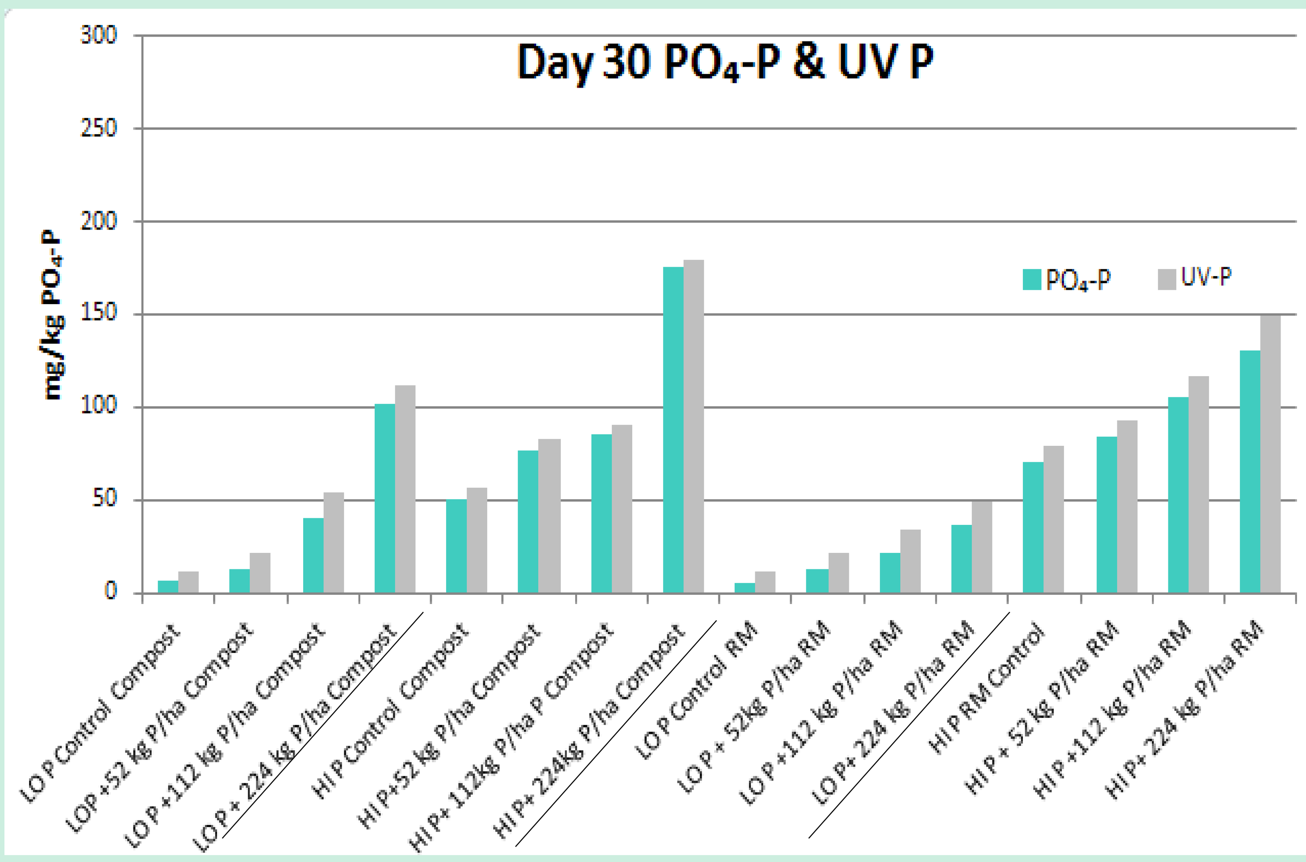

Figure 5. Raw manure P is more available with time in HI P soils. LO P = low STP soil; HI P = high STP soil; RM = raw manure.

Discussion & Conclusion

1. In both STP environments, P became less plant-available with time for compost, regardless of rate, but less so in low STP soil(Fig. 5).
2. Availability of P in raw manure increased in the high STP soil, but decreased in the low STP soil after 30 days (Fig. 5).
3. Although compost P becomes less available with time, it is initially more available to plants relative to manure (Fig. 4).
4. UV oxidizable organic P represents a small fraction of plant-available P initially and only slightly increases with time, suggesting that most of the plant-available P is water-soluble inorganic P.
5. Overall the study revealed the low STP soil decreased P availability with time, regardless of rate, and this effect was amplified with the use of raw manure.
6. More tests are needed to assess the P-availability of each amendment with time in different STP environments and mineralogy.

Broader Impacts

The dairy industry is currently undergoing a shift in relation to fertility management and animal housing. Adoption of CBP dairy barns illustrates this shift and warrants more field and lab-based data to be utilized by farmers, regulatory agencies, and nutrient management planners to develop sound phosphorus management techniques to mitigate the risk of polluting surface and groundwater.

Acknowledgements

Special thanks to the Natural Resources Conservation Service, the Klingenfus family, Dr. Jeffrey Bewley, James Crutchfield, and Tami Smith. L. Hammond was additionally supported by grants from the Kentucky Water Resources Research Institute and the NRCS, the UK Dept. of Plant and Soil Sciences, and a Lyman T Johnson Fellowship from the University of Kentucky.