Advanced Manure Treatment

Part 1: Overview

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Dairy farms are looking for ways to further partition and recover concentrated nutrient components of nitrogen, phosphorus, and potassium, from manure that has been preprocessed, typically with anaerobic digestion (AD) and/or initial manure separation. While composting and AD may be components of a manure treatment system they do not meet all the objectives of advanced manure treatment. Although both processes are considered green technologies they may not be the ultimate answer to a dairy farm manure treatment system. Composting dairy manure requires considerable carbon additions to obtain the suitable C:N ratio and optimum moisture content. AD creates CH_4. where most of this can be captured and burned in a combined heat and power (CHP) unit, or compressed and stored as renewable natural gas (RNG). However, even after the digestate exits the reactor CH_4 is still produced, as well as NH_3. If the effluent is no longer in a closed vessel, the gases are released directly to the atmosphere.

Furthermore, a reduction in overall mass may be achieved where the end products are nutrients, a concentrated carbon material and water clean enough for dilute land application, reuse or even discharged directly into the environment. Nutrient removal operations are generally implemented sequentially. Each operation increasing in complexity and cost as the process moves toward more specific byproducts. A modular design approach allows dairies to install new technologies as they become available, as they are needed, as time and finances allow, and/or opportunities for byproducts arise. Figure 1 shows potential components of an advanced manure treatment system.

Why?

Economic pressure to keep costs of production low and societal demand for farms to reduce their environmental impact are driving the need for improved and cost-effective manure and nutrient management options. Average manure application cost on NYS dairy farms in 2012 was $0.53 per cwt of milk; farm consolidation has increased manure hauling distance and cost. Dairy farms recycle manure for soil health and crop nutrient demand reasons but are limited in nutrient additions by concerns for water quality in many nutrient management plans (NMP). Impacts of manure storage on greenhouse gas (GHG) emissions and manure spreading on watersheds are documented. Anaerobic digestion has been implemented to reduce GHG and farmstead odor emissions and generate renewable energy; impacts and economics are documented. Specific manure processing to improve nutrient recycling and reduce water pollution is desired; to do this, manure nutrient partitioning is needed. Manure treatment after solid-liquid separation (SLS) can produce an N rich liquid and a P rich organic solid; both can be more easily stored and land applied according to the 4 Rs or exported; eliminating fall/winter spreading and associated negative environmental impacts.

Phosphorus (P), is a non-substitutable macronutrient required by all living organisms and is an essential component of energy metabolism that can be utilized by recycling manure. Existing global sources are small, finite, and projected to last only 50 to 100 years at current rates of usage. However when phosphorus is excessively land applied it can be a contributor to algal blooms in freshwater systems. Separating P from manure reduces the need for over application and the potential for environmental losses.

Over 90% of the nitrogen (N) in agricultural and food systems is eventually lost to the environment. This environmental impact potentially results in high nitrate concentrations in groundwater, eutrophication of lakes and streams, greenhouse gas (GHG) emissions, and ammonia particulates. Replacement of this N loss requires the production of synthetic N fertilizer, which is an energy intensive process that also has a negative impact on the environment.

Efficient and effective recovery of these nutrients could reduce losses to the environment and the resulting air and water quality issues. Moreover, recycling of these nutrients diminishes the need for synthetic fertilizers and/or the mining of physical resources. Concentrating P by processes including sequential screening, advanced biological removal, and struvite formation would allow economically transporting (or even selling) P to more remote fields to comply with a NMP.

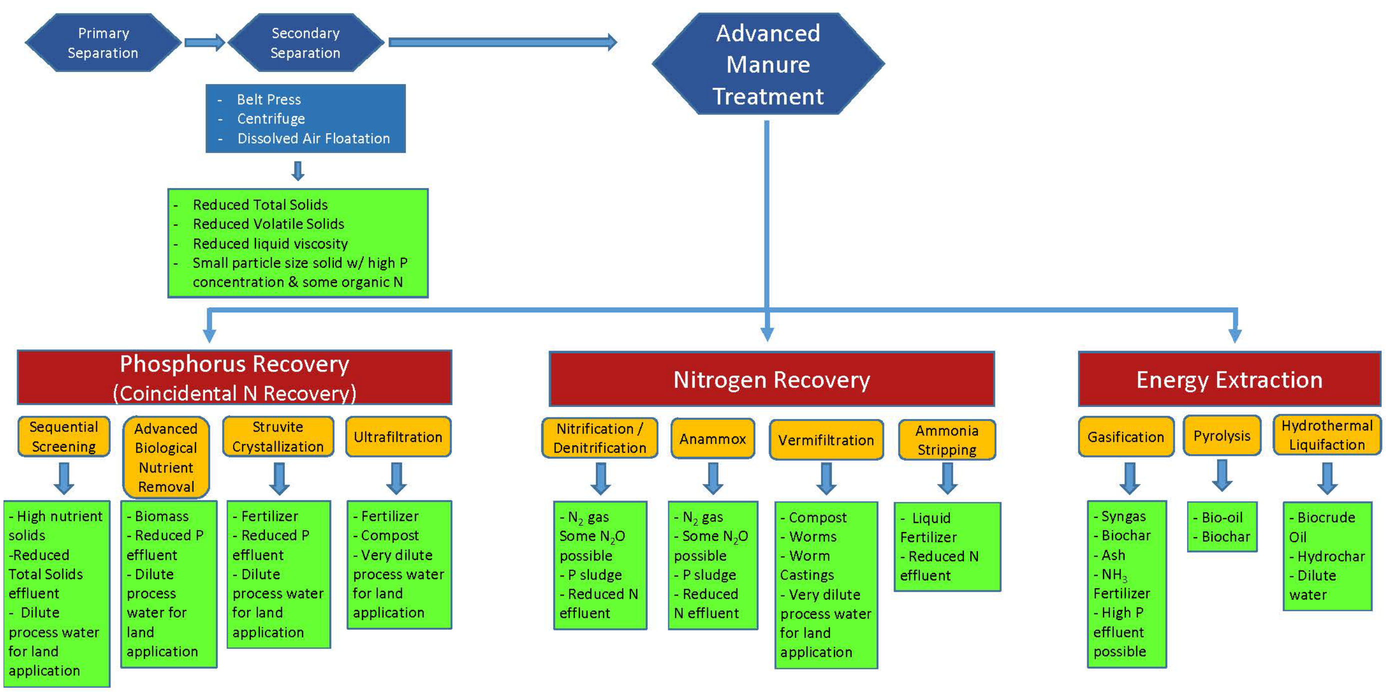
Manure passing through an ultrafiltration (UF) process produces a clean, or nearly clean, water permeate that may be used for irrigation, process water, or direct discharge. The retentate is concentrated nutrients that may be used for fertilizer, composting, or feedstock for an anaerobic digester (AD) and biogas production. Depending on the process, UF may also remove odors, odor substrates, GHG, and certain pathogens. Producing a dilute liquid that can be land applied at irrigation rates (low enough in both N and P) can potentially reduce hauling costs as it is applied close to the site of production. The liquids from secondary separation may be dilute enough depending on the soil and crop grown. Secondary SLS additionally reduces pumping costs, especially over long distances and/or where distributed through small orifices. Nitrogen removal through nitrification-denitrification, Anammox treatment, and ammonia stripping (the ammonia may be recovered as a byproduct) may also be possible to further treat the liquid. Although technology exists, reverse osmosis (RO), to further treat the liquid for reuse or direct discharge, the cost to do this may not be justified where land application is feasible.

Specific soil amendments, solids from SLS, may be desired to promote soil health while not also overloading the soil with other elements.

Economics and market for byproducts

In some cases, sales of the separated product may provide a secondary income stream to the farm. Separated solids may be reused for bedding (cost recovery), composted and sold as a soil amendment or soil-less potting mix, pressed into planting pots (proprietary process), as an input of a secondary operation (vermiculture), or refined into a specific fertilizer (Struvite). The markets for these products may be mature, in their infancy, localized, or non-existent. Investigation of the markets and price possibilities prior to formulating a budget is required.

Figure 1. Advanced manure treatment technologies and outputs.



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