MANURE PROCESSING

for Farm Sustainability

Extension

UNIVERSITY OF WISCONSIN–MADISON

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Manure Processing Fact Sheet Series

Treating Manure to Produce Clean Water

Introduction

Manure can be used in a sustainable manner by returning nutrients to the soil to grow crops that feed animals. However, on many livestock farms, manure poses operational, economic, and environmental constraints. Managing manure every day requires labor and money. Losses of manure constituents from the system result in negative environmental impacts such as degrading water and air quality. The amount of water in manure makes management more difficult in many ways. More water leads to greater volumes, which are more costly to move and store. Removing this water for reuse can lead to ease in managing the end products.

Excreted manure contains anywhere from 75 to 90% water depending upon the animal species (Lorimor and Sutton 2001). Current trends in manure handling and processing systems are adding more water in the manure systems (Aguirre-Villegas and Larson 2017). As it moves through the system where additional by-products are added (e.g., runoff, washwater, bedding, etc.), manure contains anywhere from 50 to 99% water.

Increasing the water content of manure can ease some operational issues, such as enabling the use of pumping and flush systems to transport manure. However, increasing water content increases the volume required for storage and handling capacity of land application systems, increasing both capital and operating costs for the farm. The increased amount of water can also cause environmental issues such as increasing the risk for runoff and leaching when stored and land applied, emissions that contribute to global climate change, and the risk for spills throughout the handling and land application process. Removing the water in manure and treating it for reuse or discharge can reduce issues associated with handling, storage, and land application and improve environmental impacts.

Figure 1. Stainless steel ultrafiltration towers of a manure to clean water system.
Photo provided by Don Heilman, Digested Organics. Picture taken on September 28 2022 by Don Heilmann, Digested Organics.

Technology Basics

Figure 2. Superfiltration and Reverse Osmosis equipment of a manure to clean water system. Photo provided by Don Heilman, Digested Organics. Picture taken on September 28 2022 by Don Heilmann, Digested Organics.

Treating manure to achieve clean water standards for reuse involves removing all the constituents to achieve a final water quality that meets the characteristics needed for end use (e.g., standards for discharge, quality suitable for animal drinking water). The end use of the product is key in determining the water quality parameters and relevant regulations. To achieve clean water for discharge or for animal drinking, several processing steps are required. Each processing step produces a by-product that must be managed. The treatment processes can vary based on the selected treatment system, but there are some processes common to most systems currently commercially available for installation at a livestock facility. First, as manure contains solids, a separation system (or multiple separation systems in series) physically removes larger particles from the liquid or slurry manure. This step is required to reduce clogs and maintenance in further treatment processes. Following separation, the separated liquids then undergo ultrafiltration (removal of suspended solids using pressure-driven membrane filtration) and reverse osmosis (removal of dissolved solids) resulting in clean water for reuse (**Figures 1 and 2**). Additional processes may be integrated to achieve changes in end products or by-products that improve efficiency or cost/value (e.g., disinfection, additional separation, digestion, nitrogen recovery).

Performance and End Use

System performance can be measured in many ways, a few are presented here. One is the fraction or percentage of clean water produced from the initial manure volume. A second performance indicator is the amount and type of the multiple by-products recovered. This includes the form of the by-products (e.g., the water content, pathogen content) and the nutrient form and concentration within those products. Additional parameters of energy use, operating cost, maintenance needs, system downtime as well as other operating parameters are important to consider when selecting a system. In many cases, clean water produced from these systems on livestock farms is either fed to the animals for drinking water or discharged into a nearby waterway (requires a permit for discharge). The quality of the water using multiple parameters must be monitored for both uses.

Generalized data from two different clean water treatment systems are provided here as examples (**Figure 3**). Each treatment process indicated has a by-product (e.g., separated solids, ultrafiltration concentrate, reverse osmosis

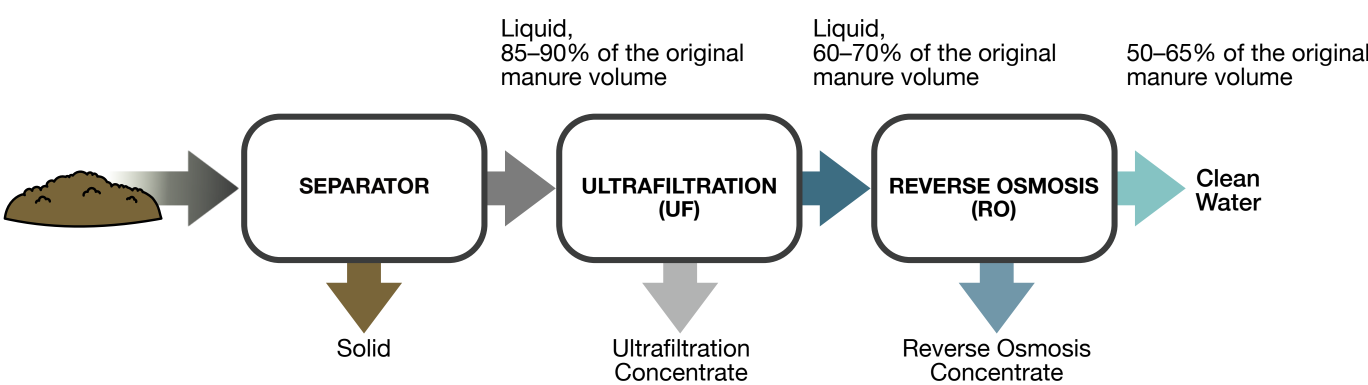

Figure 3. Common processing steps involved in a manure-to-clean water system.

concentrate) that can vary in nutrient content and generally is used as a fertilizer to produce crops. There are many commercial systems available for purchase and researchers do not endorse any specific product. It should also be noted that influent manure characteristics do impact performance and may alter these numbers. Therefore, these data should be used for educational purposes to understand the system components and general operation.

Environmental Impacts

In a recent assessment of emissions, a treatment to clean water system (including separation and anaerobic digestion) was evaluated using a life cycle assessment (LCA) approach in a manure processing systems for beef and dairy (Hu et al. 2022). Greenhouse gas emissions decreased by 57 to 64% when compared to dairy and beef farms with no manure processing (not yet modeled for other livestock systems) (**Table 1**). In addition, the anaerobic digestion system provided more than enough energy to cover the requirements for the manure to clean water system. Additional energy available from the anaerobic digestion system can be used to offset fossil energy and the resulting environmental impacts. The separation of nutrients into multiple manure-based products throughout this treatment system also provides the opportunity to increase management of on-farm nutrients. This includes reducing the volume of manure transported to fields as only the separated products require land application reducing the environmental burdens associated with transport and application. In addition, the separation of nutrients may also provide the potential to increase nutrient movement to nutrient deficient locations if there are excess nutrients at the farm, reducing the potential for nutrient losses and the associated environmental risk.

Table 1. Summary of greenhouse gas (GHG) emissions and fossil fuel consumption in a dairy and beef farm in Wisconsin with and without a manure-to-clean water system.

Farm Description	Processing system	GHGs kg CO_2eq/Ton excreted manure			Fossil fuel consumption MJ/Ton excreted manure			
		Emissions	Offsets	Net	Consume	Produce	Offsets	Net
Dairy: 1000 lactating, 605 growing heifers, 286 mature heifers and dry cows	No processing	215	0	215	88	0	0	88
	Manure-to-clean water system	93	-84	9	102	-480	-1,594	-1,972
Beef: 1000 bulls and cows, 210 replacements, 750 stockers and 750 finishing	No processing	157	0	157	96	0	0	96
	Manure-to-clean water system	69	-65	4	99	-370	-1,227	-1,498

Cost

Systems costs are in the multimillions of dollars for the equipment. Systems are designed for a wide range of animal numbers but are generally designed for larger farms, with a minimum design scale of 50,000 gallons a day of manure to be treated. The system costs increase based on the size of the system, but the cost per animal decreases with increasing size due to economies of scale. A recent assessment indicates that systems can range from $290 to $2,255 per cow for capital equipment costs (wide range based on the components included, such as ammonium capture, and the size of the system). The cost of the system ranges in capacity from $15 to $120 per gallon of manure treated per day, with larger systems cheaper per gallon of manure due to economies of scale. Additionally, the operating costs generally range from 10 to 25% of the capital costs on an annual basis. If you assume the system will operate for 15 years, the capital and operating costs to treat the manure range from $0.01 to $0.03 per gallon of manure for systems without ammonium capture (costs increase when installing ammonium capture technology).

Limitations

Treatment of manure to clean water offers many advantages, however there are some limitations. Installation of the system requires significant capital and may be more expensive for smaller facilities per animal. In addition, the system requires permitting for discharging clean effluent into a waterway and may also require engineering assessments to determine the impact of discharging the water to the waterbody. Systems also require management of the various fertilizer products produced, while beneficial, may require more management of multiple products.

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