MANURE PROCESSING

for Farm Sustainability

Extension
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Manure Processing Fact Sheet Series

Systems Approaches to Managing Manure using Coordinated Markets

Introduction

Livestock produce high protein sources of food, but they also produce manure. When used effectively manure can provide a sustainable source of fertilizers, energy, and other valuable products. However, when not managed effectively, manure components including nutrients, organic matter, and pathogens can be lost to the environment causing negative environmental impacts. Manure processing and management approaches can be integrated into livestock systems to reduce environmental burdens (Aguirre-Villegas et al. 2019) (**Figure 1**), but investment in these systems has been limited (Aguirre-Villegas and Larson 2017). Lack of investment in manure processing systems has developed because of high capital costs, limited knowledge of performance and payback periods, limited or lack of confidence in incentives, and lack of a market to facilitate commercialization of manure-derived products. Assessing livestock manure using a systems modeling approach can aid in developing a market that supports investment of a processing system that can reduce environmental impacts and increase revenues to rural communities. This fact sheet details the development and use of markets for manure-based products to incentivize and increase manure processing systems that support environmental and economic sustainability.

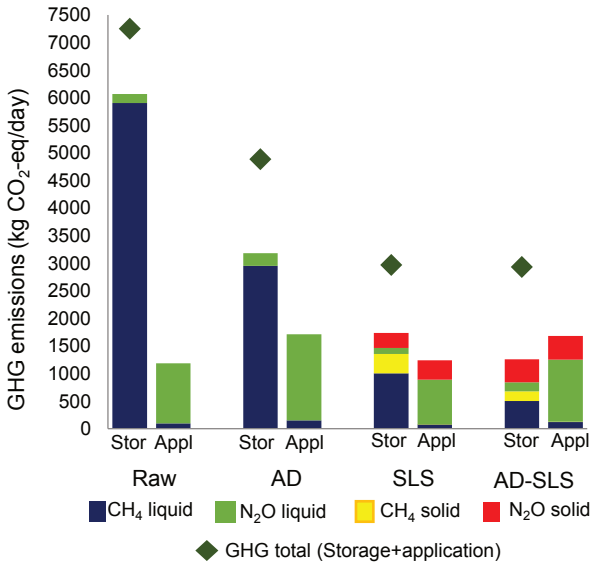

Figure 1. Greenhouse gas emissions from manure storage and application from unprocessed manure (Raw), and with the integration of manure processing systems of anaerobic digestion (AD), and a screw press solid liquid separator (SLS), and both (AD-SLS) at a Wisconsin dairy (Aguirre-Villegas et al. 2019).

Market Potential of Manure Based Products

Manure has value. In recent decades, manure has been valued based on its fertilizer content. However, accessing this value proves challenging as manure has a high water content that makes it difficult to transport economically. Manure processing has the potential to recover products from manure with higher market value (**Figure 2**). These products include biogas, electricity, renewable compressed natural gas (rCNG or bioCNG), and a variety of fertilizers and chemical products. However, not all products can be recovered simultaneously, which makes it necessary to evaluate products and processes within the system to highlight the most economically viable processing paths. In addition, many times products cannot be produced at current market values, limiting market development and investment (**Table 1**). In these cases, incentives can be used to encourage market investment.

Figure 2. Examples of recovered manure products, separated dairy manure solids (left), unprocessed and pelletized manure solids following pyrolysis or biochar (middle), and pelletized swine manure solids (right).

Table 1. Cost to produce or recover manure-based products as calculated from models compared to their respective market values (Sampat et al. 2018).

Product	Units	Market Value (from Literature)	Break-Even Value (from Model)	
Electricity	USD/kWh	0.04	0.18	Not Viable in U.S.
Biogas	USD/scm	0.048	0.15	
Biomethane	USD/scm	0.15	0.40	
Liq. Biomethane	USD/gal	1.00	1.50	Small Gap
Struvite	USD/ton	800	3300	
Struvite + Solids	USD/ton	77.3	350	Large Gap

Coordinated Markets

Developing a coordinated market can provide the framework for which investments in the sector can be used to support development. Coordinated markets have been developed before such as coordinated electricity markets that currently operate in the United States. In coordinated electricity markets, independent system operators manage capacity needs, cost, and reliability by coordinating market players to find cost-effective solutions to deliver reliable electricity to consumers. This market system maximizes overall profits of all players involved and captures constraints of such players.

Developing a coordinated waste market would use a similar framework. One key difference in this market is the transformation of the product (e.g., manure to biogas), this is unique to this system. In this market, suppliers produce manure, technology providers process manure into useable end products, transportation providers move feedstocks, intermediate, and developed products, and consumers purchase and use the products. The developed market would make the space for these market players to work together more effectively and to allow for evaluation and integration of policy incentives to develop the market and encourage investment. Incentives are generally monetary incentives that can add value to a product, provide tax incentives, or reduce costs to encourage investment. The Low Carbon Fuel Standard (LCFS) and the US EPA Renewable Fuel Standard (RFS) are both examples of incentive systems used to support renewable fuels and growth of manure based anaerobic digesters. Developing markets also provides the framework to standardize products, a key factor in developing manure products. The development of the market would reduce risk and thereby increase growth in manure processing technologies. With increased use of manure processing, environmental impacts can be reduced.

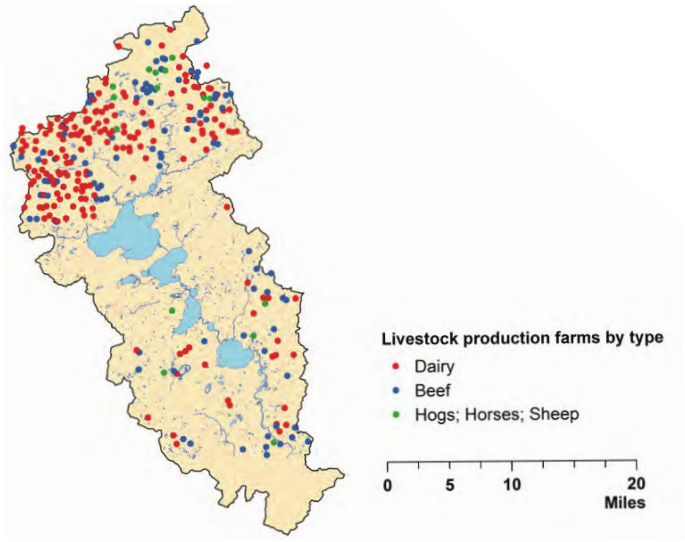

Figure 3. Distribution of Livestock Farms in the Yahara River Watershed (Larson et al. 2016).

Coordinated Manure Market Case Study

In Dane County, WI, case studies were conducted to examine the use of manure processing systems to improve environmental outcomes at the lowest cost (Sampat et al. 2018; Hu et al. 2022). The county has a high density of livestock facilities in the northern portion of the county (**Figure 3**). The high density of livestock farms reduces the availability of cropland that has an agronomic need for manure phosphorus. This requires an increase in the transport distance for manure to avoid excess application of manure phosphorus. This has led to a buildup of phosphorus in the soils. Excess phosphorus lost from the cropland receiving manure in this area contributes to the eutrophication of waterways. Manure processing has the potential to densify manure nutrients to increase the transport distance and move manure phosphorus to land with agronomic need, allowing for drawdown of existing soil phosphorus within the land base. Using optimization techniques with a coordinated market framework, it was found that incentives can facilitate movement of manure phosphorus to reach a phosphorus balance within the county (Sampat et al. 2018). As the incentive price per pound of phosphorus increases to $30 per pound, the resulting imbalance (or excess phosphorus beyond agronomic needs) can be reduced (**Figure 4**). If you increase the incentive to $45 per pound, markets respond and promote the movement of manure phosphorus to cropland with agronomic need reaching a point where the phosphorus inputs are equal to the agronomic plant needs resulting in no excess or imbalance within the study area. This is achieved by integrating transport and processing systems, primarily solid liquid separation, that develops products which can be transported more economically. Additional technologies can be introduced to examine

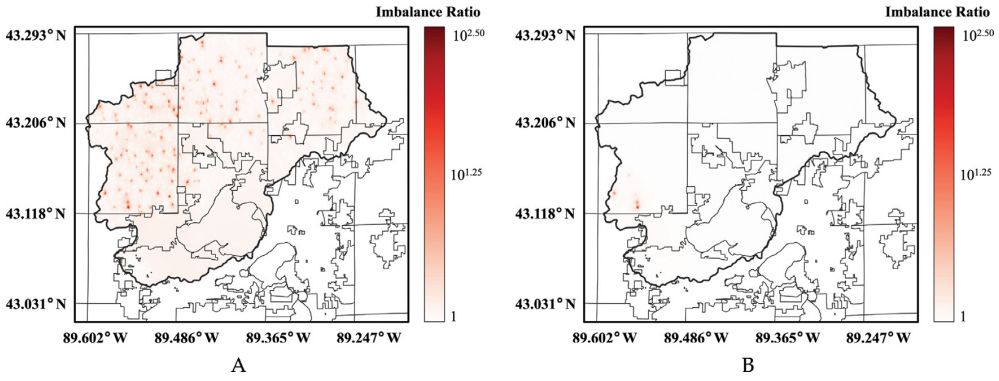

Figure 4. Phosphorus imbalance ratio in the Upper Yahara Watershed with no incentive for manure processing (A) and with an incentive price of $30 per pound (B) which encourages manure processing and movement (Sampat et al. 2019).

manure processing technologies with the greatest potential to reach a specific goal.

Limitations

These markets provide a way to examine the technologies and market developments needed to make investments in manure management. However, the data needs for these types of assessments can be significant. Improved data on livestock systems is needed without infringing on the rights of farmers. In addition, while these models can provide insight into selection of technologies that may have less barriers to adoption, many additional steps are needed to install the systems (e.g., education and funding). These tools however can prove useful in developing strategies to improve the environmental and economic outcomes of livestock manure systems.

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

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Systems Approaches to Managing Manure using Coordinated Markets (A4192-008) I-05-2022