Manure Processing Technologies

Potential for Use on Iowa Farms

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2018 Nuffield Scholar
Supplement to official Nuffield Scholarship Report
September 2019

Support provided by:
Iowa Corn Growers Association
Iowa Farm Bureau
Iowa Pork Producers Association
Iowa Soybean Association
Iowa State University
National Pork Board

Introduction

Manure processing technologies play a significant role in the livestock industry in some European countries. Due to the long history of animal agriculture in Europe, many soils there test high in phosphorus (P) from animal manure application. This is particularly true in the Netherlands, a country with considerable on-farm and centralized manure processing facilities. The country allows a limited amount of phosphorus to be applied to farm fields, primarily due to water quality concerns from P entering waterways. The remainder of the P must be shipped outside the country, thus the need to separate solid and liquid fractions of manure. The economic driver behind manure slurry separation in Europe is that it allows the more nitrogen (N) rich liquid to be land applied closer to the source, and the more P laden solids to be shipped to areas with lower soil P concentrations.

Manure separation has been commonplace on dairy farms in the U.S. for some time. However, these systems are typically designed for removing or recovering sand bedding. Systems for manure solids separation are less common but are much discussed as a manure management strategy. Examples of these systems and discussion about their performance can be found in several publications listed in the References and Publications section. Solids separation of swine manure is much less common and is currently not very economically feasible in the U.S. This report gives a brief description of three manure separation and processing technologies currently being used in the European market for separating swine and dairy manures. There are many other technologies available that are not discussed in this report. A thorough review of the prevalence and use of manure processing in Europe is available from Foged et al. (2011).

Solid-liquid fractioning of nitrogen and phosphorus

The ability to separate N and P is one of the primary benefits of more advanced manure separation technologies. This is accomplished by dewatering (separating) the solids from the liquid portion of manure slurry. Phosphorus typically concentrates more in the solid fraction during the manure separation process, whereas the liquid portion will contain more of the N. However, this is not always the case and can vary considerably with different separation technologies.

The specific fractions of N and P in the solid vs. liquid portion will depend on the technology used for the separation process. Sedimentation typically does not substantially change the proportion of P in the solid vs. liquid fraction (fractioning) but tends to accumulate around 70% of N in the liquid fraction. However, P separation into the solid fraction can be enhanced significantly by precipitating out the P with struvite or other chemicals during sedimentation.

Centrifuge systems typically accumulate 70% to 80% of P in the solid fraction and 70% to 80% of N in the liquid fraction, but this varies with centrifuge speed. Drainage (screen and belt separator systems) perform similarly for separation of N, but vary considerably for P fractioning, with some systems resulting in more P in the liquid fraction. Pressurized filtration (screw press or press auger) systems are quite effective for separating N into the liquid fraction (70% to 90+%), but also result in more P in the liquid fraction in many cases. Membrane technologies (e.g. reverse osmosis) can also be used to fraction N and P but a majority of the solids need to be removed prior to this process. Data on fractionation of N and P from several technologies can be found in Hjorth et al. (2010).

Manure slurry processing

Agro America B.V. operates a centralized manure collection and processing facility east of Eindhoven in the Netherlands. The facility takes in pig manure slurry from surrounding farms and uses wastewater treatment technology to separate manure. Dissolved Air Flotation (DAF) is used to separate solids, which go through a belt press for dewatering (Figure 1). During DAF, air is bubbled up through the slurry from the bottom of a holding tank. This floats a majority of the solids to the top of the tank where they are scraped off the surface into a belt press.

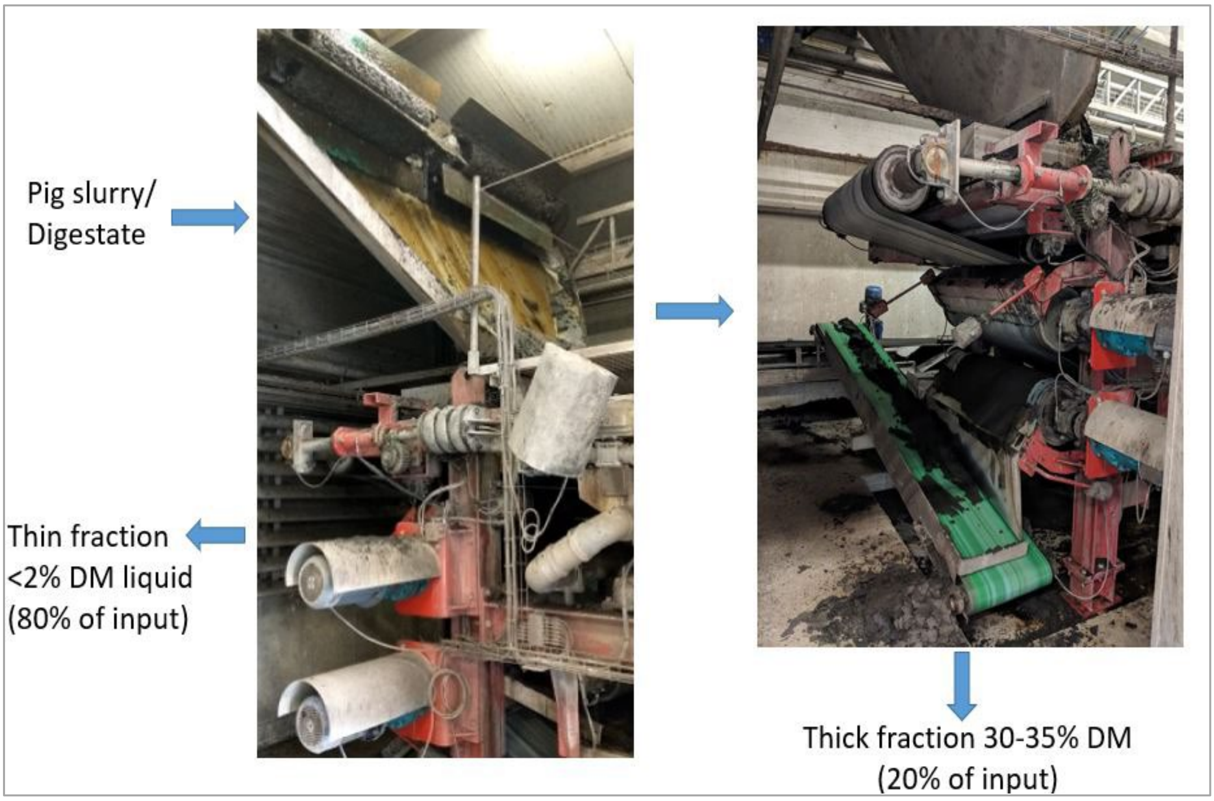

Figure 1. Dissolved Air Flotation and belt press separation of manure solids at Agro America.

The solids (cake) that comes out of the belt press goes through a cyclone dryer and Coaltec gasifier to produce heat and biochar. Biochar is a charcoal product that has numerous uses but is typically sold as a soil amendment. The heat from the gasification system is reused in the cyclone drier. The liquid portion goes through a reverse osmosis membrane and evaporator. The end products from this process are clean water and N & P fertilizer products (Figure 2).

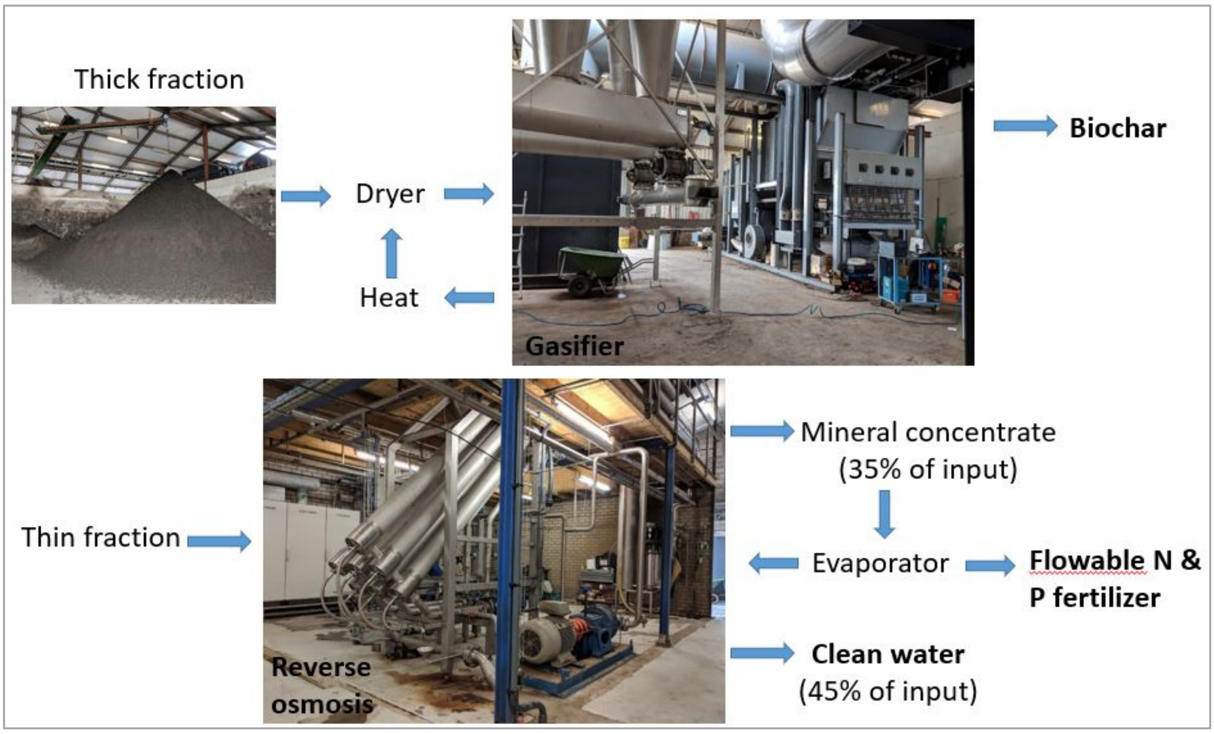

Figure 2. Gasification of solids for biochar production and purification of liquid fraction into N and P fertilizer products at Agro America.

The plant currently contracts to take manure from about 150 farms within a 10-mile radius. Current capacity is 250,000 tons slurry/yr (approximately 66 million gal), with the potential to expand to 450,00 tons/yr. Each line of equipment is designed to handle about 100,000 tons/yr. This process has the benefit of resulting in three saleable products: ammonia water (24.5% N), liquid P (5.5% P) fertilizer, and biochar. The ammonia water product has several industrial uses and can be used as a fertilizer. As of September 2018, the system was discharging about 3200 gal/hr of clean water.

There are many technical difficulties with operation and maintaining all the equipment needed for what the owner refers to as the 'manure rendering' process. The reverse osmosis system is particularly expensive to operate. The full environmental benefit of this type of system is questionable. A life cycle assessment by De Vries et al. (2012) found that the process resulted in increased overall environmental consequences in terms of climate change (except for dairy cattle manure), terrestrial acidification, and fossil fuel use compared to current agricultural practice. The economics of this system can work in the Netherlands because farmers there pay about 30 euros/ton to have someone take excess manure slurry that they cannot land apply. The farmer also pays for trucking the slurry to the facility. There is potential for this type of system to become feasible in the U.S. if lucrative markets develop for the fertilizer and biochar products.

On-farm manure slurry dewatering

The Gelli Aur College Farm in Wales is developing an on-farm slurry dewatering system on their dairy farm. They are experimenting with both screw presses and centrifuges for dewatering the slurry. This would be followed by DAF, electro-chemical reactions, and advanced oxidation to separate solids and produce clean water as a by-product, which can be discharged into a nearby watercourse. Initial testing showed that the effluent was below 0.5% solids after the screen/centrifuge and DAF steps. The project has received significant government funding to research and develop the system. The overall goal is to reduce slurry volume by up to 80% to minimize the need for manure storage, improve application efficiency, and reduce air and water pollution. A flow diagram of the process can be seen in Figure 3.

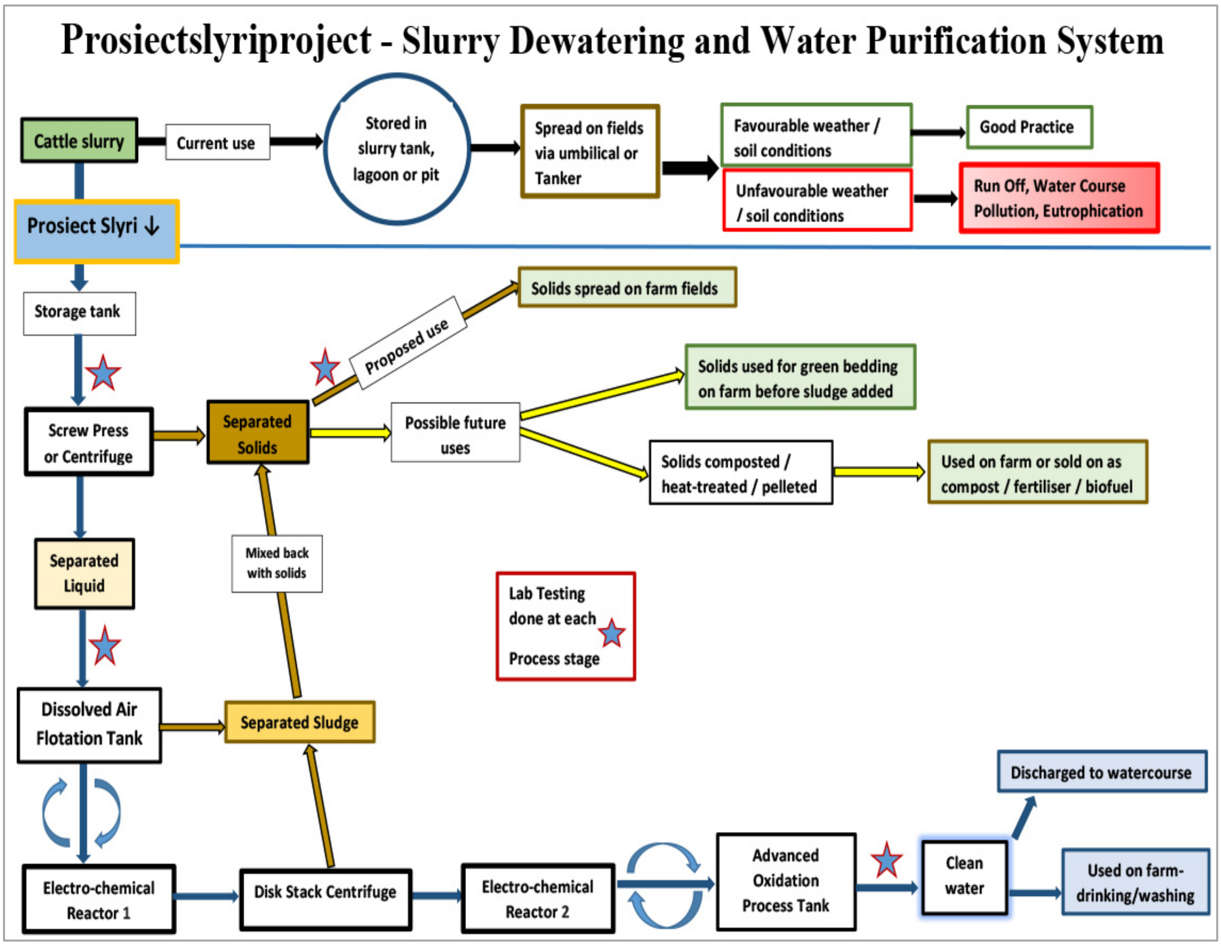

Figure 3. Flow diagram of the slurry dewatering process at the Gelli Aur College Farm.

This system has the potential to be a good on-farm solution to slurry dewatering, but technical challenges remain with the electro-chemical reaction processes being used for coagulating and separating solids from the liquid fraction. In a wetter environment such as the one that the college dairy farm operates in, this type of system could reduce the pressure on outdoor manure storage capacity and alleviate the need to apply manure during wet conditions. It shows promise as a technology that could be feasible in Iowa, but the system needs to be fully optimized and made more efficient to drive cost down.

Figure 4. View of the equipment used for slurry dewatering at Gelli Aur College Farm.

The system, shown in Figure 4 is sized to accommodate a 500-cow dairy. A possible variation on this system could be to follow the screw press or centrifuge and DAF with a biofilter (e.g. vegetative buffer) treatment. This would eliminate the need for the electro-chemical reactions and bring the cost of the system down considerably. Vegetative buffer systems have not performed well in Iowa due to cold temperatures during a portion of the year, but it may be possible in this scenario to store manure and only process it during periods when there was good growth in the vegetative buffer.

Mobile solids separation

EPM Machining in Deurne, Netherlands manufactures a semi-trailer mounted manure solids separation system that can be moved from farm to farm to do on-site solids separation. The separator uses centrifuge technology to process up to 20,000 gallons of slurry per hour. Figure 5 shows a 10,000 gal/hr unit under construction in the EPM factory. It is powered by an onboard 280 kW diesel generator and has an adjustable speed centrifuge, which is typically operated at about 3,000 rpm. Manure is pumped to the EPM mobile unit from the manure pit. The liquid fraction is pumped to a secondary pit after separation. If a secondary storage area was not available it could be recycled back to the original storage pit, but this would reduce the efficiency of the unit over time. Another option may be to pump directly to a small travelling gun, K-Line, or other type irrigation system for application of effluent to crop fields or pasture. This could be done in-season to open up a much longer application window than we currently have in Iowa.

Figure 5. EPM Machining mobile slurry dewatering system under construction.

The purchase cost of the 10,000 gal/hr unit as of September 2018 was 550,000 euros (currently about $608,000 U.S). The company owner estimates that unit would have a maintenance cost of around 1 euro/m^3 of manure (about $0.004/gal) and a total cost of about 2.3 euros/m^3 (about $0.009/gal) to operate. The machine needs maintenance (new bearings, possibly a new centrifuge screw, etc.) about every 2 to 2.5 million gallons of throughput. The unit can be remotely operated and is monitored with cameras. The owner noted that a stationary unit would be much cheaper to build, but you lose the ability to process manure from multiple farm sites. The centrifuge system has worked well and is quite efficient at solid-liquid separation. However, manure foaming is an issue due to considerable agitation of the manure that occurs during the process. To address this, the unit is set up to add an anti-foaming agent during the process.

The solid portion coming out of the centrifuge is stackable (Figure 6). The owner noted that the same thing can be done with a belt press machine, but they are much harder to adjust and require a very consistent product going into the press. The owner also noted that Bauer makes a belt press unit for around $45,000 that can process about 4,000 gal/hr. This technology has more potential for Iowa farms than those discussed above. The unit is likely cost-prohibitive for an individual farm, but the portability allows it to be moved from farm to farm. This creates opportunities for a custom manure separation business to purchase the unit and separate manure for multiple farms. The company owner estimated that a custom business would need to charge around $0.02 per gallon to be profitable and make a business plan work. This is in the range of what it now costs producers in Iowa to haul and apply liquid manure. Using this system on a typical Iowa farm would likely double the cost of manure handling. This is not currently feasible, but within the context of manure separation technologies it is relatively affordable.

Figure 6. The EPM technology being used for on-farm swine manure dewatering.

Conclusion

Manure processing technologies are a necessary part of livestock production in some places in Europe, particularly the Netherlands. This trend is also happening elsewhere in the world. Manure separation could eventually become necessary in Iowa depending on regulatory requirements and/or environmental conditions. Many of these technologies are currently far too expensive for practical use on most Iowa farms. Livestock manure can still be land applied as-is on most fields in Iowa, thus the benefits of separating and/or processing manure likely would not outweigh the costs in the current operating envoronment. However, it is likely that at some point in the future regulatory changes or economic conditions (e.g. higher fertilizer costs) will make manure separation and processing a viable option in Iowa. A possible shortage of P fertilizer worldwide in the coming decades may make P recycling a necessity (Obersteiner et al., 2013). This could make manure separation much more attractive economically. It is uncertain when these changes will happen but monitoring the regulatory and technological advances in other countries is warranted so that we are informed and prepared for the future.

When manure separation becomes a necessity, serious consideration should be given to mobile manure separation units. These units have the potential to be relatively low-cost and create opportunities for machinery sharing or custom manure separation arrangements. Consideration should also be given to coupling versions of these technologies with vegetative treatment systems that have the capacity to handle high seasonal effluent flows. This type of system would have the potential to clean water such that it could be discharged overland rather than needing to be pumped or hauled to fields. This has the potential to make these systems more feasible from a cost standpoint.

Acknowledgments

I would like to thank the National Pork Board, Iowa Pork Producers Association, Iowa Farm Bureau, Iowa Corn Growers Association, and Iowa Soybean Association for their generous support that made my Nuffield Scholarship travels possible. Traveling on a Nuffield International Farming Scholarship was a life-changing experience and I am forever grateful for the opportunity.

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