Manure Digester Technology: Seneca Lake Watershed

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Seneca Lake, the largest of the Finger Lakes, is home to over 100,000 people that rely on it for clean, safe drinking water everyday (Halfman p1). Along with being a reliable water source, many industries rely on the lake in order to run a profitable business. Food service, agriculture, tourism and recreation are just to name a few. The largest input into the finger lakes area economy is through tourism and recreation. This industry pumps over 100 million dollars annually into our local economy (Halfman p1). As with many large bodies of water, people often overlook how fragile they can be and the impacts our activities have on them. With such demand on Seneca Lake it is important for us to find ways to protect it so that future generations will continue to thrive and benefit from it. Currently Seneca Lake is experiencing an influx of nutrients. Excess nutrients in an area like Seneca lake can have long lasting negative effects. Dissolved oxygen levels will become depleted and the lake will become eutrophic.

Nutrient loading can come from many different point and non-point sources. Point source pollution often comes from waste water treatment facility discharge pipes or similar activities and are easily regulated. Non-point source pollution comes from runoff from extended areas of the watershed. Non point source is not as easily regulated and is often the leading cause of nutrient loading. Runoff from agriculture fields and concentrated animal feeding operations (CAFO's) often contain large amounts of phosphorus from fertilizers and manure (Halfman p2). A part of system that has been implemented in various countries throughout the world with great success is the manure digester. Manure digesters work by harvesting the methane produced by the

decomposition of manure and turning it into electricity.

The process of manure digesting begins with the dairy cow. In the US there are six breeds of cow used for dairy products. The Aryshire, Brown Swiss, Guernsey, Holstien-Freisian, Jersey and the Milking Shorthorn. In an average day of grazing, milking and mooing they can produce an average of 120 - 150 lbs of manure per day. For the average farm of 1000 - 5000 cows this equals 60 - 375 tons of manure per day. The largest operation in the US can have over 15,000 cows that produce over 500 million tons of manure annually (Moser).

The nutrient composition of a cow pie is largely dependant on the type of operation and what is used in the feed. But they all contain large amounts of nitrogen, phosphorus and potassium with micro nutrients such as sulfur and boron. It also contains trace amounts of hormones, pesticides along with whatever else a cow may eat that is not turned into milk or meat.

The nutrient content of manure is largely dependant on a variety of factors. The method of storage, housing and bedding systems, diet of cattle and environmental temperatures all have an effect. As an example solid will have 11 lbs of nitrogen 5 lbs or phosphorus and 11 lbs of potassium per ton. Semi liquid manure will have 5 lbs of nitrogen 2 lbs of phosphorus and 4 lbs of potassium per ton. Overall a single dairy cow will produce 223 - 260 lbs of nitrogen 40 - 69 lbs of phosphorus and 88 - 146 lbs of potassium (Pennington). 1 lb of phosphorus can grow up to 500 lbs of algae (Erb).

Manure management was first developed under the clean water act with first defined CAFO's as point source pollution in order to regulate such operation. Over the years the Dairy industry has trended towards consolidation with fewer CAFO's that house

larger numbers of animals. The EPA began requiring farms to have either zero discharge or obtain a National Pollution Discharge Elimination Permit. The permit required farms to implement a management plan which for NYS was developed in the mid 1990's. The plan requires farmers to spread manure when it will be most beneficial to the crop and reduce the amount of runoff (ProCon.org). The problem is that nutrient levels in raw manure are difficult to control and farmers often spread manure based off crops highest needs.

All types of digesters use the same basic process to create power, the anaerobic process which consists of two stages. The acid forming stage where solids are broken down to a series of fatty acids and then the methane formers, which are bacteria that converts the acids to methane gas and CO2. The bacteria is most efficient at 95 - 100 degrees Fahrenheit which is considered mesophilic conditions. Digesters that operate between 125 - 135 are operating under thermophilic conditions (Fulhage). Thermophilic conditions allow a more complete digestion of the manure and shorter times in the digester. In order to maintain higher temperatures the tank must be insulated which can add additional costs. The amount of methane produced depends on several factors concerning the efficiency of the operation. On average one dairy cow can produce about 23 cubic feet of methane per day through the anaerobic process (Fulhage). To give an example, it takes about 4 cows to run a refrigerator based of it running for 12 hrs per day and 14 to run a kitchen range based of it running for 2 hrs per day.

There are four main types of digesters currently in use. The first is the covered lagoon system. It is basically a retention pond with a custom tarp covering the pond. The tarp funnels to a pipe that is connected to generator. This is the least expensive system

and is also the least controlled heat is dependant on solar energy created by the tarp (Liebrand). It is generally not used in colder climates such as New York because it wont produce any gas in the during the winter months.

The second is a plug flow system that consists of rectangular concrete tanks with an airtight cover. Manure flows in one side and out the other. As new manure is added it pushes the older material down the tank. The manure is typically heated to 100 degrees Fahrenheit and held for approximately 20 days. The tank is heated to maintain thermophilic environment by water pipes that run along the bottom of the tank. The water that is heated by gas recovered during the process. Agitator or mixers are often installed to prevent the material from crusting and to minimize settling (Liebrand).

The third system is the fixed film system is a concrete or steel tank that is filled with a plastic media called a biofilm. The biofilm supports a thin layer of anaerobic bacteria and maintains a concentrated population of microorganisms that produce methane during anoxic conditions. The film is submerged where the waste water can either up flow or down flow through the system. As the manure flows through the media the suspended and fixed bacteria break down both soluble and particulate matter contained in the manure. This system is typically used in operations that produce larger amounts of dilute, low strength waste water. The advantage to using this type of system is lower residence times in the digester. Material is typically broken down in 4-6 days. Fixed film digesters also take up less space which can be advantageous where land is scarce (Wilkie).

The fourth and most commonly used system is the complete mix digester shown in figure one. This type of system consists of a concrete of steel tank where manure is

mixed by an impeller or pump. Manure is pumped from a holding tank through a heat exchanger where it is heated to ideal operating temperatures. From there it is pumped into the main tank where the manure undergoes the anaerobic process. The impeller keeps the manure solids suspended to allow the material to break down more efficiently. Gas is collected off the top portion of the tank where 1/3 of it is returned to the system for heating purposes while the rest is used directly for powering generators, heating water or many other various uses (Liebrand). Due to the difficulty of storing methane gas it must either be used right away or flared as it is collected. Material that has undergone the digestion process is collected where it can be dried and used as a more efficient fertilizer, pathogen free bedding for the cows or sold as soil amendments.

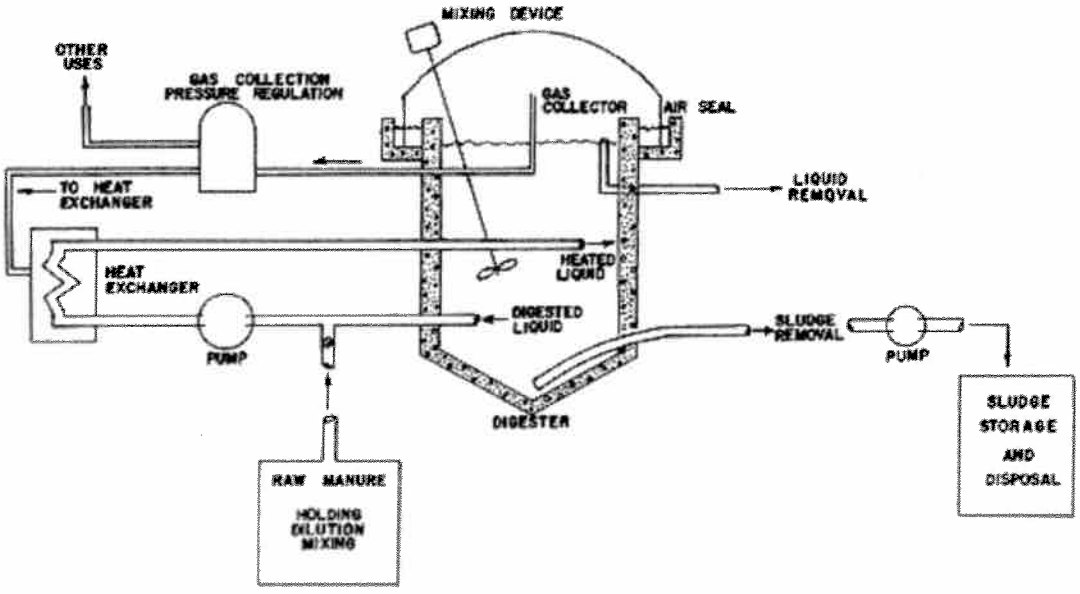

Fig 1. Complete Mix Digester (Moser)

Current costs to install digester operations can range from around $250,000 $4,000,000. This includes the tank, generators, piping, gas pumps and meters, buildings for the engines and engineering fees. The income produced from electricity sales digested fiber sales and savings from hot water production are about $50,000 per year. Additional

income could possibly come from tipping fees if the farm could accept manure from other farms or other organic materials such as food wastes. Other ways farmers can offset costs of digesters in to let other companies operate the digesters on their property. The company Microgy, based out of California, currently has contracts with farms in California, Colorado and Texas that allow the company to build digesters on the farm property and then sell the methane produced to the local utility company. At its facility in Colorado, Microgy produces enough electricity to power 15,000 homes with plans to expand their operation to other parts of the state (Kenellos).

There are many advantages to using a digester. Odor control, pathogen destruction, weed seed destruction, waste water recovery and nutrient stabilization. Digester systems do not reduce the amount of nutrients contained in the manure, although a small amount will settle out. One of the largest benefits of managing nutrients with a digester is nutrient stabilization. Raw manure is much less stable than the digested effluent. During the digestion process nutrients such as nitrogen and phosphorus are mineralized into more predictable forms. These biochemical changes that occur during the process take organic nitrogen is converted into ammonium which makes nitrogen more available to plants. This could potentially benefit because the more nutrients that are available to crops the less is being lost during runoff events. This could have a positive impact on the Seneca Lake watershed by containing more nutrients in plants instead of attached to soils. Another benefit is that effluent can be separated into solids and liquid portions for different uses. An example is a farm in Washington State that sells all of its digested solids to a company that produces a peat moss substitute for wholesale. This means that nutrients are spread out over a larger area instead of being concentrated

only on the farmers fields. By selling soil amendments farmers would also allow more nutrients to be spread outside the watershed area without adding transportation costs to the farmer.

Examples of successful digester faculties are numerous. Some examples from across the United States are the Craven Farm in Oregon that installed a plug flow digester that handles a 1000 cow operation. They reported easier manure handling which reduced costs during application and the digested liquids were producing higher quality hay, which relates back to the availability of nutrients in digested effluent. The AA Dairy in New York installed a complete mix digester that can handle 550 cows. They also reported reduced costs in manure management application and significant odor control. The Freund Dairy in Connecticut installed a plug flow digester for 220 cows. They have the benefit of heating for the farmhouse and are able to sell digested solids for bedding. The martin Family Farm in Virginia installed a two cell lagoon for a 600 cow facility. They reported significant odor control, nutrient content reduction and the production of several thousand dollars in electricity.

In the US digester technology is still in the infancy stage. There are currently 175 digesters in operation, compared to 7000 currently operating in Germany (Jenson). In New York State there are 14 digesters in operation with 7 in the planning phase and this number continues to grow.

Locally Lawnhurst Farms, a family owned farm with 1300 milking cows and 1700 young-stock beef cattle, has plans to install a complete mix digester this fall. The farm operates on a total of 2000 acres which is primarily used to grow corn, alfalfa and snap beans. Manure production for Lawnhurst is 1 million gallons per hundred cows per year.

This equals 13 million gallons per year or around 35000 gallons per day. Manure on the dairy is put through a separator, the liquid effluent is pumped into a holding lagoon where it will then be applied to the land as fertilizer high in NPK. The separated solids are put through a mechanical dryer called a BRU (Bedding Recovery Unit) and used as bedding for the cows.

Lawnhurst, as with all large dairy operations, is required to comply with nutrient management regulations according to CAFO rules. They are accountable for every load of liquid or solid manure that is spread and everything has to be documented for record keeping. All of there liquid manure is handled from the spring through the fall where it is immediately incorporated with tillage tools to prevent runoff, minimize odor and retain nutrients in the manure from volatilizing.

The complete mix digester they are planning to install will have a 1 million gallon holding tank and they will be able to run approximately 90% of there own manure through the system. In addition to manure they plan on adding other substrates such as fats, oils and greases, apple pumice, whey and even there own waste feed dependant on the availability of such materials and this will not exclude other sources of bio-materials. By adding biomaterials besides manure they will be able to boost methane production and improve efficiency. Once the system is installed they will be able to determine exactly what the methane production from these added materials will be and will be able to regulate the production using a computer feeding system.

The farm plans to use the methane produced to power a 500 HP engine that will be capable of producing up to 525 kW of electricity. This will power the entire farm operation as well as provide heat energy that will be put to use around the dairy. Solids

recovered from the digesting process will be used as bedding for the cows while the liquid effluent will be pumped into a holding lagoon where it will be applied to the land.

The costs of their project will be approximately $3,000,000 some of these costs will be covered by tax incentives which make the project more feasible and payback more realistic for the farm. The digester will also offset costs of their daily operations such as electricity, heating and other operational costs.

Lawnhurst has been working with a German based company for the past three years during which they have toured multiple other digester sites. With the implementation of this system they will be able to diversify their operation and become more self sufficient. They will also be able to convert there waste streams and the waste streams of other processes into renewable green energy (Jenson).

Adding a digester system to farming operations will not have a significant effect on the Seneca Lake watershed alone. Combined with manure storage facilities, solids separators and composting facilities they can be an important part of an overall improved system that can have a larger impact on reducing the amount of nutrients entering Seneca Lake. The combined system will also proved opportunities to improve water quality by transporting nutrients to fields where they will be more readily available to crops. This will provide us with cleaner waters and a healthier environment.

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