

Vendor:

Digested Organics, LLC

PO Box 3386

Ann Arbor, MI 48106

734-545-9016

www.digestedorganics.com

Industry:

Wastewater treatment,
manure management

Project type:

Clean Water Generation

Project goal:

Concentrate manure nutrients, create clean water for dairy cattle to drink or for direct discharge to nearby river, and produce value-added fertilizer product for sale offsite.

Study Prepared by:

Dana Kirk

Date of Case Study:

November 2017

Updated June 11, 2018

Digested Organics—Integrated Manure Management System (IMMS)

Majestic Crossing Dairy, Sheboygan Falls, WI

OVERVIEW

850 Wet Cow Equivalents

In 2015, Digested Organics, LLC installed an Integrated Manure Management System (IMMS) that harvests energy and generates biogas, concentrates and captures nutrients for crops, and reclaims clean water for farm use at Majestic Crossing Dairy near Sheboygan Falls, WI. The system was designed to treat approximately 20,000 gallons per day (gpd) of raw manure, equivalent to the manure and wastewater production of approximately 850 dairy cows. The IMMS is comprised of a high-rate anaerobic digester and a Nutrient Concentration & Water Reclamation (NCWR) System, which uses ultrafiltration and a Reverse Osmosis system to filter the digested manure. In addition to biogas made by the digester, the NCWR generates about 30 yd³ of fiber product, two separate concentrated fertilizers, and about 10,000 gpd of clean water. Clean water from the system is reused at the dairy, but meets general guidelines for stream discharge. Majestic Dairy owns the system and Digested Organics is under contract to provide operational support, maintenance, and supplies for the system..

BACKGROUND

Modular system for concentrating manure nutrients and producing clean water suitable for cattle.

Majestic Crossing Dairy is a 6th generation family farm located near Sheboygan Falls, WI. At the location visited, there are about 850 milk cows. In 2015, the dairy purchased and installed the first Digested Organics LLC (DO) Integrated Manure Management System (IMMS), comprised of an anaerobic digester and the Nutrient Concentration & Water Reclamation™ (NCWR) system. The IMMS incorporates coarse solid-liquid separation, anaerobic digestion, ultrafiltration, reverse osmosis, and UV disinfection to convert manure into several valuable products. Entering the system, dairy manure first passes through a coarse solid-liquid separation. Depending on the separator technology and operation, the recovered coarse solids have a dry matter (DM) of 25 to 30%. Recovered manure solids can be used as bedding or compost, but at this farm they bed on sawdust. Following the coarse separator, effluent is introduced to the anaerobic

digester (AD). The AD consists of a micronizer to reduce particle size and a 100,000-gallon fixed film digester called the BioEliminator. A proprietary trace mineral and bioactivator called BioSupport is used to enhance biological activity and increase volatile solids destruction during digestion. The AD operates at mesophilic temperatures (100-105° F) with a short, 5-day hydraulic residence time. Effluent from the digester is transferred to the ultrafiltration (UF) unit that removes fine solids and a majority of the phosphorus from the digestate. The solids concentrate from the UF represents about 15% of the input volume. Tea water (also called UF permeate) from the UF is transferred to the Reverse Osmosis (RO) system that further concentrates nutrients using membranes. The RO concentrate is about 20-30% of the input volume and contains high levels of nitrogen and potassium, along with trace minerals. The RO also produces clean water, which is aerated in a packed tower and then passed through a UV disinfection system prior to use. About 50-60% of the raw input material is returned as clean water.

KEY LEARNINGS

Due to challenges with the original RO system installed, the NCWR has not run consistently. The single module UF system was able to process approximately half of the design flow rate. In early 2018, DO was planning to install a new Two-Step RO (TSRO) system that utilizes a low-pressure membrane system which is highly resistant to fouling. Operational data showing multiple cleaning cycles with the new NCWR configuration have not yet been provided.

- The system at Majestic Crossing is still operated by Digested Organics personnel.
- The contract with Majestic Crossing is to produce at least 8,000 GPD of clean water for reuse or discharge.
- The system as installed is capable of treating about 10,000 GPD, approximately half of the target volume established by the dairy.
- Continuous operation of the NCWR system has been limited due to challenges with the RO.
- Overall, the UF has shown good results with consistent flux rates and manageable cleaning cycles.
- Installation of a TSRO is planned to reduce membrane fouling, reduce cleaning time and water requirements and improve overall NCWR performance.

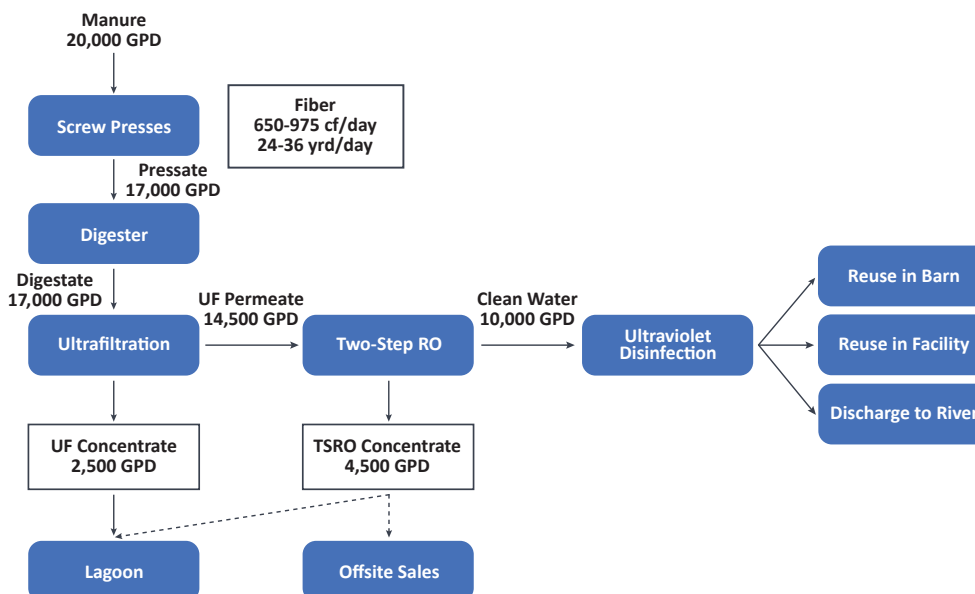
- Concentrated products from the NCWRS are recombined and stored in an earthen storage lagoon until land application.
- Clean water is used as drinking water for the livestock or can be discharged through a WPDES permit.
- Biogas production has been inconsistent due to the inability to maintain consistent temperature. Challenges with the fixed film media also resulted in the digester being operated as an unmixed plug-flow reactor.
- The methane content of the biogas has been between 45-55% (CH₄).

KEY BENEFITS

Clean water — In the case of Majestic Crossing the ability to reuse water was their primary reason for installing the NCWR System. If the Digested Organics system can achieve the target of 8,000 GPD of clean water, it will have displaced the water withdraw for roughly 260 milk cows, approximately 1/5th of the herd.

Significant learning about RO — Through significant evaluation and trial, Digested Organics has identified an RO technology that they believe will be capable of meeting the farms clean water requirement with reduced maintenance and improved longevity. They were just preparing to install pilot TSRO System at the time of Newtrient's visit.

FIGURE 1: DIGESTED ORGANICS NUTRIENT CONCENTRATION & WATER RECLAMATION SYSTEM, MAJESTIC CROSSING DAIRY



Key Benefits & Results

Summary:

- Concentration of nutrients and production of clean water are the target benefits of the DO IMMS and NCWR.



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10255 W. Higgins Road
Suite 900
Rosemont, IL 60018
1.866.123.4567
info@newtrientllc.com

www.newtrient.com

Public perception a key driver — Another important benefit of the NCWR System for Majestic Crossing is the message they can provide their neighbors and consumers. Demonstrating a desire to be more sustainable through reduced freshwater consumption, application of concentrated nutrient fertilizers and reduced odor/GHG emissions is important to the farm to maintain good relations. In addition, handling fewer gallons of manure in tankers reduces road traffic reducing congestion and road damage and increasing safety.

RESULTS

Results from the NCWR System are limited due to operational challenges with the RO.

Digested Organics has demonstrated that screw-pressed manure can be ultrafiltered to consistently remove a majority of the phosphorus, virtually all the suspended solids, and virtually all pathogens. Their stainless steel UF system has operated well, but intermittently for over a year (see recent analytical results in table below, lbs./1000gal). The UF permeate/tea water product, has less than 0.3 lbs. Phosphorus/1000 gal may be ideal for

many farms looking for high quality irrigation liquid. Challenges with the original RO system have resulted in very limited, intermittent operational data.

CONCLUSION

With two years of operational experience, the Digested Organics IMMS/NCWR has successfully produced clean water, concentrated nutrients and biogas from dairy manure on an intermittent basis. During this time, Digested Organic has identified opportunities to improve the efficiency and economics of their system and is currently modifying the process in the NCWR, particularly the RO. With membrane systems, cleaning and life of the membranes continues to be a challenge. Digested Organics is in the processes of installing their new TSRO technology that they believe will improve performance and life, while lowering capital and operating costs. As installed, the current system has operated in a pilot mode for the last two years, after upgrading the RO, the system is poised to go into continuous use at which time the dairy farm will assume ownership and operation.

TABLE 1: MAJESTIC CROSSING DAIRY IMMS PRODUCT NUTRIENT CONCENTRATION (LB/1,000 GAL)

Sample	DM (%)	TN (lb/1000 gal)	NH ₄ -N (lb/1000 gal)	P ₂ O ₅ (lb/1000 gal)	K ₂ O (lb/1000 gal)	S (lb/1000 gal)
Digestate	5.27	28.39	23.35	10.07	24.07	2.82
UF Permeate	1.43	14.44	12.51	0.22	19.2	0.99
UF Concentrate*	7.48	33.7	28.86	16.07	24.39	3.47
% Removed by UF	73%	49%	46%	98%	20%	65%

*UF was operating at 65% permeate recovery on the day sample was taken, so concentrate was not as thick as it typically would be.



Digested Organics UF Installation, Majestic Crossing Dairy



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Suite 900
Rosemont, IL 60018
1.866.123.4567
info@newtrientllc.com

www.newtrient.com



Digested Organics RO Installation, Majestic Crossing Dairy



Digested Organics NCWRS screw presses, fiber storage and UF, Majestic Crossing Dairy



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Suite 900
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DIGESTED ORGANICS AT MAJESTIC CROSSING DAIRY PROJECT BY THE NUMBERS

Location type	Dairy farm, Sheboygan Falls, WI
Number of animals	1,200 milk cows, manure from approximately 850 milk cows is the basis for system design
Type of bedding	Wood shavings/sawdust
Manure collection	Scrape to central location
Daily flow	In the current configuration the NCWR system can process up to 10,000 GPD, year-round. Adding a second UF module, as planned, will allow 20,000 GPD to be process through the UF. Flow through the RO is dependent on the testing and evaluation of the TSRO.
System designed by	Robert Levine, Digested Organics, LLC
Date operational	Broke ground July 2015. Operational late fall 2015.
Energy produced/required	Data on energy production or requirement was not discussed during site visit. Energy production was not viewed as critical product.
Installed energy production capacity	None
Products produced	As currently installed the system is capable of producing the following products: <ul style="list-style-type: none"> • Coarse fiber, 24 to 36 yd/d • Clean water, approximately 2,000 GPD as installed (when RO operational) • UF concentrate, approximately 1000-2000 GPD • RO concentrate, approximately 1,000 GPD (when RO operational) • Biogas, undetermined volume, biogas quality of approximately 45 to 55% CH₄
Contracted prices	Target cost is \$1,000 per cow CAPEX, OPEX of \$0.01 per gal
Residual storage	<ul style="list-style-type: none"> • Fiber storage in underroof, concrete bunker • Concentrate products (UF, RO) combined in earthen storage • Clean water storage in water holding tank until use
Residual use	<ul style="list-style-type: none"> • Biogas – flared, intended to generate hot water for the process • Clean water – drinking water for cattle • Coarse fiber – used as fertilizer or sold as bedding • Concentrated phosphorus & fine solids – field application • Concentrated nitrogen & potassium – field application or sold
Ownership structure	Project is currently owned by the farm, but Digested Organics provides operational support. The farm will assume complete operational control once the contracted 8,000 GPD of clean water are generated.

FIANCIAL INFORMATION

Capital investment	\$1,300,000 for the complete IMMS
Annual operating and maintenance cost	Anticipated to be \$0.01-\$0.02 per gallon of raw manure
Revenue	None currently. The farm is also not under regulatory pressure currently. The system is intended to allow flexibility with manure application and enhance public relations.

For more information about Digested Organics, LLC, or to join our mailing list, email robert.levine@digestedorganics.com.

Newtrient's mission is to help all dairy farmers reduce the environmental footprint of manure while enhancing their economic opportunities and their social license to operate. The information contained in this case study was developed with the cooperation of the organizations involved and Newtrient has endeavoured to make sure it is accurate and complete as possible.

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