NEWTRIENT™
INNOVATIVE SOLUTIONS IN RESOURCE RECOVERY

CASE STUDY

DVO Phosphorus Recovery System

Edaleen Dairy, Lynden, WA

Vendor:
DVO Incorporated
820 W. Main St.
Chilton, WI 53014 USA
1-920-849-9797
info@dvoinc.com
www.dvoinc.com/phosphorus-recovery.php

Industry:
Fine Solids and Phosphorus Separation

Project type:
Post Anaerobic Digestion Fine Solids and Phosphorous Separation

Project goal:
Partition remaining suspended solids and associated phosphorus and nitrogen into stackable solid

Study Prepared by:
Craig Frear

Date of Case Study:
September 27, 2017

OVERVIEW

Edaleen dairy is a 1,800 wet-cow dairy in Northwest Washington State producing an approximate 7% total solids manure wastewater from a combination of alley-scrapers, maternity barn flush and parlour/wash water. This manure wastewater is then pumped to a DVO mesophilic mixed plug-flow anaerobic digester that practices limited co-digestion with off-farm organics (<5% volume). Effluent from the digester is then sent to a GEA/Houle two-stage, slope-screen solids separator for separation of fibrous, coarse solids. The resulting liquid, still containing large amounts of suspended solids and associated nutrients, is sent through a DVO Phosphorus Recovery System, which is a modified dissolved air flotation (DAF) system. Separated solids are a wet but stackable product rich in nutrients, particularly phosphorus. Final liquid wastewater is then sent to lagoon for storage and subsequent land application.

BACKGROUND

The DVO Phosphorus Recovery System adds important nutrient partitioning capabilities to the Edaleen dairy manure management system.

Edaleen dairy is a family-owned producer/processor located in Lynden Washington, presently milking approximately 1,800 Holstein wet cow equivalents. Edaleen dairy has one of the more complete, modern manure management systems in the US, which they have phased into place since 2012. The system starts with alley cable-scrapers as well as a flush system within their maternity barn. The combined scrape and flush manure are mixed with farm wash water to manure pits. The manure wastewater from these pits is sent to a DVO mesophilic mixed plug-flow anaerobic digester for treatment and production of renewable electricity and carbon credits in a Dresser-Rand Guascor SFGLD 560 engine/generator combined heat and power system packaged by Martin Energy Group. Effluent from the digester is passed across a GEA/Houle two-stage, slope-screen separator, producing a high-quality fibrous solid used as both an internal animal bedding and sold off-farm as a soil amendment ingredient to a commercial retail product. Liquid effluent from the screen is sent to an equalization pit for control of flows and timing,

FIGURE 1. MANURE MANAGEMENT SYSTEM FLOWCHART — DVO PHOSPHORUS RECOVERY SYSTEM (SOLID PRODUCT CIRCLED).

"We invested in the advanced solids/nutrient system because the future of the dairy industry is evolving, and the needle is moving towards nutrient management systems as a key element in creating a closed loop, sustainable farm where nothing goes to waste, and we steward the land with utmost care so it can feed future generations."

***Mitch Moorlag,** General Manager Edaleen Dairy*

with dispersal to a DVO Phosphorus Recovery, modified dissolved air flotation (DAF) system for recovery of fine solids and associated nutrients. Collected solids are hauled and stored to an off-site location, with local agricultural producers with fields in transition using the solids as carbon/nutrient soil amendment. Final liquid effluent is stored in lagoons until ultimate use as fertilizer for nearby fields/forage crops.

KEY LEARNINGS

The DVO Phosphorus Recovery system provides a unique ability to produce both low solids/nutrient irrigation water and a stackable nutrient-rich solid.

The DVO Phosphorus Recovery System is a modified DAF system comprising several key components: a polymer mixing and dosing system, a micro-air compression and injection system, a proprietary manure/polymer/air mixing tube for optimal treatment, the DAF vessel itself for separation, rise and skimming of solids, and lastly dewatering moving disc presses for production of a stackable solid under continuous flow conditions. The system is placed at an elevation that allows for gravity feed of manure to an equalization pit, mixing/pumping from the pit to the system, and gravity feed of both produced solids to a concrete pad and treated tea-water liquid to a storage lagoon. The system is placed within a dedicated processing building. Solids are presently trucked daily to a long-term storage building with sales to nearby crop producers with transition fields in need of carbon and nutrient supplementation.

The entire system is automated for continuous operation, only turning off when float valves on the equalization pit determines low flow and temporary stop/restart of operations. Regular operations/maintenance is a daily 20-minute walk-through and completion of monitoring checklist with a morning filling of solid polymer to a feed hopper.

KEY BENEFITS

Production of a low-solids, low nutrient irrigation tea water — The system is effective in removing nearly all suspended solids and a large fraction of total solids, producing an irrigation water more suitable for use in a variety of irrigation systems. Importantly, during lagoon storage, prior to irrigation of fields, there exists reduced need for costly agitation and/or dredging due to the removal of these solids. Removal of solids from the anaerobic lagoon to a more primarily aerobic storage and processing also reduces the greenhouse gas footprint of the dairy, beyond what is already accomplished.

Production of a nice, stackable pile of nutrient-rich solids — The system partitions these solids and associated nutrients to a dewatered, stackable pile. With approximately 90% of phosphorus and 35% of nitrogen and appreciable amounts of secondary and micro-nutrients from the influent within the solids, the solids can be either sold off-farm or more optimally applied to dairy fields as an organic-matter fertilizer.

Savings in both energy and manure management costs — While hard to quantify from a true accounting of farm manure management and application costs, the partitioning as noted above can clearly lead to important savings in both energy and manure management costs. Specifically, reduced energy to mix, dredge, pump and haul liquid manure; greater flexibility in targeting specific fractions and types of nutrients to individual fields/crops; and with potential export off the farm, reduced acreage, haul and/or application costs to meet dairy nutrient management plans.

Potential sales/export of solids and nutrients off-farm — Presently, the dairy has negotiated contracts for the solids whereby neighboring crop producers with transition fields in need of organic matter and nutrients will pick up the solids. This is in-part due to the new product, lack of mature markets and the raw, wet nature of the product. There is potential with either time or down-stream drying/processing to achieve higher sales and revenues. Even without, significant benefit exists for the dairy to remove this nutrient load from their nutrient management plan accounting.

RESULTS

Washington State University (WSU) recently monitored the Edaleen DVO Phosphorus Recovery system for a combination of solids/nutrient partitioning performance, solids product characteristics and project techno-economics (2-week period, morning and afternoon duplicate grab samples mixed into single sample for approximately n =12 samples with replicates for reporting of mean and standard deviations). While the study report is not complete and is finalizing additional data and flow refinements, the following is a summary of the early results.

Key Benefits & Results Summary:

- Production of nearly 6 wet tons of solids per cow per year at 25% total solids
- 62% and 92% reduction of total solids and total suspended solids in liquid wastewater
- 40%, 88%, and 15% N, P, K reduction in liquid wastewater
- Third party purchase/installation capital costs of $219 and $339 per cow, respectively for equipment and total installed system
- Third party O/M costs average of $50-68 per cow per year

NEWTRIENT
INNOVATIVE SOLUTIONS IN RESOURCE RECOVERY

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

www.newtrient.com

Highlights of the following tables are:

- Strong partitioning of key nutrients out of the liquid fraction and into the solids product, notably approximately 62%, 92%, 40%, 88%, and 15% total solids, total suspended solids, total nitrogen, total phosphorus, and potassium. Total liquid fraction reduced in volumetric flow rate by approximately 10%.
- Solids were produced as a relatively dry stackable pile, with a yield of 5.68 tons per cow per year (1.14 dry tons per cow per year), having a density of 1,149 lbs. per cubic yard. Fertilizer value as reported in typical dry units are 4.5%, 3.8%, 0.9% NPK with significant amounts of carbon (39%), calcium (4.1%), and magnesium (1.2%), with no concerns regarding heavy metals. Salts as a measurement of electro-conductivity (EC) were on the moderate end while pathogen as measured by faecal coliform indicators were well below Class A bio-solids standards at a mean of 145 MPN/g DW.
- Economics highlight equipment and total installed costs of $219 and $339, respectively with installed including design, permitting, engineering, groundwork, pads, pumps/mixers, equalization tank, and building. The data collected was performed while dosing polymer at 136.5 parts per million, although the dairy has subsequently lowered the dosing significantly and is seeing no negative effects on performance (WSU data still to be completed). At both the lower and higher ranges of polymer dosing, the estimated operating costs including electrical, chemical, labour and maintenance are $50-68 per cow per year.

TABLE 1. SOLIDS AND NUTRIENT PORTIONING PERFORMANCE

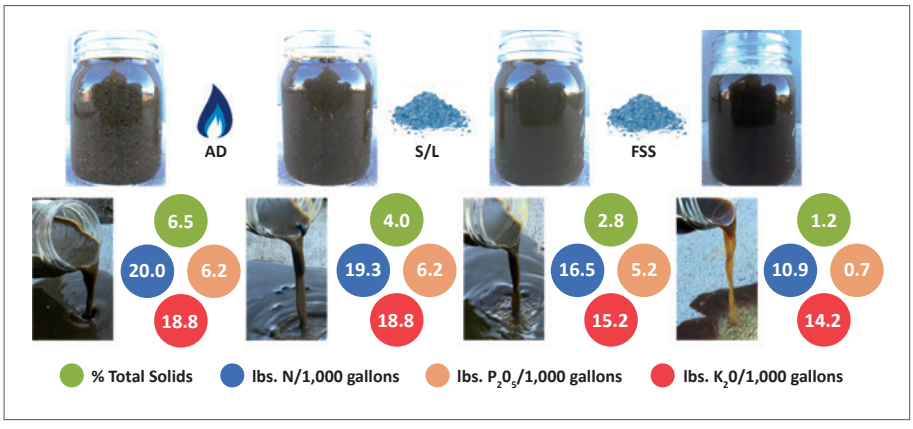
	TS (%)	CA (% of TS)	TSS (g/L)	N (g/L)	P (mg/L)	K (g/L)	Flow Rate (GPM)
Post AD/Sep Liquid	2.82 ± 0.29	71.3 ± 2.7	20.98 ± 3.4	1.98 ± 0.21	270 ± 19	1.51 ± 0.12	46.13
DVO FSS Effluent	1.17 ± 0.26	59.5 ± 8.8	1.85 ± 0.32	1.30 ± 0.25	36 ± 6	1.41 ± 0.09	41.75
Reduction by Conc. (%)	58.5	16.6	91.2	34.3	86.7	6.6	9.5
Reduction by Mass (%)	62.5	16.6	92.0	40.6	87.96	15.5	

TABLE 2. DAF SOLIDS CHARACTERISTICS AND PARAMETERS

	TS (%)	CA (% of TS)	EC (mmhos/cm)	N (% DW)	P (% DW)	K (% DW)	Flow Rate (yd³/day)
DVO FSS Solids	24.4 ± 4.1	79.9 ± 2.9	2.31 ± 0.48	4.5 ± 1.1	3.8 ± 0.8	0.9 ± 0.2	40 ± 7
	C: 39.3 ± 5.1	Ca: 4.1 ± 0.6	Mg: 1.2 ± 0.1	Fe: 0.2 ± 0.04	S: 0.7 ± 0.1	% DW	
	Mo: 0.95	Ni: 0.77	Se: 0.30	As: 0.09	Cd: 0.04	Cr: 0.76	Co: 0.62	Cu: 25.6	Pb: 0.12	Hg: 0.01	Zn: 83.7	ppm

TABLE 3. ECONOMIC SUMMARY

DVO FSS Capital Installed	$607,465	$21.20 per 1,000 gallons throughput	$339 per cow	
DVO FSS O&M	80-140 ppm polymer dosing	40 kWh/h electrical	40 minutes/day labor	3% capital parts
	$89,866-122,189 per year	$3.10-4.30 per 1,000 gallons throughput	$50-68 per cow per year	
DVO FSS Solids	103 lbs. N per cow per year	87 lbs. P_2O_5 per cow per year	21 lbs. K_2O per cow per year	



Pictogram of full-Edaleen system including DVO Phosphorus Recovery System **(a)** liquid samples at various stages of process; **(b)** liquid-poured samples at various stages of process; **(c)** NPK fertilizer values along various stages of process.

Organizations Involved:

Farm or facility
Edaleen Dairy

Electrical Utility
Puget Sound Energy

Engineers
DVO Inc.

Contractor
Regenis

Developers
Edaleen Dairy

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

www.newtrient.com

CONCLUSION

The DVO Phosphorus Recovery System is an integral part of the Edaleen Dairy manure management system, positioned after anaerobic digestion and fibrous solids separation. Produced solids partition a significant fraction of phosphorus and nitrogen into stackable, solid form while producing a low-nutrient, tea-water significantly reduced in suspended solids. While a more-costly unit operation than simple fibrous solids separation, the gains in nutrient partitioning, wastewater volume reduction, and tea-water irrigation water can be of importance to some dairies. Early evaluation shows a constant and steady operation producing a dry, stackable product with quite consistent performance. Further observation will be required to better ascertain long-term maintenance costs as well as development of markets, uses and price points for the solids.

DVO AT EDALEEN DAIRY PROJECT BY THE NUMBERS

Location type	Dairy
Number of animals	Approximately 1,800 wet cow equivalents
Type of bedding	Digested, separated fibrous solids
Manure collection	Alley cable scraper with one maternity barn flush
Daily flow	85,000 gallons per day
System designed by	• DVO Two Stage Mixed Plug-Flow Anaerobic Digester • Dresser-Rand Guascor Engine with Martin Machinery Package • GEA Houle Two stage slope screen manure separator • DVO Phosphorus Recovery system
Date operational	Fall 2017
Energy produced/required	• DVO Anaerobic digester approximately 40-45 KW parasitic load • GEA/Houle Separator approximately 2 KW parasitic load • DVO Phosphorus Recovery system approximately 40 KW parasitic load
Installed energy production capacity	Averaging 544 KW of electrical generation to the grid from the anaerobic digester
Products produced	Electrical Power, Green Tags, Carbon Credits, Tipping Fees, Fibrous Solids Bedding Offset, Fibrous Solids Soil Amendment Ingredient, Fine Solids Soil Amendment
Residual materials	• Digested, separated liquid manure wastewater • Fine Solids Soil Amendment
Residual storage	• Lagoon storage for digested, separated liquid manure wastewater • On-site storage for fibrous solids prior to use/sales • On-site storage for fine solids prior to use/sales
Residual use	• Wastewater residual fate as fertilizer for local fields/forage crops • Fibrous solids recycled internally as bedding and sold as ingredient to retail soil amendment • Fine solids as fertilizer to local fields/forage crops or sold as fertilizer/soil amendment to fields undergoing crop rotation
Electrical utility	Electrical power purchase agreement with Puget Sound Electric
Ownership structure	Family owned dairy

DVO Phosphorus Recovery System Side View.

Daily volume of stackable solids produced by DVO Phosphorus Recovery System.

For more information about DVO Phosphorus Recovery System, or to join our mailing list, email info@newtrientllc.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.

Equipment and Technology:

Manure collection
GEA/Houle Alley Scrapers, GEA/Houle mixers/pumps

Primary treatment
DVO Two-Stage Mixed Plug-Flow Mesophilic Anaerobic Digester

Secondary treatment
GEA/Houle Two-Stage Slope Screen Solids Separator

Tertiary treatment
DVO Phosphorus Recovery Modified Dissolved Air Flotation (DAF) System

Energy systems
Dresser-Rand Guascor SFGLD 560 engine/generator set, heat recovery and interconnect packaged by Martin Energy Group

Other
Regenis construction, installation and operation/ maintenance

NEWTRIENT
INNOVATIVE SOLUTIONS IN RESOURCE RECOVERY

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

www.newtrient.com