NEWTRIENT EVALUATION SUMMARY

CONSERVATION INNOVATION GRANT (CIG):

Centrisys Decanter Centrifuge Technology

Dairy Manure Treatment Innovations – Enhancing Water Quality and Sustainability

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INSIDE

BACKGROUND

Phosphorus (P) accumulation in soils and water bodies poses a significant environmental challenge, largely fueled by the overuse of fertilizers and the subsequent increase in P content within crops and animal manure. This cyclical phenomenon disrupts the delicate balance of soil and water quality, necessitating a proactive approach to break the chain. Addressing the imbalanced P cycle becomes imperative, especially in situations where farms face challenges in managing surplus dairy manure. Farms often struggle with limited land availability, creating an imbalance between supply of manure and the land available to apply manure, and intensifying the need for innovative solutions to prevent excess P from entering the environment.

In response to this challenge, technologies like the centrifuge have emerged as promising interventions, offering a potential remedy by extracting fine solids and surplus P from dairy manure. Previous studies, such as those by Massey and Payne in 2019, have demonstrated the technology's remarkable high removal rates, indicating its potential to enhance flush water performance, and drastically reduce the costs associated with liquid effluent land application. Additionally, the practical reusability of separated solids as bedding and the cost-effective transport of partitioned nutrients over extended distances have been substantiated through research by Risse et al. in 2001.

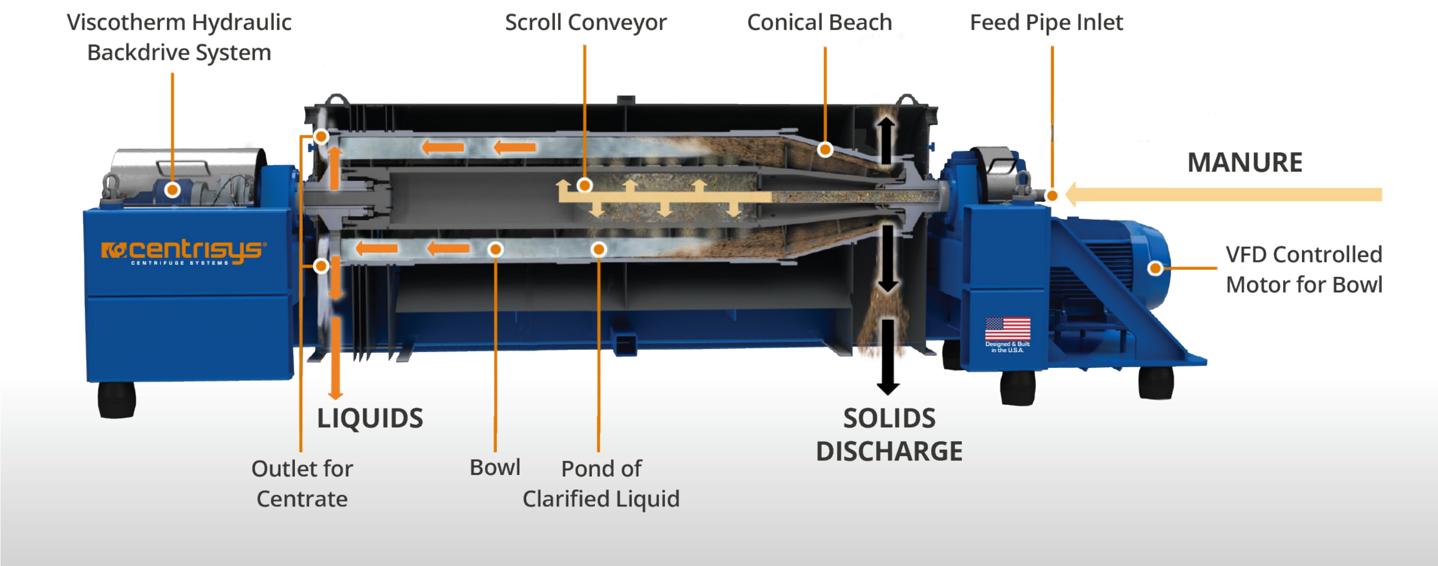
Within the framework of the USDA Conservation Innovation Grant (CIG) project, Newtrient initiated a centrifuge evaluation at Deer Valley Dairy in Fort Morgan, CO. The objective of this study was to explore the performance and water quality advantages of the Centrisys Decanter Centrifuge in separating solids and nutrients from the dairy waste stream.

INTRODUCTION

In dairy, the efficient management of waste streams is pivotal to environmental stewardship. Centrifuges, specifically tailored for dairy applications, have emerged as promising solutions, reshaping the way dairy farms handle their waste. Designed with precision, these centrifuges play a pivotal role in separating solids from liquid waste streams, ensuring both efficient waste management and recovery of valuable resources.

At its core, a centrifuge operates as a sophisticated mechanical separator, employing the principles of sedimentation and centrifugal force to achieve efficient dewatering. The process begins with the introduction of a feed slurry—a mixture of solid particles and liquid—into the rotating bowl through a feed inlet. As the bowl spins at high speeds, often ranging from 2,000 to 4,000 revolutions per minute (rpm), centrifugal force propels denser solid particles to the outer edges of the bowl, creating a clear distinction between the solid phase, known as the cake, and the liquid phase, which collects in the center of the bowl from an overflow weir, referred to as the centrate or effluent.

FIGURE 1: 2-PHASE CENTRISYS DECANTER CENTRIFUGE SYSTEM



Key Components of Decanter Centrifuges:

1. **Rotating Bowl:** The heart of the decanter centrifuge, the rotating bowl, initiates the separation process. Its rapid rotation generates centrifugal force, driving the separation of solids and liquids.
2. **Screw Conveyor:** Housed within the bowl, the screw conveyor swiftly transports the separated solid phase (cake) towards the discharge outlet, ensuring continuous and efficient processing.
3. **Drive System:** Providing the necessary power and control, the drive system facilitates the rotation of both the bowl and the screw conveyor, enabling seamless, uninterrupted operation.

METHODOLOGY

Throughout the study, a total of five different samples were collected three times a week for 15 weeks from Deer Valley Dairy, using a Centrisys CS30-4 centrifuge for separation. The sampling process involved determining liquid inflow and outflow rates through a static sloped screen separator and the centrifuge. Manure was passed over a static sloped screen at an average flow rate of 491 gallons per minute (gpm). The collected solids were categorized as coarse (from the screen) and fine (from the centrifuge). Three liquid samples were collected: "Liquid 1" from the sloped screen inflow, "Liquid 2" from the discharge pipe to storage ponds, and "Liquid 3" after passing through the centrifuge and destined for crop irrigation.

Each of the 45 samples were stored appropriately, and those sent to an external lab were packed in ice and shipped weekly to A&L Great Lakes Laboratories in Fort Wayne, IN.

DISCUSSION OF RESULTS

The study conducted at Deer Valley Dairy provides valuable insights into the composition of solid and liquid samples collected. The research aimed to understand the impact of centrifuge operations on various analytes (substances being analyzed), shedding light on the efficiency of the separation process. This comprehensive analysis evaluated both solid and liquid components, providing a holistic view of the dairy waste processing system.

Key Benefits of a Centrifuge

Performance: The centrifuge exhibited outstanding performance in the separation of solids from liquid waste, as evidenced by the significant enrichment of key elements in the fine solid samples compared to coarse solids (Table 1). Elements such as aluminum, iron, manganese, phosphorus,

TABLE 1: SOLID MEASUREMENTS

	COARSE SOLIDS (n =39)			FINE SOLIDS (n=39)		
	Mean	Median	Std. Dev.	Mean	Median	Std. Dev.
Moisture	83.83	84.87	2.49	71.79	72.13	2.28
Organic Matter (%)	14.31	13.68	1.95	19.89	19.66	1.96
Organic Carbon (%)	8.33	7.95	1.13	11.54	11.40	1.14
C:N	31.8	31.6	4.5	23.7	23.7	2.6
Kjeldahl Nitrogen (%)	0.264	0.261	0.036	0.489	0.490	0.034
Ammonium (%)	0.059	0.060	0.023	0.082	0.080	0.016
Organic Nitrogen (%)	0.205	0.208	0.043	0.407	0.406	0.033
Phosphorus (%)	0.043	0.044	0.008	0.154	0.150	0.019
Potassium (%)	0.108	0.107	0.019	0.140	0.141	0.015
Sulfur (%)	0.05	0.05	0.01	0.10	0.10	0.01
Magnesium (%)	0.06	0.06	0.01	0.18	0.18	0.02
Calcium (%)	0.21	0.19	0.06	0.76	0.74	0.09
Sodium (%)	0.07	0.07	0.01	0.07	0.07	0.01
Aluminum (ppm)	104.2	99.0	27.6	585.5	564.0	98.7
Copper (ppm)	6.6	6.4	2.8	18.9	19.0	5.1
Iron (ppm)	125.0	120.0	41.4	611.5	589.0	89.1
Manganese (ppm)	8.4	8.1	1.7	32.7	32.0	3.6
Zinc (ppm)	14.7	15.0	3.6	39.5	39.0	6.9

and copper displayed remarkable enrichment factors, indicating the centrifuge's effectiveness in removing these components from the liquid waste stream. Additionally, the observed depletion of analytes in the liquid samples after centrifugation illustrated the technology's efficiency in eliminating solid particles and associated nutrients.

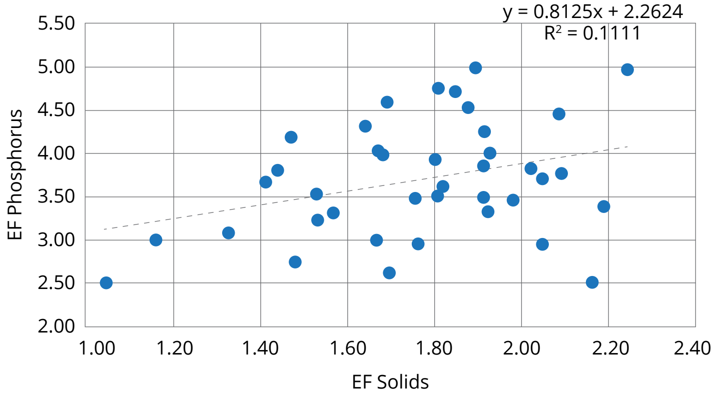
Enhanced Nutrient Concentration: The study revealed a substantial increase in essential nutrients, including phosphorus, organic carbon, and organic nitrogen, in the fine solid samples. This enrichment implies that the centrifuge technology effectively concentrates valuable nutrients present in dairy waste. Such enhancement is crucial for agricultural applications, as nutrient-rich organic matter is highly beneficial for soil fertility and plant growth. The concentrated organic material obtained through centrifugation can serve as a valuable organic fertilizer, promoting sustainable farming practices.

Visual analysis (Figure 2) provided tangible evidence of enrichment, with the fine solids appearing darker and nutrient-rich compared to coarse solids. This visual confirmation underlines the technology's effectiveness in enhancing organic matter and nutrient content in the separated material.

FIGURE 2: FINE AND COARSE SOLIDS COMPARISON

Phosphorus enrichment, a critical element for plant growth, occurred nearly four-fold without the use of polymers. This efficient phosphorus concentration highlights the technology's potential to enhance soil fertility. The positive correlation observed between phosphorus enrichment and solid material (Figure 3) indicates the consistent performance of the centrifuge. Understanding such correlations can aid in optimizing the separation process, ensuring a more precise concentration of valuable nutrients.

FIGURE 3: LINEAR REGRESSION OF PHOSPHORUS VS. SOLIDS



Reduced Water Content and Efficient Land Application: The reduction in moisture content observed in fine solids indicates the efficient removal of excess water during the centrifugation process. This reduction not only makes the waste material more concentrated but also enhances its suitability for land application. Lower moisture content increases the cost efficiency of transportation, handling, and application, making the process more economically viable for farmers.

Potential for Crop Irrigation: Although diluted, the liquid effluent fraction still contains valuable nutrients (Table 2). The ability to use this nutrient-enriched effluent for crop irrigation is significant. It minimizes waste by recycling nutrients back into agricultural systems, thereby reducing the environmental impact of dairy operations. Additionally, the reduction of clogging issues in the irrigation system makes the technology more practical for real-world agricultural applications.

TABLE 2: LIQUID MEASUREMENTS

	LIQUID 1 (n = 39)		LIQUID 2 (n = 31)		LIQUID 3 (n =39)	
	Mean	Median	Mean	Median	Mean	Median
Moisture	95.80	95.79	96.62	96.72	97.85	97.85
Organic Matter (%)	3.18	3.05	2.39	2.36	1.32	1.28
Organic Carbon (%)	1.85	1.77	1.39	1.37	0.77	0.74
C:N	10.9	10.9	8.3	8.4	5.2	5.1
Kjeldahl Nitrogen (%)	0.168	0.169	0.166	0.165	0.145	0.148
Ammonium (%)	0.064	0.070	0.064	0.070	0.067	0.070
Organic Nitrogen (%)	0.104	0.106	0.102	0.104	0.078	0.077
Phosphorus (%)	0.031	0.034	0.032	0.033	0.024	0.023
Potassium (%)	0.099	0.105	0.104	0.106	0.101	0.102
Sulfur (%)	0.03	0.03	0.02	0.03	0.02	0.02
Magnesium (%)	0.04	0.04	0.04	0.04	0.03	0.03
Calcium (%)	0.11	0.11	0.11	0.11	0.07	0.07
Sodium (%)	0.07	0.07	0.07	0.07	0.07	0.07
Aluminum (ppm)	61.41	59.00	56.81	57.00	31.85	29.00
Copper (ppm)	3.88	4.00	3.89	4.00	2.88	2.80
Iron (ppm)	59.31	54.00	49.84	48.00	23.15	22.00
Manganese (ppm)	4.84	5.00	4.87	5.00	3.18	3.20
Zinc (ppm)	9.56	9.90	9.84	10.00	7.72	8.00

Evaluation Key Issues and Challenges

It is worth noting that the provided report focused more on presenting findings and results rather than explicitly highlighting key issues and challenges. Therefore, the identified challenges are inferred based on the information provided in the report.

Performance and Enrichment Factors: The study revealed that the enrichment factors of various analytes differed between the fine and coarse solid samples. While most analytes showed enhancement in the fine solids, sodium was an exception. Understanding and optimizing the performance and enrichment factors of the centrifuge posed a challenge to maximize the separation of solids and nutrients effectively. Research and refinement are necessary to address this challenge comprehensively.

Although not used during this study, one consideration to further enhance nutrient enrichment would be the use of chemicals in coagulation and flocculation processes. Coagulation is a chemical process that utilizes alum (aluminum sulfate), ferric chloride, or other chemicals to neutralize the charge of suspended particles, forming small flocs. Flocculation is a physical process that allows for the binding of the smaller flocs together, making them larger and easier to separate from a liquid stream. Polyacrylamides, a type of polymer, are a commonly used chemical to enhance the formation and size of flocs. The selection and dosage of chemicals depends on the amount of solids and nutrients one wants to remove from the waste stream. As much as 70% of the nitrogen and 95% percent of the phosphorus can be removed when both a coagulant and polymer are used.

Depletion in Liquid Samples: The analysis of the liquid samples indicated a depletion of analytes as they progressed from the sloped screen to the centrifuge and further to the irrigation system. The centrifuge was found to be a significant contributor to this depletion. Managing and mitigating the loss of nutrients during the centrifuge process presented a challenge for ensuring efficient nutrient recovery and utilization. Understanding the factors contributing to this discrepancy poses a challenge, requiring further investigation. Addressing this issue is vital to ensure a comprehensive understanding of nutrient dynamics during the separation process.

IMPLICATIONS

This evaluation emphasizes the importance of operational protocols and equipment functionality in ensuring the technology's optimal performance. While the Centrisys Decanter Centrifuge offers notable benefits in nutrient enrichment, challenges persist in achieving uniform depletion and optimizing enrichment factors. Addressing these issues through further research and development efforts is essential to harness the technology's full potential within the dairy context.

In conclusion, the study demonstrates that centrifuge technology holds significant promise for dairies. Its ability to concentrate valuable nutrients, reduce water content, remove additional solids, and offer potential applications in agriculture makes it a valuable tool for promoting environmental stewardship within the dairy industry. Addressing the identified challenges and conducting further research will pave the way for the widespread adoption of this technology, contributing to a more sustainable dairy industry.

For additional information on the vendor, environmental impacts, financial implications, and Centrisys Decanter Centrifuge technology visit the Centrysis Vendor Snapshot on the **Newtrient website**.

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Newtrient's mission is to reduce the environmental footprint of dairy while making it economically viable to do so.

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