NEWTRIENT EVALUATION SUMMARY

CONSERVATION INNOVATION GRANT (CIG):

PondLift Wastewater Aeration Technology

Dairy Manure Treatment Innovations – Enhancing Water Quality and Sustainability

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INSIDE

BACKGROUND

Effective management of slurry storage represents a pivotal aspect of dairy farming operations, significantly influencing both farm productivity and environmental sustainability. As dairy farms seek to optimize their waste management strategies, the storage of slurry — an amalgamation of liquid manure and water—emerges as a critical challenge. The proper handling and storage of slurry is essential not only for regulatory compliance but also for harnessing its potential downstream use. Moreover, creating conducive conditions within slurry storage facilities is paramount to foster the development of specific microbial communities capable of efficiently breaking down bacteria.

Mechanical aeration systems, such as PondLift aerators, have emerged as possible tools in this endeavor, offering a means to enhance aerobic biologic activities within slurry storage ponds. By facilitating the proliferation of beneficial microbes and accelerating the breakdown of organic matter, these systems not only mitigate odors but also promote the generation of homogenous, nutrient-rich material suitable for land application. By implementing mechanical aeration systems, manure storage ponds can experience improvements in various aspects, including decreased sludge volumes, increased nutrient availability, and mitigation of odor formation.

Within the framework of the USDA-NRCS Conservation Innovation Grant (CIG) project, Newtrient initiated a 52-week evaluation to assess the efficacy of PondLift aerators in reducing sludge accumulation and increasing plant-available nutrients in a slurry manure pond at Hood Farms Family Dairy in Paw Paw, MI. At the conclusion of this study in the fall of 2023, PondLift ceased manufacturing of the aerators and discontinued operations; however, this had no impact on the study's findings or outcomes.

INTRODUCTION

Pond systems serve as integral components in dairy farm wastewater management, primarily aimed at reducing the organic content in effluent discharged from dairy operations. The quantification of organic matter in effluent, typically measured as biochemical oxygen demand (BOD), holds significant importance in monitoring pond performance. Mechanical aeration involves the introduction of oxygen into wastewater systems through the use of specialized equipment, such as aerators and agitators. This process fosters aerobic biologic activities, facilitating the breakdown of organic compounds by beneficial microorganisms.

While various types of mechanical aeration systems exist, each with their own unique design and functionality, this evaluation focuses specifically on the PondLift aeration system, a surface aeration system. The PondLift equipment includes a motor, typically situated above the water surface, powering the aerators. These aerators are equipped with propellers or impellers, generating agitation by creating an upward current that lifts water and solids from the pond bottom and disperses them across the surface, suspending solids in the liquid. This action facilitates the acceleration of oxygen intrusion into the pond water, essential for promoting aerobic bacterial metabolism, which efficiently metabolizes organic matter in manure.

FIGURE 1: PONDLIFT FLOATING AERATOR

Source: Livestock and Poultry Environmental Learning Community (LPELC.org), 2019.

Key Components of PondLift Aeration Systems:

1. **Aerators:** The PondLift system includes aerators equipped with a motor and propeller or impeller. These aerators are designed to float on the water surface of the pond, ensuring ease of installation and maintenance.
2. **Poly cords and stands:** The aerators are positioned within the pond using poly cords attached to stands. This setup ensures stability and proper alignment of the aerators.
3. **Number of aerators:** In the specific case of Hood Farms Family Dairy, there were initially nine aerators installed in the pond. However, the number of aerators changed over time due to repairs and maintenance needs. Although the manufacturer of the aerators used in this study went out of business, the dairy continued using them until the study concluded. At the time of the final sampling, seven aerators were still in operation.

METHODOLOGY

This evaluation summary presents findings from a comprehensive analysis of samples collected over a 52-week period from a slurry manure storage pond at Hood Farms Family Dairy. With a herd of 500 cows, the farm utilizes sand bedding in its barns and has extensive land for feed production. Given the nature of this operation, efficient management of manure and wastewater becomes imperative. The dairy's wastewater treatment begins with a sand separation process followed by an aeration-equipped storage pond. Prior to sampling, weather conditions were recorded, and notes on the pond's operational status including filling, emptying, and land application were taken, with any abnormal observations noted.

Over the course of a year, two or three samples (16 ounces each) were collected per week depending on the status of the waste manure storage facility (Table 1). Sampling locations included various scenarios such as when the facility was filling, during land application, and when the facility was emptied, with composite liquid samples collected from inflow and outflow points, as well as from sludge material. Composite samples, comprising samples from three different locations during the periods that the banks of the pond allowed access, were mixed in a bucket for analysis. Special measures were taken during periods when the inflowing stream was inaccessible, such as during summer when plants obstructed access. Samples were collected using a pole with a plastic bottle attached to avoid sludge contamination and properly stored for transportation and analysis.

The flow rate of the inflow stream was constant at 300 gallons per minute (gpm) when the motor was running and 0 gpm when the motor was off. Additionally, liquid flow rates were measured to calculate average flow rates, while sludge thickness and clean water additions were noted. Detailed records were kept, documenting any changes in weather, operations, influent conditions, or anomalies throughout the study period.

TABLE 1: THE SAMPLING PROTOCOL IS BASED ON THE OPERATION OF POND

Operation status	Samples to be collected
Waste Storage Filling	1. Composite liquid entering the pond 2. Composite liquid from the pond
Land Applying from the Manure Storage Facility	1. Composite liquid entering the pond 2. Composite liquid from irrigation water
Manure Storage Facility Emptied	1. Composite liquid entering the pond 2. Composite liquid from the pond 3. Composite sample of sludge

Following data analysis, which involved the removal of any outliers using Box-Whisker plots, trends and differences in storage samples compared to the manure added to the pond were determined through statistical tests.

DISCUSSION OF RESULTS

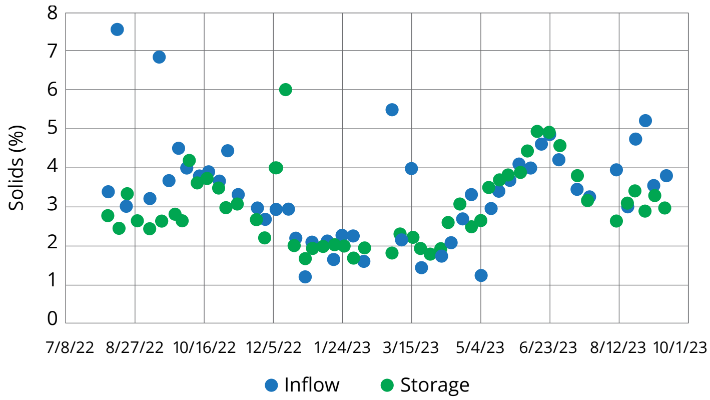
Key Benefits of Aeration

The study conducted at Hood Farms Family Dairy provides valuable insights into the efficacy of the PondLift aeration system. By examining trends, observations, and precipitation data gathered during the study, this research provides meaningful information about the system's performance and its impact on dairy farm operations.

Storage and Handling: One key benefit of the PondLift aeration system is its ability to enhance flush water quality by reducing solids content consistently over time. This improvement was not only validated through personal communications with the landowner but also proved critical in preventing water line clogging during transfer and irrigation processes. Consequently, the owner prioritized the maintenance and operation of the aerators, ensuring they remained functional by conducting repairs and fixes as long as the necessary parts were obtainable.

Additionally, data analysis using Box-Whisker plots revealed a notable reduction in solids content in stored samples compared to inflow samples, as evidenced by a smaller variation from the median value in the former. Paired sample permutation test results further supported this observation, indicating a statistically significant difference ($p<0.05$) in solids content between inflowing manure and stored samples throughout the study period.

FIGURE 2: SOLIDS CONTENT OF THE SAMPLES DURING THE STUDY PERIOD



Odor Reduction: High organic content in slurry can contribute to foul odors due to the decomposition of organic matter, especially when stored in anaerobic conditions. Reducing organic content can help mitigate odor issues, improving the environmental quality of the surrounding area. Although this study did not evaluate air emissions directly, it did find a reduction in organic content. Paired sample permutation test results revealed that, on average, the organic content of the inflow samples was higher than that of the storage samples throughout the entire year of monitoring (Figure 3). This difference was found to be statistically significant, meaning that it was unlikely to have occurred by random chance alone ($p<0.05$). However, when specifically looking at the organic carbon (C) content within the samples, no significant variation was observed between the inflow and storage samples (Figure 4).

FIGURE 3: ORGANIC MATTER OF THE SAMPLES DURING THE STUDY PERIOD

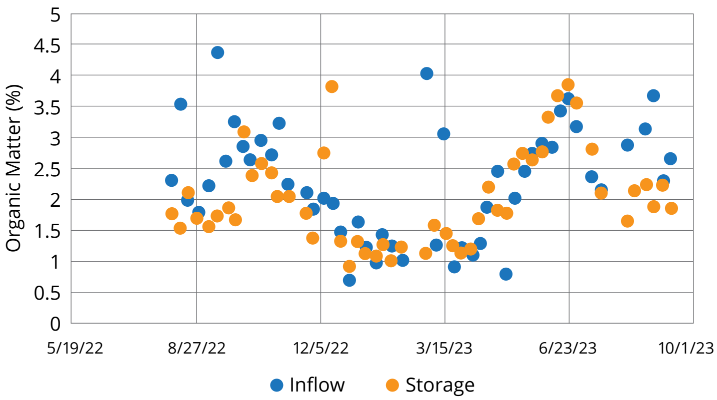
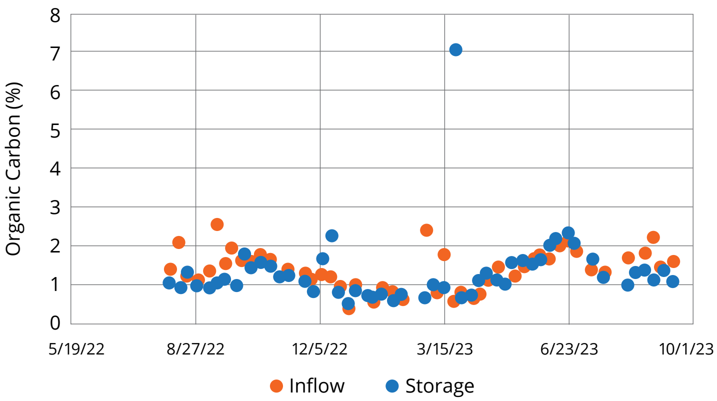


FIGURE 4: ORGANIC C CONTENT OF THE SAMPLES DURING THE STUDY PERIOD



Potential for Crop Irrigation: Storage of manure over extended periods already aids in containing nitrogen (N) and phosphorus (P), allowing them to undergo beneficial biological activities and break down into plant-available forms. The PondLift aeration system further enhances this process by introducing oxygen and facilitating mixing, which helps suspend organic matter in the liquid, ensuring its stabilization within the manure flushed into the pond. This contributes to the retention and recovery of N and P, thus reducing the risk of their runoff and leaching into freshwater sources. While the nutrient and element concentrations in the stored samples did not significantly differ from those in the inflow samples (Table 2), the presence of organic matter and essential nutrients in the slurry still holds value. Additionally, the reduction of clogging issues in the irrigation system makes the technology more practical for real-world agricultural applications.

TABLE 2: THE COMPOSITION OF INFLOW, STORAGE, AND OUTFLOW SAMPLES DURING LAND APPLICATION OF SLURRY MANURE

	9/15/2022			12/8/2022		
	Inflow	Storage	Outflow	Inflow	Storage	Outflow
Moisture (%)	93.15	97.44	96.25	97.13	96.03	97.43
Solids (%)	6.85	2.56	3.75	2.87	3.97	2.57
Ash @ 550 C (%)	2.51	0.88	1.18	0.89	1.26	0.86
Organic Matter (LOI @ 550 C) (%)	4.34	1.68	2.57	1.98	2.71	1.71
Organic Carbon (LOI @ 550 C) (%)	2.52	0.98	1.49	1.15	1.57	0.99
Nitrogen, Total Kjeldahl (TKN) (%)	0.233	0.17	0.199	0.195	0.215	0.188
Nitrogen, Ammonium (NH_4-N) (%)	0.1	0.1	0.1	0.11	0.12	0.11
Nitrogen, Organic (N) (%)	0.133	0.07	0.099	0.085	0.095	0.078
Phosphorus (P) (%)	0.049	0.029	0.04	0.032	0.057	0.029
Potassium (K) (%)	0.179	0.135	0.153	0.162	0.175	0.14
Sulfur (S) (%)	0.03	0.02	0.02	0.02	0.03	0.02
Magnesium (Mg) (%)	0.08	0.04	0.05	0.05	0.07	0.04
Calcium (Ca) (%)	0.19	0.09	0.12	0.09	0.15	0.09
Sodium (Na) (%)	0.06	0.06	0.07	0.05	0.05	0.05
Aluminum (Al) (ppm)	72	32	47	38	66	32
Copper (Cu) (ppm)	36	24	39	35	49	32
Iron (Fe) (ppm)	226	80	133	100	171	91
Manganese (Mn) (ppm)	22	12	16	15	22	13
Zinc (Zn) (ppm)	16	9.3	13	16	18	11

Key Issues and Challenges

Two key issues emerged during the study period underscoring the need for further investigation and highlighting potential implications for effective pond management and manure storage system efficacy.

Sand Accumulation in the Sludge Layer: Since the pond was not emptied throughout the study period, measurements of sludge thickness and composition were not possible. However, towards the conclusion of the sampling, samples were collected from the bottom of the storage sample collection location to gain insights into the composition of the accumulated material. The results of compositional analyses, shown in Table 3, revealed that the ash content of the sludge samples closely resembled the solids content. This similarity suggests that the sludge may predominantly consist of soil or sand, indicating a potential accumulation of sand within the sludge layer. This finding highlights the need for further investigation into the composition and buildup of sediment within the pond, as sand accumulation can have implications for pond management and overall effectiveness of the manure storage system. It should be noted that a sand settling lane was used during the study; however, it was not being operated properly, resulting in a significant amount of sand entering the holding pond. No other solid-liquid separation method was used, which contributed to a high organic and solids loading rate within the manure storage facility.

TABLE 3: THE COMPOSITION OF SLUDGE SAMPLES DURING FILLING OPERATION

	8/24/2023			9/7/2023			9/14/2023		
	Inflow	Storage	Sludge	Inflow	Storage	Sludge	Inflow	Storage	Sludge
Moisture (%)	95.3	96.65	49.22	96.45	96.72	56.82	96.23	97.05	51.06
Solids (%)	4.7	3.35	50.78	3.55	3.28	43.18	3.77	2.95	48.94
Ash @ 550 C (%)	1.61	1.16	44.65	1.31	1.09	39.14	1.15	1.11	45.86
Organic Matter (LOI @ 550 C) (%)	3.09	2.19	6.13	2.24	2.19	4.04	2.62	1.84	3.08
Organic Carbon (LOI @ 550 C) (%)	1.79	1.27	3.56	1.3	1.27	2.34	1.52	1.07	1.79
Nitrogen, Total Kjeldahl (TKN) (%)	0.227	0.231	0.339	0.222	0.203	0.164	0.213	0.207	0.179
Nitrogen, Ammonium (NH_4-N) (%)	0.11	0.12	0.07	0.12	0.12	0.07	0.12	0.12	0.05
Nitrogen, Organic (N) (%)	0.117	0.111	0.269	0.102	0.083	0.094	0.093	0.087	0.129
Phosphorus (P) (%)	0.043	0.043	0.217	0.032	0.036	0.127	0.039	0.034	0.097
Potassium (K) (%)	0.208	0.234	0.219	0.186	0.216	0.243	0.218	0.227	0.217
Sulfur (S) (%)	0.03	0.03	0.09	0.02	0.02	0.05	0.02	0.02	0.04
Magnesium (Mg) (%)	0.08	0.07	0.4	0.06	0.07	0.24	0.07	0.07	0.29
Calcium (Ca) (%)	0.12	0.11	1.25	0.1	0.11	0.68	0.12	0.11	0.87
Sodium (Na) (%)	0.06	0.06	0.05	0.07	0.07	0.07	0.07	0.07	0.05
Aluminum (Al) (ppm)	56	46	884	117	50	3602	79	59	2617
Copper (Cu) (ppm)	33	35	151	37	39	106	37	37	83
Iron (Fe) (ppm)	161	130	2272	183	126	3867	160	129	3309
Manganese (Mn) (ppm)	20	18	182	17	17	187	18	17	156
Zinc (Zn) (ppm)	16	15	84	13	19	60	16	14	45

Sampling Limitations: One of the key issues encountered during the study pertains to the limited frequency of sample collection from the outflow and sludge. Due to operational constraints at the farm during the days of sample collection, only a few sampling occasions were feasible for these specific types of samples. As a result, there was insufficient data available to conduct thorough statistical analyses and report on trends or changes in the composition of these samples over time. This limitation impacts the comprehensiveness of the study findings, particularly regarding the assessment of the outflow and sludge composition. Without a more robust dataset, it becomes challenging to draw meaningful conclusions or insights regarding the dynamics of these critical components of the manure management system.

IMPLICATIONS

The evaluation at Hood Farms Family Dairy has shed light on the potential of mechanical aeration systems, such as PondLift, in enhancing dairy farm wastewater management. While the study demonstrated some benefits such as improved flush water quality, reduced solids content, optimized storage and handling, capability for crop irrigation, and potential odor mitigation, it also highlighted key challenges and avenues for further exploration.

Despite the discontinuation of PondLift operations, other companies offer similar technologies, suggesting ongoing interest and potential for adoption within the industry. However, research on such systems remains limited, warranting further investigation to better understand their efficacy and economic feasibility for dairy farm operations. Moving forward, future research should prioritize addressing gaps in knowledge, including the assessment of air quality impacts and more comprehensive data on water quality benefits. For additional information on aeration technology, visit the **Newtrient website**.

REFERENCES

Livestock and Poultry Environmental Learning Community (LPELC.org), 2019.

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

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