NEWTRIENT

NEWTRIENT EVALUATION SUMMARY

CONSERVATION INNOVATION GRANT (CIG):

SWECO Vibratory Separation Screen

Dairy Manure Treatment Innovations – Enhancing Water Quality and Sustainability

University Partner
Dr. Amy Shober
Dr. Tanya Gressley
University of Delaware
College of Agriculture and
Natural Resources
531 South College Avenue
Newark, DE 19716, USA

JUNE 2024

INSIDE

Header Image: **https://sweco.com/addinfo/Round-Separator.pdf**

BACKGROUND

Manure management practices are a critical aspect of sustainable dairy farming. As dairy farms expand in both size and productivity, the handling of manure becomes increasingly complex, particularly regarding nutrient management and minimizing environmental impacts. One promising solution to these challenges is the use of advanced manure separation technologies, such as the SWECO Vibratory Separator. This system uses vibrative motions to separate manure into liquid and solid fractions, improving the management and utilization of waste products.

The separation of solids and liquids in manure serves multiple purposes. It not only aids in managing waste, but it also holds potential to enhance nutrient cycling on farms. By reducing the volume of solids in the liquid waste stream, this technology makes it easier to repurpose solids for materials like bedding or compost. Meanwhile, the liquid fraction can be managed for agricultural applications such as irrigation or as feedstock for anaerobic digestion. These processes can enhance both the environmental sustainability and efficiency of manure management systems on dairy farms.

Despite the promising potential of manure separation technologies, there is limited research on their effectiveness on large-scale commercial dairy operations. A deeper understanding of their performance under real-world conditions is crucial for optimizing manure management practices and furthering sustainability efforts in the dairy industry.

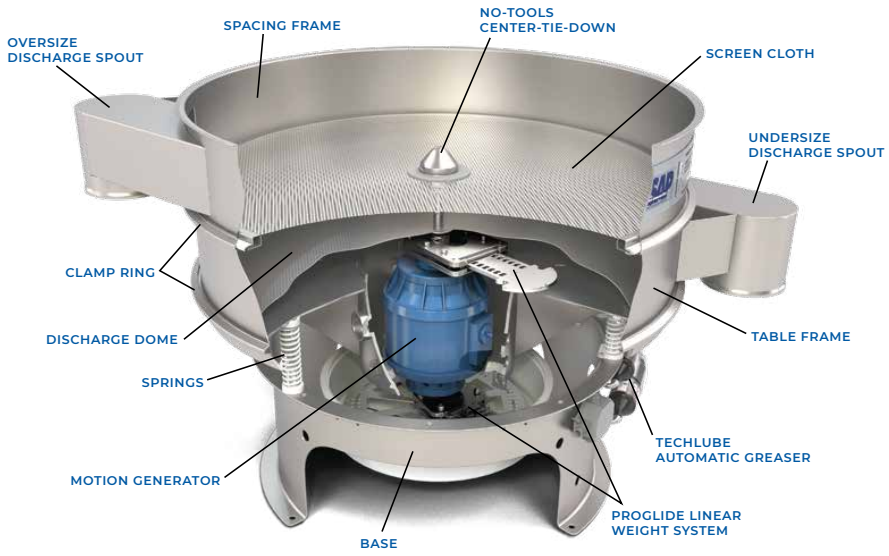
INTRODUCTION

Vibratory separation screen technologies like the SWECO Vibratory Separator have become a focal point of research due to their potential to enhance manure management and sustainability on dairy farms. These systems separate manure into solid and liquid fractions through vibrational movements, facilitating improved nutrient recycling, reduced manure volume, and diminished environmental impacts. Liquid effluent can be utilized for applications like irrigation or anaerobic digestion,

while the solid fraction manure can be repurposed as compost or bedding, reducing the need for purchased bedding materials, commercial fertilizers, and disposal methods like landfilling. Efficient manure management is essential for reducing nutrient runoff and leaching, particularly nitrogen and phosphorus, which contribute to water pollution and eutrophication. Proper treatment and handling of manure is crucial to mitigating these environmental risks.

However, while manure separation technologies show promise, further studies are needed to explore their application in large-scale, commercial dairy operations. This study aims to evaluate the effectiveness of the SWECO Vibratory Separator in real-world conditions, focusing on its ability to improve manure management, reduce environmental impact – particularly in regard to water quality – and support sustainable practices in the dairy industry.

FIGURE 1: SWECO VIBRO-ENERGY ROUND SEPARATOR INTERIOR VIEW



The Process

Source: **https://sweco.com/addinfo/Round-Separator.pdf**

1. **Vibration Mechanism**
   - At the core of the SWECO Separator is a motion-generator shaft equipped with two eccentric weights:
     - The **upper weight** creates horizontal vibrations, propelling materials across the screen cloth toward the edges.
     - The **lower weight** tilts the machine, introducing vertical and tangential vibrations to enhance separation.
2. **Material Movement Across the Screen**
   - As the separator vibrates, materials fed onto the screen cloth are sorted based on size and weight:
     - **Liquids** and ultrafine solids pass through the mesh screen, leaving behind coarse and/or fine solid materials.
     - **Solids** move outward to the edges of the screen for collection.
3. **Adjustable Settings for Optimization**
   - The operator can control the speed and spiral motion of the material flow, customizing the separation process for:
     - Different material characteristics (e.g., wet or dry, coarse or fine).
     - Desired throughput and separation efficiency.
4. **Continuous and Efficient Operation**
   - The vibration mechanism ensures continuous material flow without clogging, maximizing performance efficiency in separating solids and liquids.
   - The separator accommodates a variety of materials, making it versatile and adaptable to diverse dairy operations.

METHODOLOGY

This evaluation was conducted as a single-stage study to assess the SWECO Vibratory Separator's ability to separate solids and liquids from manure at Kilby Dairy, an 870-cow commercial dairy farm in Rising Sun, MD. Sampling and flow rate measurements were performed over 16 weeks, from February 6 to May 24, 2023.

Manure was sourced from various locations on the farm (e.g., milking parlor, cow barn, sand lane, ramp tank) and pumped through piping into the separating barn. The SWECO vibratory screens separated solids and liquids, with larger particles falling through a chute into a screw press and liquid effluent flowing to a post-liquid weir tank. Effluent from the weir tank was subsequently directed to an anaerobic digester. Samples were collected at five points in the system: raw manure inflow, SWECO liquids, SWECO solids, screw press liquids, and screw press solids.

Sample Collection and Flow Rate Measurement

Sampling was conducted three times weekly, and flow rates were measured at designated collection points as follows:

- **Raw Manure Inflow:** The inflow rate was measured by manually sealing the pipe, filling a 13-liter bucket three times, and averaging the collection times. A composite sample was created from subsamples of each bucket.
- **SWECO Liquids:** Liquid effluent passing through the screens was collected using a 32-ounce ladle. The flow rate was calculated by subtracting the SWECO solids rate from the inflow rate.
- **SWECO Solids:** Solids retained by the screens were collected into a bag for 30 seconds. The volume was recorded, and a subsample was taken for analysis.
- **Screw Press Liquids:** Liquids pressed out of SWECO solids were collected with a ladle from beneath the screw press.
- **Screw Press Solids:** Dewatered solids were sampled directly from the conveyor belt exiting the screw press.

Samples were collected consistently from one of the two SWECO units equipped with a shut-off valve and removable feeder cone, alternating between chutes to ensure representative data.

Data Analysis

All samples were analyzed for moisture, solids, organic matter, nitrogen, and select minerals at A&L Great Lakes Laboratory. Outliers exceeding three standard deviations were excluded from the dataset.

Throughout the sampling period, weather conditions (temperature, humidity, and precipitation) were recorded using a smartphone app. Operational notes, including system downtime and maintenance, were documented to account for variability in the system's performance.

A total of 198 samples were collected over 41 sampling days, providing a comprehensive dataset to evaluate the SWECO Vibratory Separator's performance in separating solids and liquids from manure.

DISCUSSION OF RESULTS

Key Benefits of the SWECO Vibratory Separation System

The evaluation of the SWECO vibratory screens and associated manure management system at Kilby Dairy reveals several key benefits, both operational and environmental, that significantly enhance the farm's manure handling efficiencies. The primary advantages include:

Enhanced Nutrient Separation and Recovery for Targeted Nutrient Management: The integration of the SWECO vibratory screen and Nutrient Control Systems (NCS) tapered screw press at Kilby Dairy has demonstrated significant benefits in nutrient separation, improving both nutrient recovery and environmental management. Analysis of nutrient distribution across the system reveals efficient partitioning of key nutrients into solid and liquid fractions from manure, optimizing their potential use in agricultural applications while reducing environmental risks (Table 1).

Total Kjeldahl nitrogen (TKN) concentrations remain stable in liquid fractions (average 0.31% in inflow and SWECO liquids and 0.30% in screw press liquids) but increase in solids (0.33% in SWECO solids and 0.39% in screw press solids). This indicates effective separation and concentration of nitrogen in solids, enhancing their value as slow-release fertilizers. Similarly, organic nitrogen shows greater concentrations in the solid fractions, with the screw press solids containing the highest levels (0.23%), adding further agronomic value to the recovered solids.

Phosphorus and potassium are also efficiently partitioned into the solids, with screw press solids containing slightly elevated levels of total phosphorus (0.05%) and potassium (0.18%) compared to the inflow and liquid fractions. This allows for targeted application of these nutrients in nutrient-deficient soils. Ammonium nitrogen concentrations, meanwhile, remain consistent across liquid phases (0.20%), ensuring its availability in effluent while limiting ammonia volatilization. The system's ability to concentrate critical nutrients in solids and diminish nutrient content in liquid fractions supports precision nutrient management while reducing the potential for nutrient runoff and leaching into sensitive watersheds such as the Chesapeake Bay during storage, handling, and application.

The SWECO vibratory screen serves as the primary separator, establishing distinct liquid and solid streams, while the screw press amplifies nutrient partitioning by concentrating nutrients more effectively in the solid fraction. Together, the systems work synergistically, with the screw press playing the leading role in the nutrient partitioning observed in the study.

TABLE 1. MEAN CONCENTRATION AND STANDARD DEVIATIONS OF TOTAL KJELDAHL N, AMMONIUM N, ORGANIC N, TOTAL P, TOTAL K IN 41 SAMPLES COLLECTED FROM VARIOUS POINTS ALONG THE SWECO SOLID-LIQUID SEPARATOR AT KILBY DAIRY IN RISING SUN, MD IN 2023.

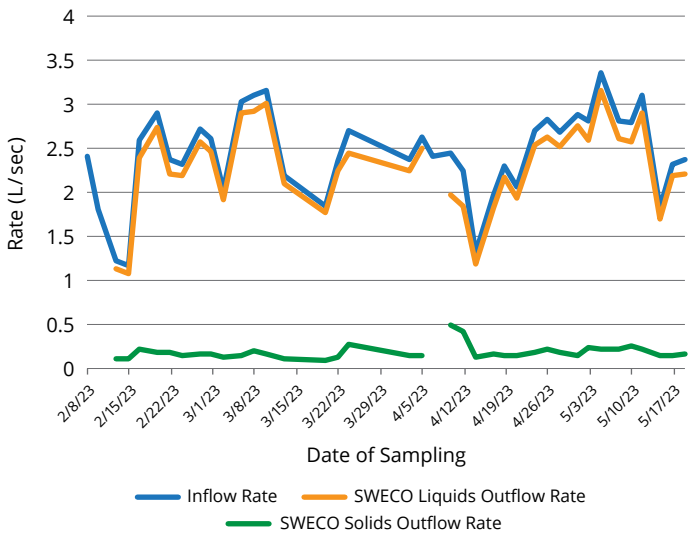
	Inflow	SWECO Liquids	Screw Press Liquids	SWECO Solids	Screw Press Solids
Total Kjeldahl N (%)					
Ave	0.31	0.31	0.30	0.33	0.39
Std Dev	0.04	0.04	0.04	0.04	0.07
Ammonium N (%)					
Ave	0.20	0.20	0.20	0.19	0.16
Std Dev	0.03	0.03	0.03	0.04	0.03
Organic N (%)					
Ave	0.12	0.12	0.11	0.15	0.23
Std Dev	0.02	0.02	0.02	0.04	0.06
Total P (%)					
Ave	0.04	0.04	0.04	0.04	0.05
Std Dev	0.01	0.01	0.01	0.01	0.01
Total K (%)					
Ave	0.15	0.16	0.16	0.16	0.18
Std Dev	0.02	0.02	0.02	0.01	0.01

Improved Anaerobic Digester Integration and Effluent Reuse: The SWECO vibratory screens play a pivotal role in optimizing the manure management system at Kilby Dairy by ensuring efficient separation of solids and liquids. This separation directly enhances the performance of the farm's anaerobic digester. Over the 16-week sampling period, the SWECO system processed liquid manure at an average inflow rate of 2.41 ± 0.52 liters per second (L/s), producing a liquid outflow of 2.27 ± 0.51 L/s and diverting solids at an average rate of 0.17 ± 0.08 L/s. On average, 7.1 ± 3.1% of the inflow was captured as solids, ensuring a steady and consistent effluent flow into the anaerobic digester.

This precision in solid-liquid separation minimizes blockages and operational issues within the digester as well as a reduction of costly solid removals, allowing it to operate more efficiently and with fewer interruptions. As a result, biogas production is enhanced, maximizing renewable energy generation and reducing greenhouse gas emissions while minimizing labor costs.

Additionally, the liquid outflow from the SWECO screens is well-suited for reuse as flush water in cow barns, further closing the loop in sustainable farm operations. The system's consistent performance, even with variable manure inflow rates, underscores its reliability and critical role in improving overall farm efficiency and sustainability.

FIGURE 2. FLOW RATE THROUGHOUT THE MANURE SYSTEM DURING THE SAMPLING PERIOD. SWECO SOLIDS OUTFLOW RATE WAS NOT MEASURED ON APRIL 7, 2023.



Increased Operational Efficiency and Resource Utilization: SWECO vibratory screens significantly enhance operational efficiency and cost-effectiveness on the farm by improving manure handling, reducing maintenance and cleanouts, and increasing resource utilization. By efficiently separating solids from liquids, the system minimizes the volume of manure that needs to be stored, making manure management easier and more efficient. This reduction in storage requirements decreases the risk of overflow during heavy rainfall and minimizes transportation costs. Additionally, the system's low-maintenance design reduces downtime and operational disruptions, saving both labor and resources. During the study at Kilby Dairy, the system ran continuously and did not require any downtime or shutdowns. The nutrient-rich solids recovered through the process can be repurposed as slow-release fertilizers, reducing the need for synthetic inputs and creating potential new revenue streams. Moreover, the SWECO system's scalability and adaptability make it suitable for farms of all sizes, offering flexibility in its application and integration with other technologies to further optimize farm operations.

Evaluation Key Challenges and Issues

Operational Challenges and System Maintenance: The SWECO system and screw press, while effective at nutrient separation and enhancing manure management, present certain operational challenges. Routine maintenance and cleaning are necessary to ensure optimal performance, particularly with regard to the wear and tear on the vibratory screens and screw press. Periodic inspections and potential adjustments are required to keep the system running efficiently, especially when dealing with the physical characteristics of the manure and potential abrasive bedding material like sand. Managing these operational tasks is vital to maintaining long-term performance, particularly in a large-scale farm operation.

Variability in Manure Inflow and System Adaptability: While the SWECO system demonstrated efficient performance in handling manure inflow at an average rate of 2.41 ± 0.52 L/s, the study noted variability in manure inflow rates over the sampling period. This variability did not disrupt system function but required the system to adapt to different

manure volumes. While the SWECO screens and screw press effectively handled the fluctuations, continuous monitoring is necessary to ensure optimal nutrient separation and avoid potential inconsistencies that could arise during extreme variations in manure inflow.

Economic Feasibility and Return on Investment: While the SWECO system provides substantial environmental and operational benefits, the financial feasibility of implementing and maintaining such systems remains a critical consideration. The initial investment and ongoing operational costs for the SWECO system and screw press require careful financial planning, especially for smaller or resource-limited operations. Understanding the long-term economic benefits, such as enhanced biogas production, reduced nutrient runoff, and improved nutrient recovery, is essential to justifying the upfront costs and ensuring a positive return on investment. These economic factors must be weighed against the system's operational challenges to determine its overall viability for broader adoption in dairy operations.

IMPLICATIONS

Key findings from the Kilby Dairy study indicate that the SWECO vibratory screens effectively reduce solids accumulation in the digester, improving its operational efficiency and increasing biogas production. By preventing solids from forming a crust in the digester, the system maximizes methane production and helps maintain consistent digester function. Additionally, the separated solids are higher in nutrient concentrations, which reduces environmental impact and provides value as a slow-release fertilizer for agricultural applications. The system also enables efficient liquid effluent reuse for irrigation, reducing water and energy costs for the farm. Overall, the SWECO system presents significant potential for cost savings, environmental benefits, and improved farm sustainability for both solid and liquid fractions. Further evaluation is needed to fully assess the long-term economic viability of the system and its broader impact on farm operations.

For additional information on the vendor, environmental impacts, financial implications, and SWECO vibratory screen technology, visit the SWECO Vendor Snapshot on the **Newtrient website**.

REFERENCES

SWECO (2024). **https://sweco.com/addinfo/Round-Separator.pdf**

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

This study was funded by the Natural Resources Conservation Service (NRCS) through a Conservation Innovation Grant (CIG). The views and findings presented in this publication are those of the author(s) and do not necessarily reflect the official views or policies of NRCS or the U.S. Department of Agriculture.

Newtrient, LLC
10255 W. Higgins Road
Suite 900
Rosemont, IL 60018
847-627-3855
info@newtrient.com

www.newtrient.com