NEWTRIENT™

APPLICATION FOR COMPONENT ADDITION TO NRCS

NRCS Practice Standard 632

For Acceptance of Polymer-Enhanced Solid Separation

STUDY PREPARED BY:

Mark Stoermann
Newtrient Technology Advancement Team

July 2025

APPLICATION FOR COMPONENT ADDITION TO NRCS Practice Standard 632:

Polymer-Enhanced Solid Separation Technology

REQUEST

As dairy farms face increasing environmental, regulatory, and legal pressures related to nutrient management, interest in advanced manure treatment technologies continues to grow. Yet, the decision-making process for producers is often complicated by a lack of independent, standardized evaluations—leaving many to rely primarily on information from technology vendors. In response to this challenge, Washington State University, in collaboration with Newtrient, has developed a science-based evaluation framework. Initially designed to align with the USDA NRCS Conservation Practice Standard (CPS) Waste Treatment (629), this framework has since been adapted to evaluate technologies under the Waste Separation Facility Practice Standard (632).

Polymer-enhanced solid separation systems represent an innovative approach to manure treatment. These systems aim to improve nutrient recovery by separating organic solids and the nutrients associated with the fine solids more effectively, producing concentrated solids and low solids “tea water” that can be used for irrigation purposes. The potential benefits include reduced land application volumes, improved transport and handling of nutrients, and greater flexibility in nutrient management planning, particularly in areas with limited land access or high phosphorus soils.

To better understand these benefits and potential trade-offs, Newtrient conducted an evaluation of a polymer-enhanced separation system called the “First Wave” system sold by Livestock Water Recovery (LWR) operating on a commercial dairy in northeastern Wisconsin. This dairy also had the LWR reverse osmosis (RO) portion of the system, but this was not operational during the evaluation period and was not included in the field-based performance assessment. The evaluation focused on the solid separation stages of the system, nutrient partitioning, and related management implications under actual on-farm conditions.

Newtrient submits this report for consideration under NRCS Conservation Practice Standard 632, presenting evidence that this technology—based on the operational components evaluated—aligns with NRCS objectives by improving manure handling methods and improving or protecting both air and water quality, and providing producers with a more sustainable and manageable manure solution. We recommend the continued evaluation of this technology, including full RO system performance, under a broader set of operating conditions to support future adoption across diverse farm types and regions.

BRIEF DESCRIPTION OF COMPONENT CLASS

A polymer-enhanced solid separation system is a mechanical and chemical treatment process designed to separate manure into nutrient-rich solids and liquids. It follows and enhances traditional mechanical separation by introducing flocculants (polymers) to bind fine suspended particles, improving nutrient capture and reducing the solids content of the liquid effluent.

DETAILED DESCRIPTION

This class of manure treatment technology uses a multi-stage process to enhance nutrient recovery and reduce environmental risks. The system begins with mechanical separation, typically a slope screen and roller press or screw press, to remove coarse solids and fibrous material, reducing the bulk of raw manure and recovering solids suitable for bedding, composting, or direct field application.

In the next stage, polymers are added to the remaining liquid to flocculate fine suspended particles, including organic matter and nutrients such as phosphorus that are attached to these particles. This treated waste stream flows down a sloped screen allowing for some dewatering. The remaining treated material passes through a screw press, moving disc press, or similar device to dewater the solids. The resulting separated solids are a dense dough-like consistency, and enriched in phosphorus (P), organic nitrogen (N), and organic carbon (OC), allowing for easier transport and targeted land application.

Figure 1: The LWR “First Wave” system.

THE PROCESS

Polymer-enhanced solid separation is a manure treatment approach that reduces solids loading, recovers nutrients, and produces low solids irrigation water. These systems typically operate in two main phases.

The first phase focuses on coarse solids removal and capture. For instance, in the LWR system studied, this involved a slope screen and roller press. The second phase at this operation was the “First Wave” system which included a polymer make down system, polymer dosing tank with agitation, stainless steel slope screen and screw press for dewatering—with polymer addition to increase the capture of fine solids and nutrients. This stage yields two end products: (1) nutrient-rich solids that can be land-applied or exported, and (2) a clarified liquid containing soluble nutrients such as ammonium (NH_4^+) and potassium (K^+) often referred to as “tea water”.

HOW PROPOSED SYSTEM ACCOMPLISHES PURPOSES OF THE STANDARD

The proposed polymer-enhanced solid separation system aligns with the purposes of NRCS Conservation Practice Standard 632 by improving manure handling methods, improving nutrient use efficiency, enhancing the timing and placement of nutrients, and minimizing the potential for environmental loss, particularly through runoff and leaching.

Through the use of slope screens, roller and screw presses, and polymer-assisted flocculation, the system effectively separates manure into nutrient-rich solids and clarified liquids. This separation reduces the nutrient load in the liquid effluent used for land application and enables more precise nutrient management by concentrating P and organic N in the solid fraction, and NH_4^+ and K^+ in the liquid fraction. These nutrient forms can then be applied at agronomically appropriate rates, based on crop need and field conditions, improving alignment with the 4R nutrient stewardship principles (Right Source, Right Rate, Right Time, and Right Place).

When operated with RO, the system further segregates nutrients and recovers clean water for reuse. While RO performance was not evaluated in this study due to non-operability at the study location, it is a critical component of the broader technology class. The ability to recycle water reduces freshwater withdrawals and treatments, increasing on-farm water use efficiency and resource circularity.

Newtrient (https://www.newtrient.com/), a company sponsored by the dairy industry and committed to enhancing value and sustainability in manure management, has conducted a thorough assessment of technology systems and practices within the field, focusing on their impact on critical environmental metrics, specifically water quality. The information in this report is based on a University of Wisconsin-Madison evaluation of this technology on a farm located in northeastern Wisconsin.

In support of this discussion, Appendix A offers brief insights on the significant impact of polymer-enhanced solid separation on key environmental indicators related to water quality, air quality, and other relevant factors aligned with the objectives of NRCS Standard 632. Also, Appendix B presents data from an evaluation of a polymer-enhanced solid separation system, offering nutrient partitioning profiles that demonstrates how the technology concentrates P and organic N into the solid fraction while capturing NH_4^+ and K^+ in the liquid. The evaluation focuses on operational performance and nutrient separation efficiency under commercial conditions, providing insight into how this system supports improved nutrient management planning. Additionally, Appendix C contains the final report of the study conducted by the University of Wisconsin-Madison, providing further insights into the effectiveness and benefits of polymer-enhanced solid separation technology.

Reducing nutrient content, organic strength

The polymer-enhanced solid separation system effectively reduces the nutrient content and organic strength of the liquid fraction by capturing a significant portion of P and organic N in the separated solids. Data from the evaluation showed that the slope screens and screw press, aided by polymer addition, removed 70–90% of total solids (TS) and 60–80% of P from the manure stream. This removal substantially lowers the organic load and nutrient concentration in the remaining liquid, reducing its biochemical oxygen demand (BOD) and chemical oxygen demand (COD). Consequently, the treated liquid has a lower potential to contribute to nutrient runoff, leaching, or lagoon or holding pond overloading, supporting improved environmental outcomes and facilitating more efficient downstream treatment or land application.

Reducing odor and gaseous emissions

The polymer-enhanced solid separation system contributes to reducing odor and gaseous emissions by removing a large portion of volatile solids (VS) and organic matter that are primary sources of odor generation and methane (CH_4) production. By extracting 70–90% of TS and concentrating nutrients into manageable solid and liquid fractions, the system lowers the BOD in the remaining liquid, which helps minimize the production of CH_4 as well as other odorous gases such as hydrogen sulfide (H_2S) and volatile organic compounds (VOC's). Additionally, by producing a thickened manure feedstock suitable for anaerobic digestion, the technology supports further reductions in greenhouse gas (GHG) emissions through controlled biogas capture if used with this technology. Fewer field applications of concentrated nutrients also reduce nitrous oxide (N_2O) emissions typically associated with the application of manure.

Facilitating desirable waste handling and storage

The polymer-enhanced solid separation system improves waste handling and storage by significantly reducing the volume and solids content of manure requiring liquid storage and land application. By removing 70–90% of TS and concentrating nutrients into drier, more manageable solids and nutrient-rich liquids, the system decreases storage space demands and extends the operational life of lagoons and other liquid waste storage systems. This reduction in bulk also lessens the frequency and cost of storage cleanouts and agitation, minimizing labor and equipment wear. The solid fractions are more stable and easier to transport, particularly to distant fields, allowing for economical export to nutrient-deficient fields or sale as fertilizer, thereby enhancing nutrient management flexibility.

Producing value added byproducts that facilitate manure and waste utilization

The polymer-enhanced solid separation system generates value-added byproducts that enhance manure utilization and provide economic opportunities for farms. The separated solids are nutrient-dense, particularly rich in P, N, and organic matter, making them effective as soil amendments to improve soil health and crop yields. These solids can be transported economically to distant fields with P deficits or sold off farm as organic fertilizer products, creating an additional revenue stream for the farm. The nutrient-concentrated liquid fraction, enriched in NH_4^+ and K^+, can be precisely applied to meet crop nutrient demands, reducing reliance on synthetic fertilizers. Furthermore, when integrated with anaerobic digestion, the thickened solids serve as optimal feedstock for renewable natural gas production, contributing to renewable energy goals. These byproducts support circular nutrient management, reduce waste, and improve overall farm sustainability.

RANGE OF VOLUMETRIC AND MASS FLOW CAPACITIES AS WELL AS HYDRAULIC RETENTION TIME

The following section provides an overview of key parameters related to the performance of the polymer-enhanced solid separation system in manure management at the study site:

- *Volumetric Flow*: The manure processing system received a diluted manure stream of approximately 230,000 gallons per day. This translates to an average volumetric flow rate of about 160 gallons per minute, representing the continuous flow of manure and added liquids moving through the solid separation and treatment processes. This volume includes raw manure combined with parlor wash water, recycled effluent, and fresh water. The volumetric flow through the system represents the daily throughput from initial sand separation (excluded from this study) to the combined slope screen, roller press, and the LWR polymer-enhanced solid separation stages.

- *Mass Flow*: Using an estimated manure density of 8.4 pounds per gallon, the system handles roughly 1,932,000 pounds of manure solids and liquids per day. This equates to a mass flow of approximately 1,342 pounds per minute, reflecting the total weight of material processed through the manure treatment system daily.

- *Hydraulic Retention Times (HRT):* The hydraulic retention time in the manure processing system is estimated based on the volume of manure held within the treatment components and the volumetric flow rate. Assuming an estimated combined treatment volume of about 5,000 gallons within the slope screens, roller presses, polymer mixing tanks, and screw presses, and a flow rate of roughly 160 gallons per minute, the HRT is approximately 30 minutes. This residence time allows for adequate mechanical and chemical treatment to separate solids and clarify the liquid fraction before discharge to the waste storage facility.

DESIRED FEEDSTOCK CHARACTERISTICS

To ensure optimal performance of polymer-enhanced solid separation systems, the feedstock manure, after coarse solids separation, should meet certain characteristics. Proper feedstock quality supports effective nutrient recovery, efficient solids-liquid separation, and reliable downstream processing. Key desired characteristics include:

1. **Consistent and Balanced Manure Composition:** The feedstock should have stable physical characteristics (such as total solids and organic content) along with a nutrient profile (N, P, K) that aligns with crop requirements and nutrient management goals. This consistency ensures reliable system performance and produces byproducts that are valuable and compatible with farm application plans.

2. **Adequate Moisture Content:** Manure should contain a balance with enough moisture to allow for proper mixing with polymers during flocculation. Too dry of a feedstock may hinder polymer binding, while overly diluted manure can reduce solids capture.

3. **Minimal Large Debris or Non-Organic Contaminants:** Feedstock should be free of large foreign objects (e.g., rocks, plastic, wood) that can clog screens, damage presses, or interfere with mechanical equipment operation.

4. **Moderate Solids Concentration:** An optimal solids concentration balances separation efficiency and equipment loading. Excessively high solids can overload the system, while excessively dilute manure decreases nutrient recovery and increases processing costs. Generally, the amount of polymer required increases with increased solids content in the liquid waste stream.

5. **Stable pH Range:** The feedstock pH should be within a range that supports effective polymer activity and minimizes the need for chemical adjustment, typically near neutral to slightly alkaline.

6. **Temperature Within Operational Range:** Feedstock temperature affects polymer performance and separation efficiency. Maintaining manure temperatures within the recommended operational limits improves treatment consistency and solids recovery.

EXPECTED SYSTEM PERFORMANCE

Polymer-enhanced solid separation systems are designed to improve manure management by concentrating nutrients and recovering irrigation water from livestock effluent. These systems combine mechanical separation, chemical flocculation, and dewatering to segregate solids, concentrate nutrients, and clarify liquid fractions. System performance can be evaluated based on solids removal efficiency, nutrient partitioning into concentrated solid and liquid products, and reductions in the volume and nutrient load of effluent requiring land application.

- *Changes in form or handling characteristics*

    - Manure processing systems that incorporate mechanical, chemical, and membrane-based separation technologies, such as slope screens, screw presses, polymer addition, and dewatering, fundamentally alter the form, volume, and handling characteristics of manure. These systems convert raw slurry into stackable solids, and nutrient-rich liquids. This transformation simplifies transport and handling logistics, reduces storage demands, and increases the flexibility of land application by segregating nutrients into targeted, manageable forms.

      In the Wisconsin study, the polymer-enhanced solid separation stages were evaluated. The system showed strong performance in altering material form. Raw manure entering the system averaged ~4% TS. After initial treatment with the slope screen and roller press, separated solids averaged 18% TS. Further downstream, the LWR slope screen with polymer addition and screw press produced solids averaging 22% TS, with peak values as high as 28.5%. The resulting liquids had substantially reduced solids content, making them more suitable for pumping, irrigation, or additional treatment like RO.

- *Nutrient fate or end use projections*

    - Polymer-enhanced separation systems, offer enhanced nutrient control by physically partitioning and concentrating nutrients into distinct fractions. Solids, enriched in P and organic N, can be exported or strategically applied to fields with nutrient deficits. The liquid fraction retains most of the NH_4^+ and K is a liquid fertilizer suitable for on-farm irrigation. This layered separation improves nutrient targeting, reduces environmental risk, and enables farms to optimize nutrient distribution across the landscape.

In the Wisconsin study the polymer-enhanced separation system effectively partitioned nutrients: final solids contained an average of 0.171% P, while post-treatment liquid had only 0.013% P. NH_4^+ and K remained largely in the liquid, with NH_4^+ averaging 0.09% in both influent and effluent streams. These results demonstrate the system's value in reducing P loading to saturated fields while maintaining NH_4^+ and K in a form suitable for targeted reuse.

- *Macro-nutrient reductions or transformations*
    - Polymer-enhanced separation systems do not biologically or chemically transform macro-nutrients but instead, physically separate and concentrate them for better management. The primary separation step isolates solids containing P and organic N, while NH_4^+ and K remain in the liquid. This treatment enhances nutrient handling efficiency and reduces the risk of nutrient loss to the environment.

      In the Wisconsin study, the polymer-enhanced solid separation did not significantly alter the chemical form or total mass of macro-nutrients. Total NH_4^+ and total N concentrations remained largely unchanged from influent to effluent, while P was substantially reduced in the liquid fraction. This confirms that the system functions as a nutrient partitioning tool rather than a transformation technology.

- *Pathogen reductions or eliminations*
    - Polymer-enhanced separation systems are designed not only to partition nutrients and reduce solids but also to improve effluent quality, including reductions in pathogen load. The solid separation stages remove pathogens associated with particulate matter but are not capable of filtering out bacteria, viruses, and other microorganisms. Direct pathogen removal data is unavailable from this study, and any reductions in pathogen load from this study would be limited to incidental removal via solids separation. While there is some level of pathogen reduction, particularly for organisms bound to solids, the full system's capacity for comprehensive pathogen elimination was not demonstrated in this dataset.

- *Air quality*
    - Polymer-enhanced solid separation systems can reduce air emissions associated with manure storage and land application by removing volatile solids and reducing the organic loading in liquid effluent. By separating and consolidating solids early in the treatment process, these systems help minimize biological activity in stored manure, which is a primary source of gaseous emissions such as CH_4, N_2O, and ammonia (NH_3).

      The drier, stabilized solids generated through polymer-assisted screw pressing are less prone to anaerobic decomposition, thereby reducing odor and GHG emissions during storage and transport. Similarly, the clarified liquids contain significantly lower levels of degradable organic matter, which can reduce NH_3 volatilization when applied through irrigation or surface spreading.

      Although the Wisconsin study did not directly measure air emissions, it documented substantial reductions in total solids and organic load in the separated liquid, which correlates with reduced emissions potential. The polymer-enhanced system produced solids with up to 28.5% TS, while post-treatment liquids had much lower solids concentrations. These characteristics suggest that the system may help lower emission risks, particularly when paired with strategic manure storage and application practices.

- *Water quality*
    - Polymer-enhanced separation systems are designed to reduce the potential for water quality issues by lowering nutrient concentrations and organic strength in liquid effluent. These systems concentrate P and organic material in the solid fraction, while the clarified liquid contains lower levels of total suspended solids, pathogens, and water-soluble pollutants. This decreases the risk of nutrient runoff and leaching of nitrate (NO_3^-) into surface and groundwater when effluents are land applied.

      In the Wisconsin study, the data from the polymer-enhanced separation stages showed strong nutrient partitioning, reducing P from 0.171% in solids to just 0.013% in post-treatment liquid, and substantially lowering total solids in the liquid fraction. While not a direct water quality measurement, these results suggest a meaningful reduction in pollutants that contribute to nutrient loading in nearby water bodies.

PROCESS MONITORING AND CONTROL SYSTEM REQUIRMENTS

To ensure reliable performance and environmental compliance, polymer-enhanced separation systems require robust monitoring and control strategies. These systems involve multiple stages of mechanical, chemical, and dewatering treatment, each of which must operate within specific parameters to achieve desired outcomes in nutrient separation, solids management, and water recovery. Effective monitoring helps optimize performance, prevent system failures, and maintain consistency in effluent quality.

Required monitoring—To operate the system effectively and maintain compliance with nutrient management plans and other environmental regulations, the following parameters should be routinely monitored:

- **Water, Nutrient, and Manure Flow**: Ensure consistent and accurate application through real-time flow and pressure readings from up to four sensors.

- **Flow Rates:** Monitor system inlet, individual component (e.g., slope screen, screw press), and final effluent flows to evaluate throughput and detect irregularities.

- **Total Solids and Nutrient Concentrations:** Regularly measure TS and concentrations of P, NH_4^+, and K in both liquid and solid fractions to track separation efficiency and nutrient fate.

- **Polymer Dosing Rates and Mixing Efficiency:** Ensure proper polymer feed rates and thorough mixing for effective flocculation and optimal separation performance.

- **System pH and Temperature:** Monitor pH and temperature, as these factors affect chemical reactions, polymer activity, and RO membrane operation.

- **Holding Tank Levels and Pump Function:** Maintain proper tank levels and pump operations to prevent overflows, dry runs, and ensure smooth material transfers.

    - **Alarm Systems and Fail-Safes:** Implement alarms for membrane breaches, chemical feed failures, and other critical faults to allow timely corrective action.

- *Required control*—During system function, the operator must actively control the following:
    - **Polymer Dosage:** Adjust polymer feed rates based on manure characteristics and flow rates to maintain optimal flocculation and separation efficiency.
    - **Flow Distribution:** Regulate flow to each treatment stage to prevent overloading, ensure adequate retention time, and maintain system balance.
    - **pH and Chemical Additives:** Control pH and dosing of any additional chemicals to optimize polymer performance.
    - **Solids Handling and Removal:** Schedule solids discharge to avoid buildup and ensure consistent solids quality for transport or land application.
    - **Pump Operations:** Coordinate pump start/stop sequences and speeds to maintain stable flows and prevent system damage.
    - **Alarm Responses:** Promptly respond to alarms and system alerts to address faults, prevent downtime, and maintain environmental compliance.

- *Equipment included for monitoring*—The system includes the following tools for monitoring performance:
    - **Flow Meters:** To measure influent and effluent flow rates, ensuring proper system loading and throughput.
    - **Turbidity or Solids Sensors:** To monitor solids concentration in liquid streams and detect deviations in separation efficiency.

- **Polymer Feed Meters:** To track polymer dosing rates in real-time.
- **pH and Conductivity Sensors:** To monitor water chemistry for optimal polymer performance and membrane operation.
- **Temperature Sensors:** To track system temperatures that may impact chemical reactions and membrane efficiency.
- **Alarm System:** Alerts operators to abnormal conditions such as flow disruptions, pump failures, or exceeded parameter thresholds.

- *Equipment included for controlling*—The system includes the following tools for controlling operations:
    - **Automated Polymer Dosing Controls:** Adjust polymer feed rates based on real-time flow and solids concentration data.
    - **Pump Variable Frequency Drives (VFDs):** Allow precise control of pump speeds to optimize flow and pressure conditions.
    - **Valve Actuators:** Enable automated regulation of flow paths between separation units and storage tanks.
    - **Programmable Logic Controller (PLC):** Central control unit that integrates sensor data and executes control commands to maintain optimal system performance.
    - **Remote Monitoring Interface:** Allows operators to adjust settings and respond to alarms from off-site locations.
    - **Emergency Shutdown System:** Automatically stops equipment in unsafe conditions to prevent damage or spills.

TYPICAL OPERATIONS/MAINTENANCE PLAN WITH MONITORING REQUIREMENTS AND REPLACEMENT SCHEDULE

Polymer-enhanced separation systems for advanced nutrient recovery and water purification, are designed to optimize nutrient management by physically separating manure components and refining liquid streams. To maximize system performance and longevity, consistent and proper operation, thorough monitoring, and adherence to routine maintenance and replacement schedules are essential. Preventative maintenance ensures reliable operation, extends equipment life, and minimizes costly downtime during critical periods.

System Monitoring

Regular monitoring is essential for reliable system operation and functionality. Key areas to monitor include:

- **Polymer Dosing Rates:** To ensure optimal polymer use and effective nutrient separation.
- **Solids Concentration and Total Solids Levels:** In both solid and liquid fractions to verify separation performance.
- **Flow Rates:** Throughout the system, including pre- and post-RO streams, to detect blockages, leaks, or inefficiencies.
- **Pump and Equipment Operational Status:** Including pressures, speeds, motor health indicators.
- **Water Quality Parameters:** Such as nutrient concentrations (P, NH_4^+, K) and salinity levels in effluent streams.
- **System Alarms and Alerts:** For abnormal operating conditions requiring immediate attention.

Replacement Schedule

To maintain optimal performance, follow this replacement schedule:

- **Polymer Injection Pumps and Dosing Lines:** Inspect quarterly; replace pumps or tubing every 1 to 2 years or as needed based on wear and performance.
- **Pressure Sensors and Flow Meters:** Calibrate biannually; replace sensors every 3 to 5 years or upon failure.
- **pH and Conductivity Probes:** Calibrate monthly; replace every 1 to 2 years depending on sensor drift and accuracy.

- **Valve Actuators and Control Electronics:** Inspect annually; replace components showing signs of wear or malfunction as needed.
- **Mechanical Separation Screens and Screw Press Components:** Clean regularly; replace wear parts (e.g., screens, rollers) every 1 to 3 years depending on manure abrasiveness.
- **Pumps (Transfer and Circulation):** Inspect quarterly; replace seals and wear parts annually; full pump replacement every 5 years or as performance dictates.
- **Alarm and Safety Systems:** Test quarterly; replace batteries and malfunctioning components immediately.

CHEMICAL INFORMATION

The polymer-enhanced separation system utilizes specific chemicals to facilitate effective solids-liquid separation and optimize nutrient recovery:

- **Polymers:**
    - High-molecular-weight, cationic polymers are dosed to promote flocculation of suspended solids and phosphorus compounds.
    - Polymer types and dosages are selected based on manure characteristics and separation performance targets.
    - Proper polymer mixing and feed control are critical to achieving optimal separation efficiency and minimizing chemical usage.
- **pH Adjusters:**
    - Chemicals such as lime or acid may be added to maintain optimal pH levels that enhance polymer activity.
    - pH control also helps prevent scaling and fouling.
- **Safety and Handling:**
    - All chemicals used in the system require proper storage, handling, and disposal procedures consistent with regulatory requirements and safety standards.
    - Operators should use appropriate personal protective equipment (PPE) when handling chemicals.

ESTIMATED INSTALLATION AND OPERATION COST

Equipment and Installation Capital Costs

As of 2025, the estimated cost, when paid for through lease-to-own payment strategies, the “First Wave” system ranges from approximately $3,567/month for a 100-cow herd size to $14,916/month for a 6,500-cow herd size. These costs vary due to influencing factors such as capacity, project scope, farm size, market conditions, existing infrastructure, and customizable features.

Operation and Maintenance Costs (O&M)

- ***Electrical***— Electrical costs for the polymer-enhanced separation system with reverse osmosis primarily cover the energy consumption of pumps, polymer dosing equipment, and control units. These components require continuous or frequent operation to maintain optimal treatment flows and separation efficiency. The power demand will vary based on system capacity, operational hours, and seasonal usage patterns. Efficient equipment and optimized operation can help minimize electrical expenses, but energy remains a substantial part of ongoing operational costs.

- ***Labor—*** Labor costs involve the time and expertise required for system monitoring, routine adjustments, troubleshooting, cleaning, and maintenance. Skilled operators must regularly review system performance data, respond to alarms and operational disruptions, and ensure that dosing and flow controls are functioning correctly. Labor requirements depend on the system’s complexity and automation level; more automated systems may reduce manual intervention but still require oversight to maintain compliance and prevent downtime. Training and retaining qualified personnel are essential to sustaining reliable system operation.

- ***Maintenance Replacement—*** Maintenance and replacement costs, approximately 3-5% of farm capital annually, include scheduled replacements and repairs of critical system components such as pumps, valves, sensors, and polymer feed equipment. These parts experience wear over time and under continuous use, requiring periodic replacement to sustain system efficiency and prevent failures. The frequency of replacement depends on operating conditions, water quality, and adherence to maintenance schedules. Proactive maintenance helps avoid costly emergency repairs and extends the useful life of system components, contributing to more predictable O&M budgeting.

EXAMPLE WARRANTY

The polymer-enhanced separation system is warranted to be free from defects in materials and workmanship under normal use and service for a period of one (1) year from the date of installation. During the warranty period, the manufacturer agrees to repair or replace, at its discretion, any components found to be defective, provided the system has been operated and maintained according to the manufacturer’s guidelines.

This warranty does not cover damage resulting from improper installation, misuse, neglect, unauthorized modifications, or failure to perform routine maintenance. Consumable items such as polymer supplies, and filters are not covered beyond their expected service life and must be replaced according to the maintenance schedule.

The warranty is limited to repair or replacement of defective parts and does not cover labor costs for removal, reinstallation, or shipping. Extended warranties or service agreements may be available upon request.

RECOMMENDED RECORD-KEEPING FOR POLYMER-ENHANCED SOLID SEPARATION WITH RO TECHNOLOGY

Effective record-keeping is essential for ensuring system performance, demonstrating compliance with environmental regulations, and supporting nutrient management planning. The following records should be maintained for polymer-enhanced separation systems:

- **System Operating Data**: Daily logs of flow rates (influent, intermediate, and effluent), pump run times, pressures, polymer dosing rates, and operating temperatures.
- **Water Quality Data**: Routine sampling and analysis results for key parameters in both liquid and solid fractions, including TS, P, NH_4^+, K, electrical conductivity, and pH.
- **Maintenance and Service Logs**: Documentation of scheduled maintenance (e.g., polymer system servicing, screen/screw press checks), unscheduled repairs, component replacements, and system inspections.
- **Chemical Inventory and Usage**: Records of polymers and any other treatment chemicals used (product type, batch number, quantity applied, and dosing schedules) to support traceability and cost tracking.

- **Solids and Effluent Management**: Volume and nutrient content of separated solids and treated effluent; land application records including timing, location, application rates, and receiving field soil test results.
- **Alarms and Fault Responses**: Incidents of alarms or system faults (e.g., high pressure, flow disruptions, dosing malfunctions), including time, cause, and corrective actions taken.
- **Calibration Records**: Regular calibration of flow meters, sensors (e.g., pH, conductivity), and dosing equipment, with dates and results noted.
- **Compliance and Inspection Reports**: Any relevant agency inspections, permits, and regulatory compliance documentation related to nutrient management, waste separation, effluent discharge, or equipment operation.

ALTERNATIVES FOR THE USE OF BYPRODUCTS

Polymer-enhanced solid separation systems generate distinct byproducts—namely, nutrient-rich separated solids, and clarified liquid effluent. Each byproduct has specific characteristics that support alternative end uses, helping to improve whole-system value circularity and reduce environmental impact.

The separated solids, which in the Wisconsin study reached TS levels between 22% and 28.5%, are rich in P and organic matter. These solids can be land-applied to fields with low P levels to reduce soil nutrient imbalances or exported off-farm to areas with nutrient deficits. Other management options include composting with carbon sources to produce a stable organic fertilizer or drying and pelletizing the material for easier transport, storage, and resale as a value-added product.

The clarified liquid effluent can be used for irrigation, particularly on nutrient-sensitive crops or in areas with limited freshwater availability.

By aligning byproduct handling with agronomic need, nutrient management planning, and regulatory constraints, producers can optimize the use of all material streams produced by the polymer-enhanced separation, increasing both economic return and environmental stewardship.

INDEPENDENT VERIFIABLE DATA DEMONSTRATING RESULTS/CREDENTIALS

Appendix A is a summary of the expert opinion and technical data available for this class of technology and how it relates to key performance indicators within NRCS Standard 632. This information is available through Newtrient.

Appendix B provides a summary of data from a Newtrient-managed third-party review of polymer-enhanced solid separation system at a farm located in northeastern Wisconsin. The data comes from a system performance analysis conducted by the University of Wisconsin-Madison but has not been peer-reviewed.

Appendix C contains the full University of Wisconsin-Madison report detailing the third-party review at a farm located in northeastern Wisconsin.

CONTACT INFORMATION—VENDOR

The list below includes a single company based in Canada.

1. **Livestock Water Recycling (LWR)**
   Address: 7920 56th Street SE, Calgary, Alberta, Canada T2C 4S9
   Phone: 403-203-4972
   Website: https://www.livestockwaterrecycling.com/
   Company Information: Livestock Water Recycling (LWR) is a provider of livestock manure treatment technology for dairy, beef, swine, and anaerobic digester operations with a vision to help livestock producers become more efficient while simultaneously being more environmentally stable. Based in Alberta, Canada, LWR works with farms to reduce greenhouse gas (GHG) emissions and concentrate nutrients from manure waste streams for precise use in fertilizer application and improvements to water conservation and quality.

CONTACT INFORMATION—USER

According to LWR, there have been at least 16 systems installed on dairy farms or other livestock operations in the U.S. in Wisconsin, Indiana, New York, Michigan, Washington, California, and Nebraska.

Commercial facilities presently operating in the U.S. have been designated by LWR as those that Newtrient can discuss this technology with and its performance

Polymer-Enhanced Solid Separation System

Scenic View Dairy – Fennville, MI

Skyridge Farms – Sunnyside, WA

Western Valley Farms – Sunnyside, WA

OTHER CONSIDERATIONS

The NRCS documentation specifies that a third-party review shall contain 15 specific items that comprise the report above, but as part of working with the farm(s) and the technology provider during the evaluation period there are often other important and valuable learnings that may be helpful for NRCS and others as they consider this technology. Below is a list of Other Considerations that should be included in the evaluation of this technology. These points offer valuable insight into both the practical application and future refinement of polymer-enhanced solid separation systems like LWR:

High Operational and Maintenance Requirements: The system's performance is sensitive to daily conditions—such as polymer dosing, screen cleanliness, and equipment wear—requiring frequent maintenance and active oversight. Variability in separation efficiency across sampling events underscores the need for consistent operation. Farms lacking dedicated labor or automation may struggle to maintain system effectiveness.

Limited Recovery of Dissolved Nutrients: While the "First Wave" system effectively captures TS, VS, and TP, it is less effective at separating dissolved nutrients like Total Ammoniacal Nitrogen (TAN) and TK, which remain in the liquid stream post-treatment. This limits nutrient load reduction and requires careful planning for effluent land application or further treatment.

Performance Sensitivity to Manure Characteristics: Influent manure quality, particularly TS content, significantly affects separation outcomes. Too dilute of manure reduces system efficiency, highlighting the need for pre-treatment or upstream water management to optimize performance.

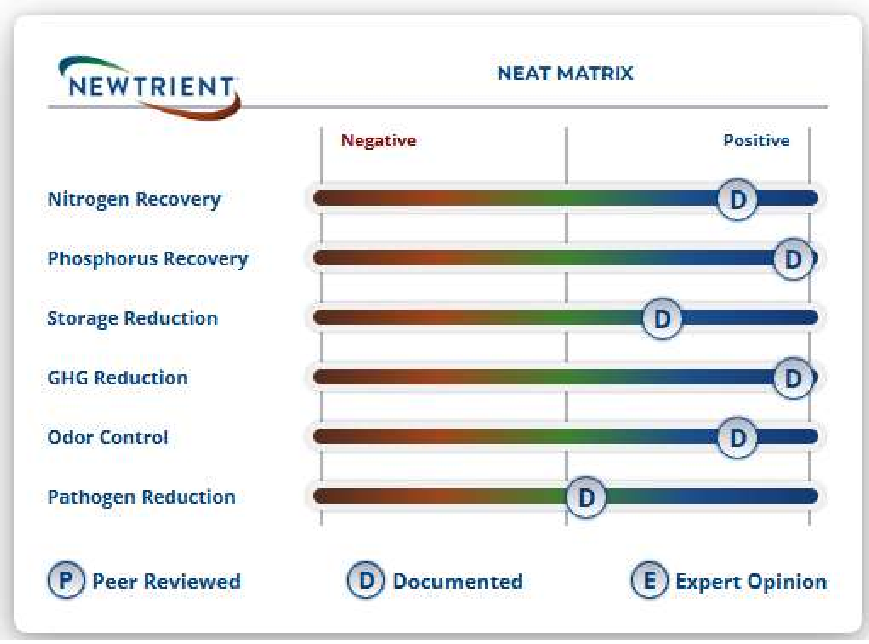
Labor and Management Capacity: These systems demand skilled operators and responsive management to adjust for changing conditions. Without this, performance may decline, affecting nutrient separation and system reliability.

Conclusion

Polymer-enhanced solid separation systems combined represents a scalable and effective strategy for addressing the environmental and logistical challenges associated with manure management. Through physical separation and chemical treatment, these systems offer a high level of nutrient control, reduce overall volume and nutrient concentrations in effluent streams, and create multiple outputs with potential on-farm or off-farm utility. The data presented from the Wisconsin study demonstrates clear improvements in nutrient partitioning, solids handling, and effluent quality, underscoring the viability of this integrated approach. While careful monitoring, control, and maintenance are required to ensure long-term system performance the benefits in terms of regulatory alignment, environmental stewardship, and operational efficiency make this an impactful technology option for nutrient management planning and implementation.

Appendix A

NEWTRIENT CRITICAL ANALYSIS – POLMER-ENHANCED SOLID SEPARATION



Overall Summary

Polymer-enhanced solid separation systems offer an advanced and efficient manure management solution capable of significantly reducing suspended solids from the liquid waste stream. This multi-stage approach begins with mechanical coarse solids separation followed by polymer dosing and dewatering, to remove the fine solids. This results in three distinct output streams: stackable coarse solid that can be used for bedding material or composting, nutrient-rich solids that are high in phosphorus, organic nitrogen and organic carbon, and a stream of “tea water” suitable for crop irrigation. When effectively managed, this system reduces storage demands, enhances nutrient recovery, supports adaptive irrigation practices, and improves water use across the farm.

Appendix B

Third-Party Review of Polymer-Enhanced Solid Separation at Robinway Dairy – Kiel, WI (Report Summary)

University Partner
Brian Langolf
Dr. Rebecca Larson
University of Wisconsin-Madison
Nelson Institute for Environmental Studies
122 Science Hall
550 North Park St.
Madison, WI 53706

JULY 2025

BACKGROUND

Effective management of manure nutrients is critical for maximizing the fertilizer value while minimizing environmental losses. As dairy operations increase in scale and animal density, the resulting manure volumes—particularly with high water content—pose significant logistical and environmental challenges. Traditional storage and land application practices can lead to nutrient losses through runoff and leaching, contributing to water quality degradation and public health concerns.

Manure processing systems have emerged as a potential solution to reduce the environmental footprint of dairy operations by concentrating nutrients and producing effluent closer to discharge quality. Mechanical separation technologies, including those that integrate slope screens, screw presses, and polymer-enhanced processes, aim to extract solids and concentrate nutrients in smaller volumes, reducing handling and application burdens. However, the separation efficiency and final effluent quality of these systems vary widely, and many still produce effluent volumes comparable to the original manure, limiting their economic advantage unless further treatment is implemented.

This study evaluated the Livestock Water Recycling (LWR) system installed at a dairy farm in Northeastern Wisconsin. The goal was to assess the system's ability to concentrate nutrients, improve separation efficiency, and generate products suitable for reuse or discharge, thereby potentially reducing land application costs and environmental risks.

INTRODUCTION

Livestock production systems are facing growing scrutiny from consumers, regulators, and environmental advocates to enhance sustainability, particularly in the area of manure management. While land application of manure can recycle nutrients and organic matter to croplands, it can also result in the loss of manure constituents to the environment—especially when application timing, nutrient loading rates, and weather conditions are not aligned with crop needs.

The challenges of manure management are further compounded by increased manure water content, driven by evolving management practices, animal housing designs, and runoff collection. This creates larger volumes of manure to store, transport, and apply—raising both economic and environmental concerns. Runoff from manure-amended fields can carry nutrients, pathogens, and organic matter into surface waters, while leaching of nitrates into groundwater presents risks to drinking water quality.

Mechanical manure processing systems play a critical role in manure management by separating manure into solid and liquid fractions, which facilitates handling, storage, and targeted nutrient application. These systems are often the first step in broader treatment strategies and can contribute to greenhouse gas (GHG) reductions by removing volatile solids. While traditional mechanical separators are effective at reducing volume and improving manageability, their nutrient removal efficiencies—particularly for dissolved nutrients—can be limited. As a result, additional treatment steps are often needed to enhance nutrient recovery and further reduce environmental impacts.

The LWR system evaluated in this study represents an advanced approach to manure processing. By combining mechanical separation with chemical treatment, the system seeks to improve nutrient recovery. This study assessed the performance of the LWR "First Wave" system on a commercial dairy in Northeastern Wisconsin over a 49-week period, evaluating its ability to remove total solids (TS), volatile solids (VS), Total Kjeldahl Nitrogen (TKN), phosphorus (P), and potassium (K). The study also considered the system's operational demands, maintenance requirements, and the quality of treated outputs with respect to potential discharge or reuse. This dairy also had the LWR reverse osmosis (RO) portion of the system, known as the "PLANT," but this was not operational during the evaluation period and not included in the assessment.

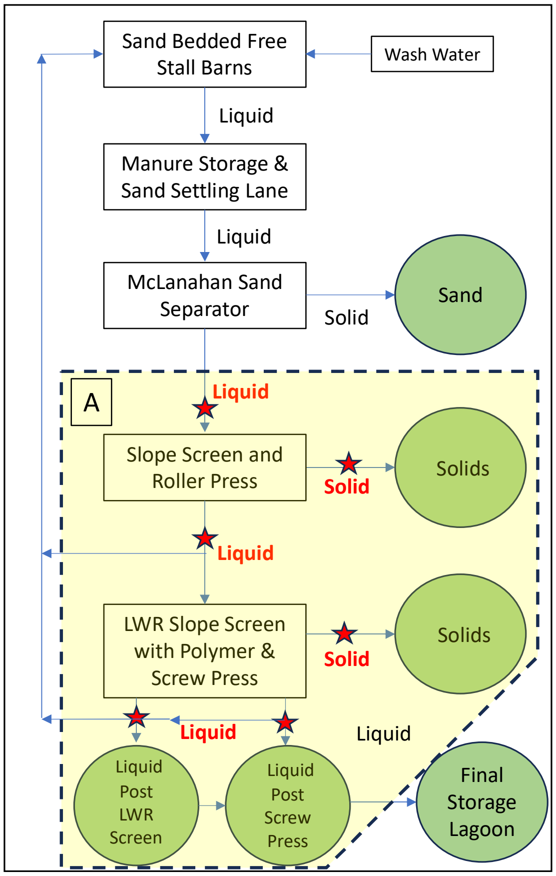


Figure 1: Flow diagram of the manure processing system, area A highlighted in yellow consisted of the manure separation system and designated sample collection area for four liquid streams and two solid streams highlighted in red.

THE PROCESS

The manure processing system (Figure 1) evaluated in this study is located on a dairy farm near Kiel, Wisconsin, which houses approximately 2,000 cows and generates an estimated 80,000 gallons of raw manure daily. As part of the farm's broader manure management infrastructure, an initial sand separation system is used to recover bedding material; however, this component was not included in the scope of this evaluation.

Following sand separation, a significant volume of additional liquid—including parlor wash water, recycled effluent from previous treatment steps, and fresh water—is added to the manure. This results in a substantially diluted manure stream totaling approximately 230,000 gallons per day. This diluted stream is then sent through a multi-stage processing system designed to concentrate nutrients, separate solids, and reduce the volume of material requiring land application.

The initial processing step includes a combined slope screen and roller press, which removes a portion of the solids (Figure 2). The partially clarified liquid then undergoes further treatment using the LWR

“First Wave” system (Figure 3), which incorporates a second slope screen with polymer addition, followed by a screw press for enhanced solid-liquid separation.

The process yields three primary end products that require management:

- **Separated solids** from the slope screen and roller press,
- **Separated solids** from the LWR “First Wave” slope screen with polymer and screw press, and
- **Effluent liquid** from the LWR “First Wave” system.

Both liquid fractions—from the initial and LWR “First Wave” treatment stages—are combined and discharged into the farm’s final holding pond. From there, the effluent is stored until it can be land applied in accordance with the farm’s nutrient management plan.

This evaluation focused on field-collected data from the LWR “First Wave” system’s solid separation stages. According to LWR documentation, the full system includes two main components: the “First Wave” for fines solids separation and the “PLANT” system for further fine solids removal, filtration, and RO to remove dissolved solids. In this study, the evaluated process included the initial slope screen and roller press, followed by the LWR “First Wave” slope screen with polymer addition and screw press. The evaluation focused on nutrient partitioning and separation efficiency through these solids removal stages and did not include direct performance testing or water quality analysis of the “PLANT” system.

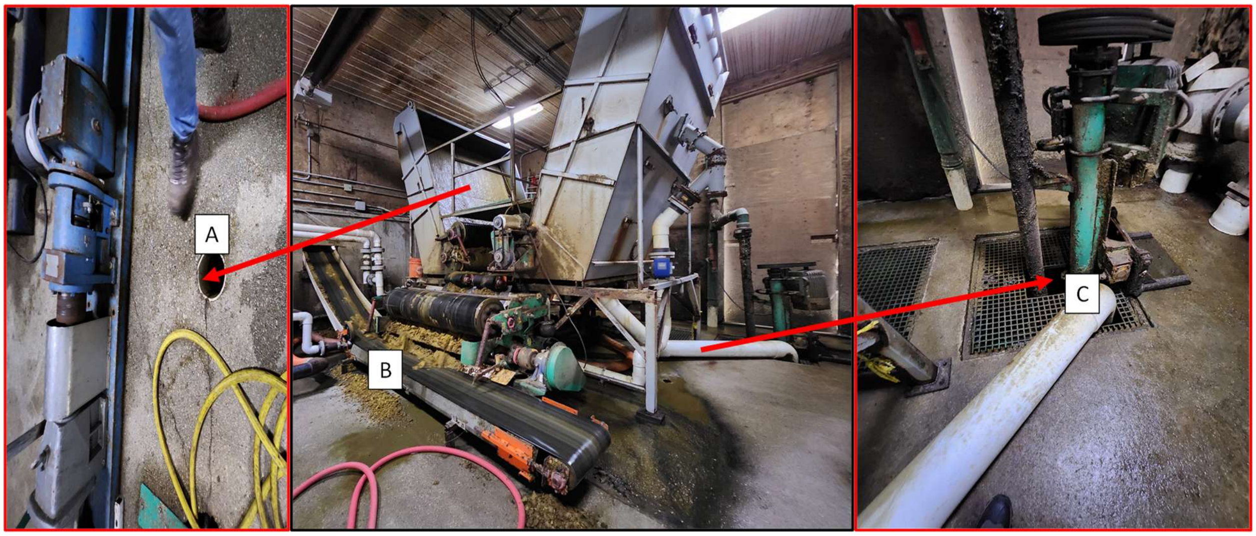


Figure 2. Slope screen and roller press. A) Liquid manure pre slope screen B) Solids post slope screen and roller press C) Liquid manure post slope screen and roller press.

Figure 3. LWR “First Wave” slope screen and screw press. A) Liquid Manure pre LWR “First Wave” slope screen B) Liquid manure post LWR “First Wave” slope screen C) Liquid manure post screw press D) Final solids post LWR screw press.

METHODOLOGY

The manure processing system at the study site was evaluated over a 49-week period, from March 19, 2024, to February 28, 2025. A total of 45 sampling events were conducted during periods when the system was operational, as determined by the farm. The primary objective of the evaluation was to assess the characteristics of various manure products and determine the separation efficiency of individual processing components, including the combined slope screen and roller press, as well as the LWR “First Wave” system (slope screen with polymer addition and screw press).

During each sampling event, seven samples were collected from key points in the system to capture manure characteristics at different stages of processing and to evaluate the composition of the recovered products (Figures 2 and 3). Liquid and slurry samples (0.5 L) were collected while systems were fully operational, and solid samples (1 L) were collected directly from the outlets of the roller press and screw press. All samples were stored at 4°C and shipped to A&L Great Lakes Laboratories for analysis.

Samples were analyzed using the M7 Manure Analysis Package plus pH, which includes a comprehensive suite of parameters: moisture, TS, VS, TKN, Total Ammonium Nitrogen (TAN), P, K, sulfur (S), calcium (Ca), magnesium (Mg), sodium (Na), iron (Fe), aluminum (Al), manganese (Mn), copper (Cu), zinc (Zn), ash, and organic carbon (OC), as well as the carbon-to-nitrogen ratio (C:N).

To evaluate system performance, data from all 45 sampling events were averaged. Non-detect values were treated as zero for analysis purposes. Separation efficiency was assessed using two key metrics:

- **Separation Index (SI)** – to evaluate how well each component concentrated constituents into the solid fraction.
- **Removal Efficiency (RE)** – to measure the purification of the liquid fraction.

These metrics were calculated based on established equations (Eq. 1, 2, & 3) (Aguirre-Villegas et al., 2019; Guilayn et al., 2019) using dry matter (DM) and constituent concentrations in influent and separated streams. Together, these methods provide a comprehensive understanding of the LWR system's nutrient partitioning and overall performance at this specific dairy operation.

$$R_{Solid,Out} = \frac{DM_{Influent} - DM_{Liquid,Out}}{DM_{Solid,Out} - DM_{Liquid,Out}} \quad (1)$$

$$SI_X = R_{Solid,Out} * \frac{[X]_{Solid,Out}}{[X]_{Influent}} \quad (2)$$

$$RE_x = 1 - \frac{[X]_{Liquid,Out}}{[X]_{Influent}} \quad (3)$$

Where $R_{solid,out}$ is the ratio of solid fraction in relation to the input mass, DM is the dry matter, and X is the constituent concentration under evaluation.

DISCUSSION OF RESULTS

The results from the evaluation of the LWR "First Wave" system provide valuable insights into its effectiveness as a manure treatment and nutrient management tool. Data from this study offers a clear understanding of the system's ability to separate solids and concentrate nutrients under real-world operating conditions. In this section, we examine the system's performance in nutrient partitioning, operational reliability, and its potential to improve environmental outcomes compared to traditional manure management practices.

KEY BENEFITS OF POLYMER-ENHANCED SOLID SEPARATION

Improved Solid-Liquid Separation Efficiency

The LWR "First Wave" system demonstrated significantly improved solid-liquid separation efficiency compared to the farm's existing slope screen and roller press setup. Separated solids from the LWR system averaged 21.67% TS, compared to 17.72% TS from the roller press solids, indicating a drier, more manageable product (Table 1). This enhanced separation is further supported by the higher Separation Index (SI) values for TS, VS, and total phosphorus (TP) observed in the LWR system (Figures 4 and 5), highlighting its effectiveness in partitioning key nutrients into the solid fraction. This improvement aids in nutrient recovery and simplifies manure handling and storage.

Table 1. Primary manure characteristics by sampling location (non-detects were given a value of zero).

Sample	Statistics	Solids [%]	Volatile Solids [%]	Total Kjeldahl Nitrogen [%]	Ammonium Nitrogen as NH_4-N [%]	Phosphorus as P_2O_5 [%]	Potassium as K_2O [%]
Manure Liquid Pre Slope Screen	Average	4.06	2.98	0.222	0.11	0.029	0.14
	Max	7.21	5.28	0.276	0.15	0.046	0.18
	Min	2.52	1.91	0.154	0.06	0.018	0.08
	Std. Dev.	0.88	0.65	0.031	0.01	0.005	0.03
Manure Liquid Post Slope Screen & Roller Press	Average	3.97	2.86	0.222	0.11	0.028	0.14
	Max	5.81	4.16	0.267	0.14	0.037	0.19
	Min	2.32	1.70	0.154	0.06	0.018	0.09
	Std. Dev.	0.78	0.58	0.030	0.01	0.004	0.03
Manure Solids Post Slope Screen & Roller Press	Average	17.72	16.12	0.331	0.10	0.033	0.15
	Max	20.17	19.94	0.452	0.23	0.042	0.21
	Min	15.22	13.77	0.217	0.03	0.024	0.09
	Std. Dev.	1.14	1.16	0.047	0.04	0.004	0.03
Manure Liquid Pre LWR Screen	Average	4.24	2.87	0.216	0.10	0.027	0.13
	Max	5.99	3.92	0.263	0.14	0.035	0.18
	Min	2.70	1.87	0.148	0.07	0.019	0.08
	Std. Dev.	0.73	0.57	0.031	0.01	0.004	0.03
Manure Liquid Post LWR Screen & Polymer	Average	1.48	0.95	0.137	0.09	0.008	0.12
	Max	2.63	1.75	0.184	0.12	0.015	0.17
	Min	0.97	0.60	0.083	0.01	0.002	0.06
	Std. Dev.	0.36	0.23	0.029	0.02	0.003	0.03
	Average	2.14	1.44	0.154	0.09	0.013	0.12

Manure Liquid Post LWR Screw Press	Max	3.41	2.42	0.215	0.12	0.026	0.16
	Min	1.02	0.74	0.083	0.07	0.004	0.07
	Std. Dev.	0.64	0.45	0.039	0.01	0.005	0.03
Manure Solids Post LWR Screw Press	Average	21.67	16.13	0.858	0.18	0.171	0.15
	Max	28.49	21.81	1.022	0.32	0.204	0.26
	Min	18.06	13.27	0.684	0.10	0.132	0.10
	Std. Dev.	2.26	1.82	0.088	0.05	0.019	0.03

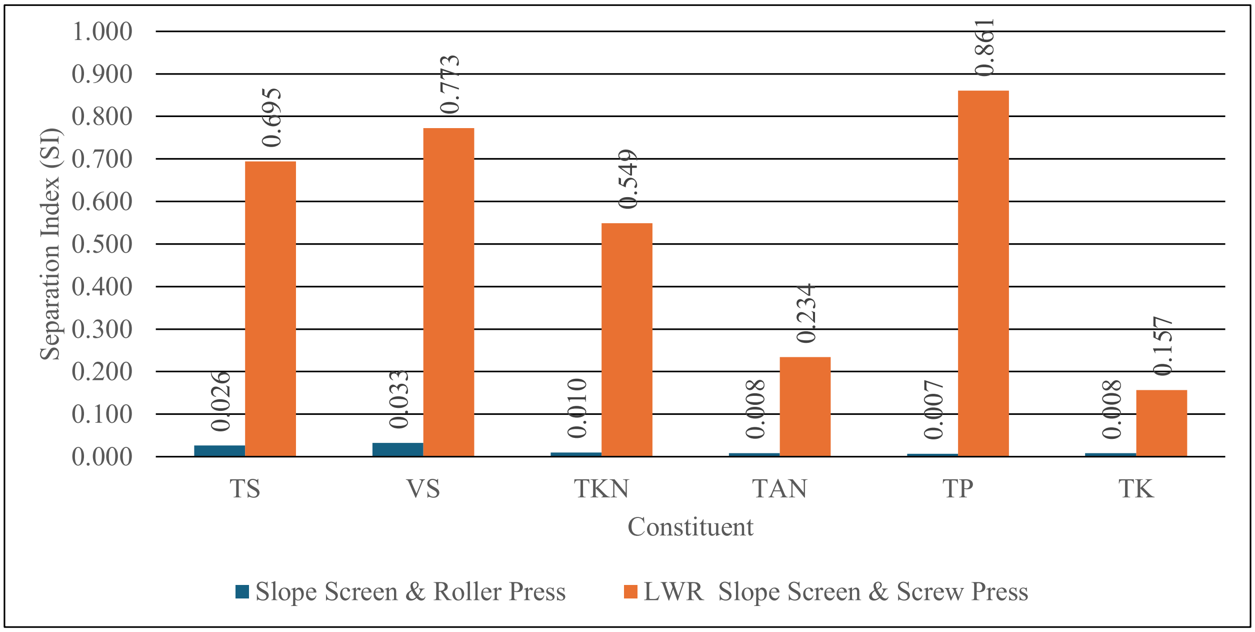


Figure 4. Separation index (SI) for total solids (TS), volatile solids (VS), total Kjeldahl nitrogen (TKN), total ammonium nitrogen (TAN), total phosphorus (TP), and total potassium (TK).

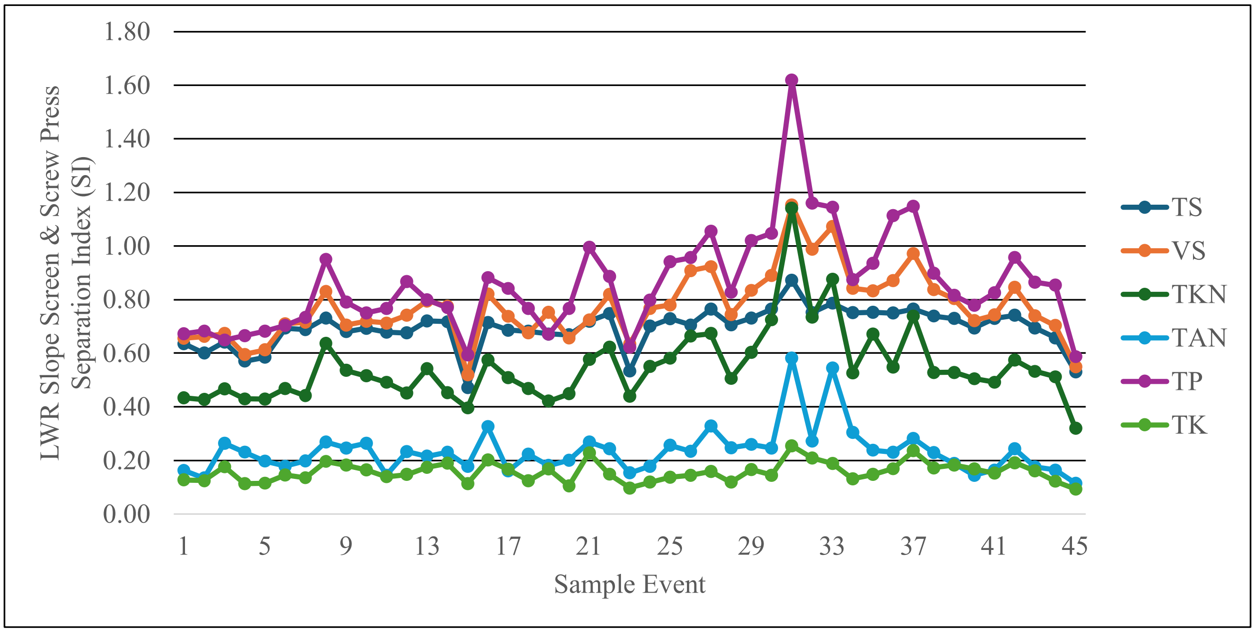


Figure 5. Separation index (SI) over time for total solids (TS, top), volatile solids (VS), total Kjeldahl nitrogen (TKN), total ammonium nitrogen (TAN), total phosphorus (TP), and total potassium (TK, bottom) for the LWR slope screen and screw press.

Enhanced Phosphorus Removal

Phosphorus removal was notably enhanced by the LWR "First Wave" system, with an average P concentration in the separated solids of 0.171%, compared to only 0.033% in solids from the roller press (Table 1). The system also exhibited high RE for P across its components (Figure 6), which is particularly important for farms managing phosphorus-sensitive soils. This enhanced P separation provides the farm with greater flexibility to meet nutrient management goals and reduces the risk of P buildup in fields and excess P runoff, thereby supporting sustainable land application practices and healthy soils. It should be noted that although the screw press provided drier solids, the mechanical action also broke some of the solids' flocculations allowing a portion of the nutrients to re-enter the liquid stream.

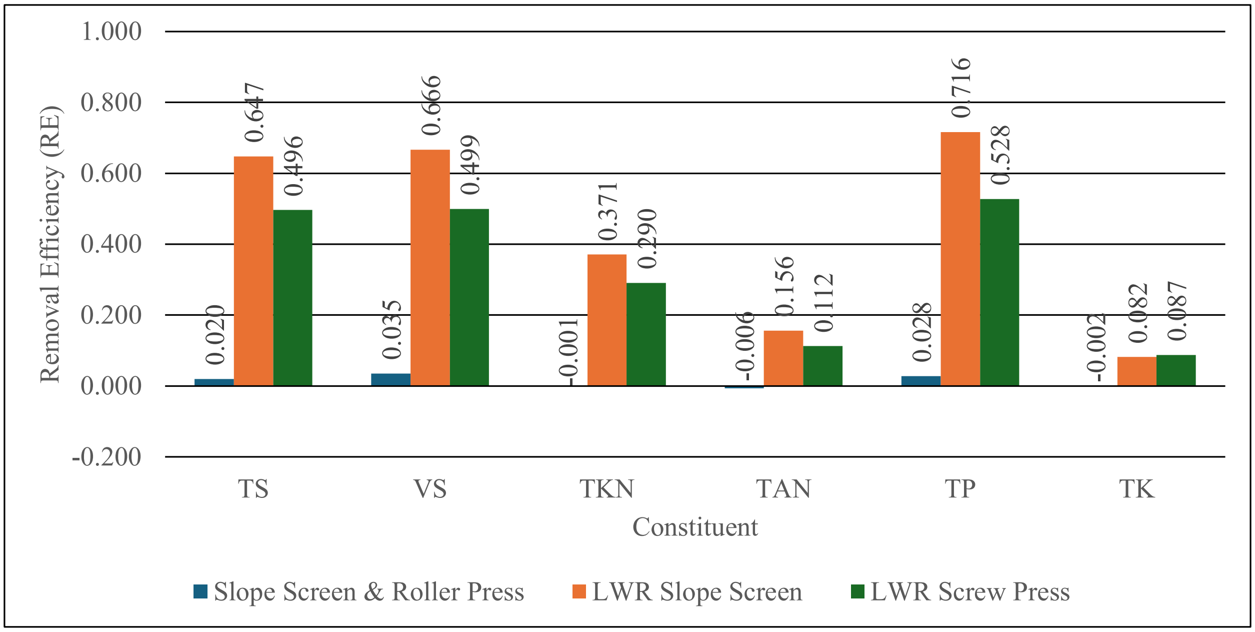


Figure 6. Removal efficiency (RE) for total solids (TS), volatile solids (VS), total Kjeldahl nitrogen (TKN), total ammonium nitrogen (TAN), total phosphorus (TP), and total potassium (TK) for the slope screen & roller press, LWR slope screen, and the LWR screw press.

Supports GHG Mitigation Through Volatile Solids Reduction

While improved separation of total and volatile solids contributes to better manure handling, the reduction in VS specifically plays a key role in lowering methane generation during manure storage. The LWR "First Wave" system achieved higher removal efficiency for VS compared to the slope screen and roller press (Figures 4, 6, and 7), supporting its potential contribution to GHG mitigation efforts. This environmental benefit adds value for farms seeking to lower their environmental footprint or participate in future carbon credit programs.

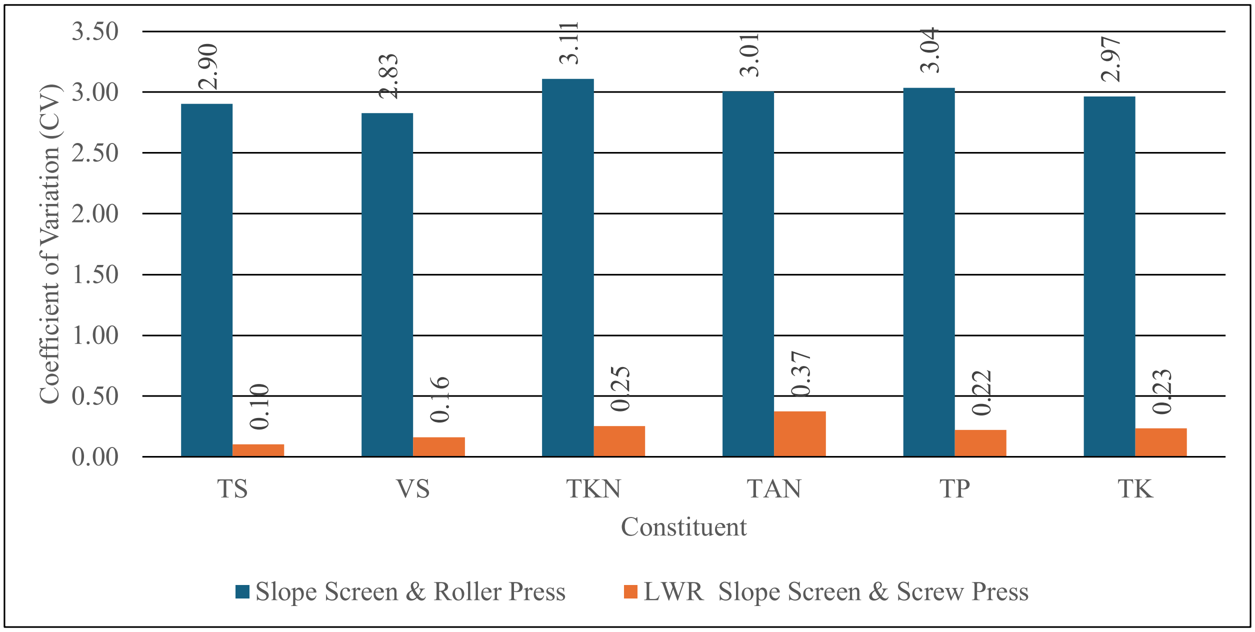


Figure 7. Coefficient of variation (CV) for the separation index for total solids (TS), volatile solids (VS), total Kjeldahl nitrogen (TKN), total ammonium nitrogen (TAN), total phosphorus (TP), and total potassium (TK).

Consistent and Reliable Performance

Finally, the LWR "First Wave" system delivered more consistent and stable separation performance over the 49-week sampling period than the roller press system. The coefficient of variation (CV) for the SI values was lower in the LWR "First Wave" system compared to the roller press system (Figure 7), indicating more reliable nutrient partitioning in daily operations. Such consistency is crucial for farms requiring predictable nutrient outputs to effectively plan storage, application, and meet regulatory environmental compliance.

EVALUATION KEY CHALLENGES AND ISSUES

High Operational and Maintenance Requirements

One of the primary challenges observed with the LWR "First Wave" system was the need for frequent and consistent maintenance to sustain its performance. As indicated by the variability in the SI values across the 45 sampling events (Figures 5 and 8), the system's effectiveness is sensitive to changes in operational conditions, including screen cleanliness, polymer dosing consistency, and equipment wear. Daily attention is required to manage the slope screens and presses, which may present a labor and logistical burden for farms without sufficient personnel or automation systems. Without regular cleaning and adjustments, separation efficiency can decline, leading to greater nutrient carryover into the liquid stream.

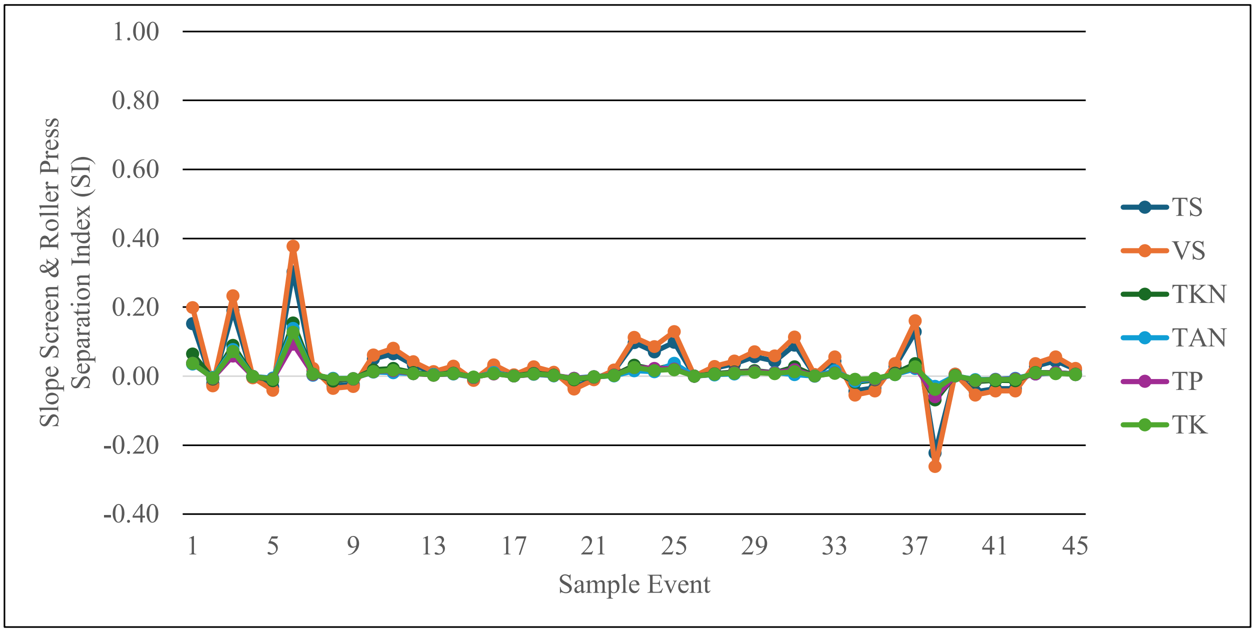


Figure 8. Separation index (SI) over time for total solids (TS, top), volatile solids (VS), total Kjeldahl nitrogen (TKN), total ammonium nitrogen (TAN), total phosphorus (TP), and total potassium (TK, bottom) for the slope screen and roller press.

Limited Recovery of Dissolved Nutrients

While the LWR "First Wave" system demonstrated strong performance in separating TS, VS, and TP—with high SI and RE values shown in Figures 4 and 6—it was significantly less effective at recovering dissolved nutrients, particularly TAN and total potassium (TK). Table 1 illustrates that average TAN and TK concentrations in the liquid fraction post-screw press remained relatively high (0.09% and 0.12%, respectively), underscoring that these nutrients are not effectively partitioned into the solids. As a result, further treatment or careful nutrient management planning is required to handle these nutrients during land application. The system's inability to significantly concentrate TAN and TK in the solid fraction (Figures 4 and 6) may limit its utility for producers seeking to minimize nutrient loads in effluent destined for surface application or storage.

Performance Sensitivity to Manure Characteristics

The effectiveness of both the initial slope screen/roller press and the LWR "First Wave" system is highly dependent on the characteristics of the influent manure. For instance, the dilute nature of the manure stream (~4% TS, Table 1) limits the initial system's ability to efficiently separate constituents, leading to low SI values for the first separation step (Figure 8). This challenge highlights the importance of upstream water management and suggests that systems like the LWR "First Wave" perform best when used in tandem with manure pre-treatment processes that can optimize solids content.

IMPLICATIONS

The findings from this study underscore the potential of the LWR "First Wave" system to improve manure management through more effective separation of solids and enhanced nutrient concentration in the recovered materials. The system demonstrated strong performance in removing TS, VS, TKN, and TP compared to the conventional slope screen and roller press, indicating that the integration of chemical treatment with mechanical separation can yield more consistent and effective results under real-world conditions.

By shifting more TP and TKN into the solid fraction, the LWR system creates a denser, more transportable product that can be managed off-site or used in accordance with the farm's nutrient management plan. This provides a practical strategy for reducing nutrient loading on phosphorus-saturated fields, expanding land application options, and improving the nutrient balance of effluent retained in storage lagoons. Additionally, by reducing VS content, the system may also contribute to lower methane emissions and reduced odor potential from storage.

However, the system was less effective at recovering TAN and TK, which remained in the liquid fraction. This limitation points to the need for complementary strategies to better manage dissolved nutrients—particularly in regions with regulatory or environmental sensitivities. The consistent daily oversight and maintenance required to ensure system performance also present operational considerations and labor limitations for producers evaluating its adoption.

Future research should focus on validating nutrient recovery performance across a broader range of farm conditions and seasons, assessing the long-term agronomic performance of separated solids and liquids when applied to fields, and exploring opportunities for recovering TAN and TK from the liquid stream. Studies that quantify the environmental benefits—such as reductions in GHG emissions or improved water quality—will also help further evaluate the full value proposition of the LWR "First Wave" system. With continued optimization and research, LWR offers a promising tool for modernizing manure management while supporting both environmental and operational goals on dairy farms.

REFERENCES

Aguirre-Villegas, H. A., Larson, R. A., & Sharara, M. A. (2019). Anaerobic digestion, solid-liquid separation, and drying of dairy manure: Measuring constituents and modeling emission. *Science of The Total Environment*, *696*, 134059. https://www.sciencedirect.com/science/article/pii/S0048969719340367

Guilayn, F., Jimenez, J., Rouez, M., Crest, M., & Patureau, D. (2019). Digestate mechanical separation: Efficiency profiles based on anaerobic digestion feedstock and equipment choice. *Bioresource Technology*, *274*, 180-189. https://www.sciencedirect.com/science/article/pii/S0960852418316274

Livestock Water Recycling (2024). The System. https://www.livestockwaterrecycling.com/the-system/plant/

For additional information on the vendor, environmental impacts, financial implications, and polymer-enhanced separation technology, visit the LWR Vendor Snapshot on the Newtrient website.

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.

Appendix C

Third-Party Review of Polymer-Enhanced Solid Separation at Robinway Dairy – Kiel, WI

LWR Nutrient Concentration System Performance Evaluation

Langolf, B.[1] and R.A. Larson[1]

[1]Nelson Institute for Environmental Studies, University of Wisconsin-Madison

Final Report for Newtrient updated on April 25, 2025

Table of Contents

Table of Figures

Table of Tables

Abstract

Manure processing systems have the potential to reduce environmental impacts from livestock operations. This study evaluated a nutrient concentration system on a dairy farm in Northeastern Wisconsin, focusing on separation efficiencies and the quality of the final treated products for discharge. The system processed manure from approximately 2,000 cows, producing separated solids from the roller press and screw press, and liquid effluent from both the slope screen and roller press, and the LWR slope screen and screw press. Over a 49-week period, 45 sampling events were conducted, collecting and analyzing samples for various parameters including total solids (TS), total Kjeldahl nitrogen (TKN), phosphorus (P), potassium (K), among numerous others. The separation index (SI) for the LWR slope screen and screw press system was higher than that for the slope screen and roller press, indicating better performance in removing TS, volatile solids (VS), TKN, and TP. However, both systems showed low removal efficiency (RE) for ammoniacal-nitrogen (TAN) and potassium (K), suggesting the need for additional treatment systems to achieve greater nutrient recovery. The system requires significant maintenance, cleaning, and operational supervision to maximize runtime and performance, which can impact the cost-benefit analysis and broader adoption of these systems.

Introduction

Livestock production systems are under increasing pressure from consumers and regulatory bodies to enhance sustainability. Land application of manure is designed to establish a sustainable cycle by returning nutrients and organic matter to the soil for crop production. Unfortunately, manure systems, particularly storage and land application of manure, can result in losses of manure constituents to the environment resulting in negative impacts. Farm growth, increasing animal densities in specific geographical locations, and an increase in water content of manure has exacerbated challenges in managing manure to minimize environmental impacts (Sharara et al., 2022; Spiegal et al., 2020).

Higher manure water content, driven by changes in farm management practices and increased runoff collection, results in larger volumes to store and transport for field applications. Applying manure to cropping systems also has implications for water quality. Runoff can transport pathogens, sediments, organic matter, and nutrients into surface waters, while leaching can contaminate groundwater with pathogens and nitrates, raising public health concerns. Increased applications of manure nutrients increase the runoff risks, particularly when applications exceed agronomic recommendations.

Manure processing systems can be used to separate manure constituents to improve handling and management. Among these, mechanical manure separation systems are some of the most widely implemented, primarily aimed at nutrient extraction (Aguirre-Villegas & Larson, 2017). These systems offer the potential to enhance the value of separated products while improving manure management to reduce environmental impacts. However, the separation efficiency of existing mechanical systems for manure is often considered low (Aguirre-Villegas et al., 2019; Guilayn et al., 2019), resulting in lower-value products that can reduce the economic and environmental impacts. The effluent remaining after product extraction must still be managed as manure unless it meets standards for discharge. Since the volume of effluent is often comparable to the original manure, handling costs remain similar to traditional land application systems, making the economic success of these systems heavily reliant on the market value of the separated products. Manure treatment systems designed to achieve discharge-quality water can reduce land application costs for producers while mitigating associated environmental risks.

However, these systems require additional processing components to meet water quality standards for safe discharge into surrounding waterways.

To optimize the effectiveness of such systems, it is essential to evaluate their performance, including the separation efficiency of individual components to provide the data for larger economic and environmental impacts when integrated into livestock facilities. This research investigates the performance of a manure processing system designed to treat manure to discharge quality.

Methods

Study site

A dairy farm located just outside of Kiel, Wisconsin, collects manure from approximately 2,000 animal units (approximately 80,000 gallons of manure per day). The manure processing system at this farm includes a sand separation system (not evaluated in this study) that incorporates a large amount of liquid (parlor wash water, recycled water from slope screens and fresh water) added to the manure resulting in a diluted manure stream (approximately 230,000 gallons per day) that is then sent on for further processing. The additional processing includes a combined slope screen and roller press, followed by an additional LWR slope screen with polymer addition combined with a screw press (Figure 1). End products from the system requiring management include slope screen and roller press separated solids, LWR slope screen with polymer and screw press separated solids, and effluent liquid from the LWR slope screen with polymer and screw press. In this system, both liquid streams are discharged into the farms final holding pond for storage and land applied in accordance with the nutrient management plan. The system is owned and operated by the farm directly.

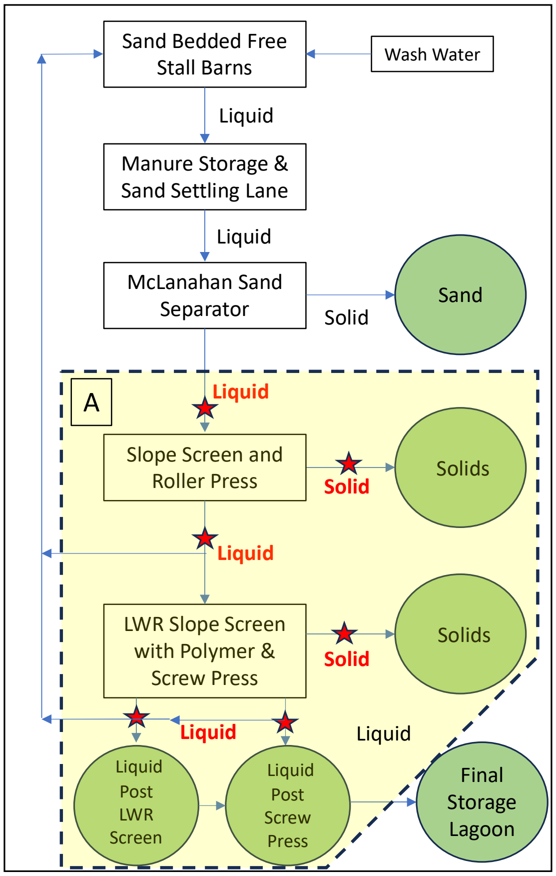


Figure 1. Flow diagram of the manure processing system, area A highlighted in yellow consisted of the manure separation system and designated sample collection area for four liquid streams and two solid streams highlighted in red.

The system was evaluated over a 49-week period (45 sampling points total) to assess the manure characteristics of various products and the separation efficiency of individual components as well as the overall system. This evaluation involved collecting manure samples at various points between system components to calculate the separation efficiencies of each processing component over time.

Sampling

Samples were collected over a 49-week period (3/19/2024 – 2/28/2025) to achieve 45 sampling events. The 45 sampling events were collected when the system was operational based on the farms discretion. During each sampling event seven samples were collected to assess each processing unit. Samples were collected from each separated product from each processing unit to assess the manure as it passed through the system as well as each recovered product (Figure 2 and Figure 3). Liquid and slurry samples, 0.5 L, were collected from all sampling locations while the systems were fully operational. Solid samples, 1 L, were collected from the exit point of the roller press and screw press. After collection, samples were stored at 4°C until shipped to A&L Great Lakes Laboratories for analysis.

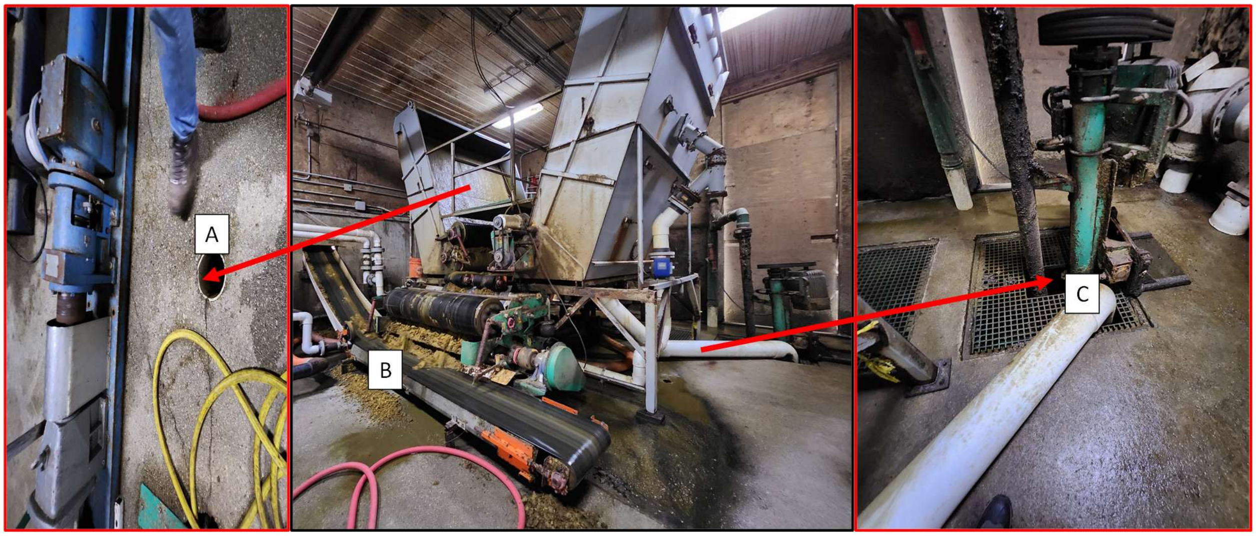


Figure 2. Slope screen and roller press. A) Liquid manure pre slope screen B) Solids post slope screen and roller press C) Liquid manure post slope screen and roller press

Figure 3. LWR slope screen and screw press. A) Liquid Manure pre LWR slope screen B) Liquid manure post LWR slope screen C) Liquid manure post screw press D) Final solids post LWR screw press

Sample analysis

All samples were shipped to A&L Great Lakes Laboratories for analysis. Samples were analyzed with the M7 Manure Analysis Package plus pH. The package includes moisture, total solids, total Kjeldahl nitrogen (TKN), phosphorus (P), potassium (K), sulfur, calcium, magnesium, sodium, iron, aluminum, manganese, copper, zinc, ash, organic carbon, volatile solids, carbon to nitrogen ration (C:N), and ammoniacal-nitrogen (TAN).

Data analysis

Data from the samples analyzed was averaged over the entire sampling period. All non-detectable results were assigned a value of zero throughout all analyses. Additional calculations were completed to assess the separation efficiency of each component after the digester.

Separation efficiencies for each processing step were determined using the separation index (SI) and the removal efficiency (RE) (Eq. 1, 2, & 3) (Aguirre-Villegas et al., 2019; Guilayn et al., 2019). The SI is used to assess the concentration of the manure components into the solid fraction compared to the input while the removal efficiency is the purification of the liquid fraction.

$$R_{Solid,Out} = \frac{DM_{Influent} - DM_{Liquid,Out}}{DM_{Solid,Out} - DM_{Liquid,Out}} \quad (1)$$

$$SI_X = R_{Solid,Out} * \frac{[X]_{Solid,Out}}{[X]_{Influent}} \quad (2)$$

$$RE_x = 1 - \frac{[X]_{Liquid,Out}}{[X]_{Influent}} \quad (3)$$

Where $R_{solid,out}$ is the ratio of solid fraction in relation to the input mass, DM is the dry matter, and X is the constituent concentration under evaluation.

Results

Manure flows

The total manure entering the separation system evaluated in this study was approximately 230,000 gallons per day (GPD), based on estimates provided by the farm. The total fiber solids recovered after the slope screen and roller press amounted to around 9,477 tons per year, according to 2024 data from the farm. The LWR slope screen and screw press processed approximately 30,000 GPD and recovered approximately 2,100 tons of solids during 2024, based on farm estimates. Manure not processed through the LWR slope screen was pipe to the liquid holding pond.

Manure analysis

All manure samples were analyzed for the parameters outlined in the methods. The average, maximum, minimum, and standard deviation by sample locations over the 49-week sampling period are reported below (Table 1). The remaining measured parameters are reported in Appendix A (Table A1). Separated solids from both the roller press and screw press had similar total solids concentrations, ranging between 15% and 28%. However, the separated solids from the LWR screw press had higher concentrations of TKN, TAN, and P.

The separated liquid post-slope screen roller press did not show significant changes in nutrient concentration but did remove some total solids (TS) and volatile solids (VS). A greater decrease in the concentrations of solids and nutrients was observed through the LWR slope screen and screw press as the liquid moved through the additional treatment unit, as expected. This can potentially improve management and nutrient use efficiency in land application systems if the streams are stored and used separately in conjunction with the farms nutrient management plan.

Table 1. Primary manure characteristics by sampling location (non-detects were given a value of zero).

Sample	Statistics	Solids [%]	Volatile Solids [%]	Total Kjeldahl Nitrogen [%]	Ammonium Nitrogen as NH_4-N [%]	Phosphorus as P_2O_5 [%]	Potassium as K_2O [%]
Manure Liquid Pre Slope Screen	Average	4.06	2.98	0.222	0.11	0.029	0.14
	Max	7.21	5.28	0.276	0.15	0.046	0.18
	Min	2.52	1.91	0.154	0.06	0.018	0.08
	Std. Dev.	0.88	0.65	0.031	0.01	0.005	0.03
Manure Liquid Post Slope Screen & Roller Press	Average	3.97	2.86	0.222	0.11	0.028	0.14
	Max	5.81	4.16	0.267	0.14	0.037	0.19
	Min	2.32	1.70	0.154	0.06	0.018	0.09
	Std. Dev.	0.78	0.58	0.030	0.01	0.004	0.03
Manure Solids Post Slope Screen & Roller Press	Average	17.72	16.12	0.331	0.10	0.033	0.15
	Max	20.17	19.94	0.452	0.23	0.042	0.21
	Min	15.22	13.77	0.217	0.03	0.024	0.09
	Std. Dev.	1.14	1.16	0.047	0.04	0.004	0.03
Manure Liquid Pre LWR Screen	Average	4.24	2.87	0.216	0.10	0.027	0.13
	Max	5.99	3.92	0.263	0.14	0.035	0.18
	Min	2.70	1.87	0.148	0.07	0.019	0.08
	Std. Dev.	0.73	0.57	0.031	0.01	0.004	0.03

Manure Liquid Post LWR Screen & Polymer	Average	1.48	0.95	0.137	0.09	0.008	0.12
	Max	2.63	1.75	0.184	0.12	0.015	0.17
	Min	0.97	0.60	0.083	0.01	0.002	0.06
	Std. Dev.	0.36	0.23	0.029	0.02	0.003	0.03
Manure Liquid Pose LWR Screw Press	Average	2.14	1.44	0.154	0.09	0.013	0.12
	Max	3.41	2.42	0.215	0.12	0.026	0.16
	Min	1.02	0.74	0.083	0.07	0.004	0.07
	Std. Dev.	0.64	0.45	0.039	0.01	0.005	0.03
Manure Solids Post LWR Screw Press	Average	21.67	16.13	0.858	0.18	0.171	0.15
	Max	28.49	21.81	1.022	0.32	0.204	0.26
	Min	18.06	13.27	0.684	0.10	0.132	0.10
	Std. Dev.	2.26	1.82	0.088	0.05	0.019	0.03

The concentrations over the 49-week sampling period showed some variability between sample events (Figure 4).

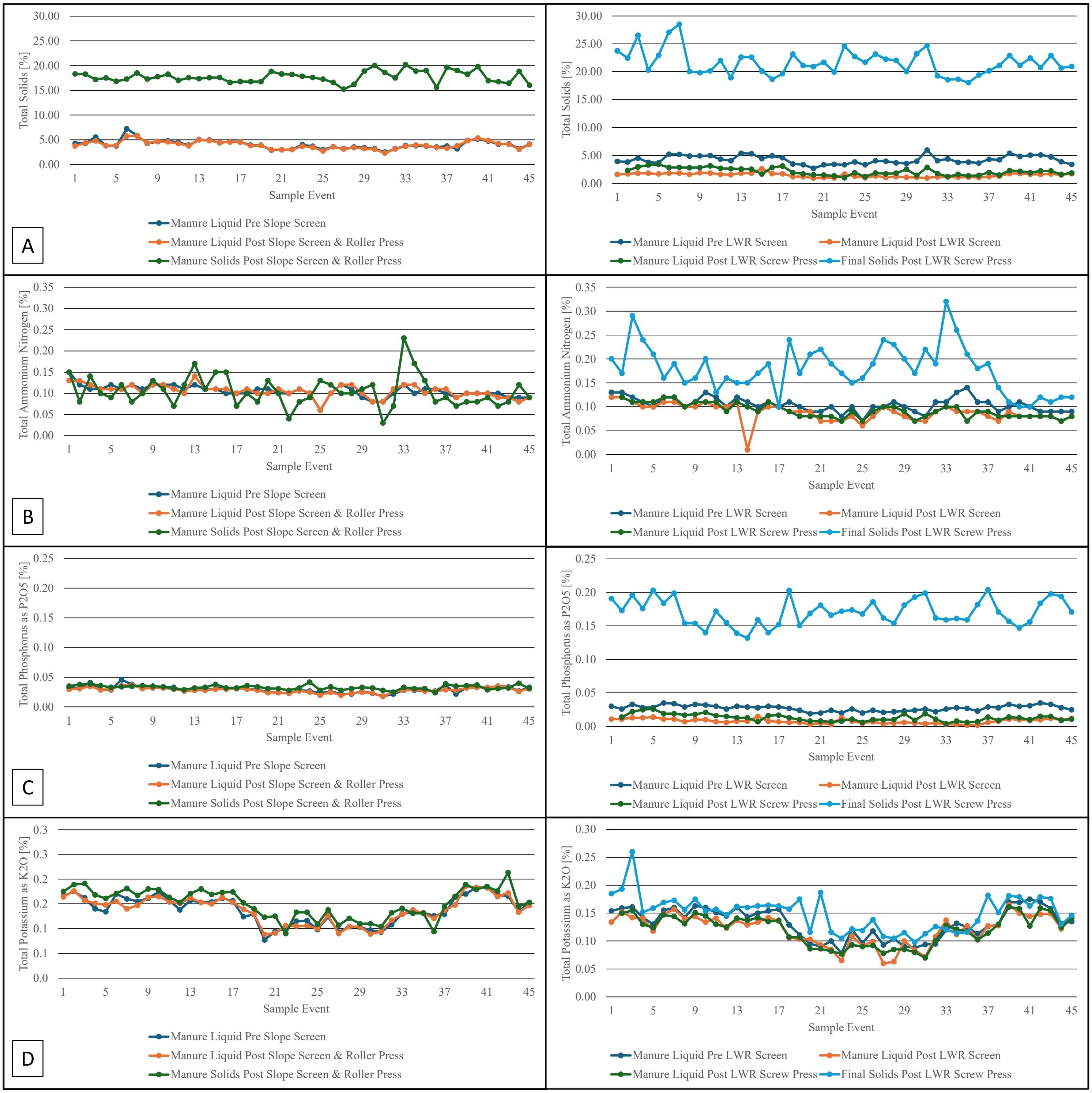


Figure 4. Manure sample concentrations over all sample events for A) total solids (TS), B) total ammonium nitrogen (TAN), C) total phosphorus (TP), and D) potassium (TK) by sampling location.

Separation efficiencies as measured by separation index (SI)

Separation efficiencies, as measured by the SI, indicate the ability of a processing unit to extract various components into the separated solid fraction. In this study, the SI was calculated for both the slope screen and roller press, as well as the LWR slope screen and screw press (Figure 5). Previous work indicates that an SI below 0.62 is considered a low-efficiency system (Guilayn et al., 2019). The slope screen and roller press had low separation efficiencies and high variation (Figure 6) for most parameters likely due to the dilute nature of the influent manure. The LWR slope screen and screw press with polymer effectively removed TS, VS, TKN, and TP with lower variation in performance. This suggests that for manure-based systems, using systems in series may achieve greater performance efficiencies for certain constituents. However, neither system resulted in significant removal of TAN and TK into the separated solids, indicating that additional treatment systems would be necessary to achieve greater recovery to the solid phase.

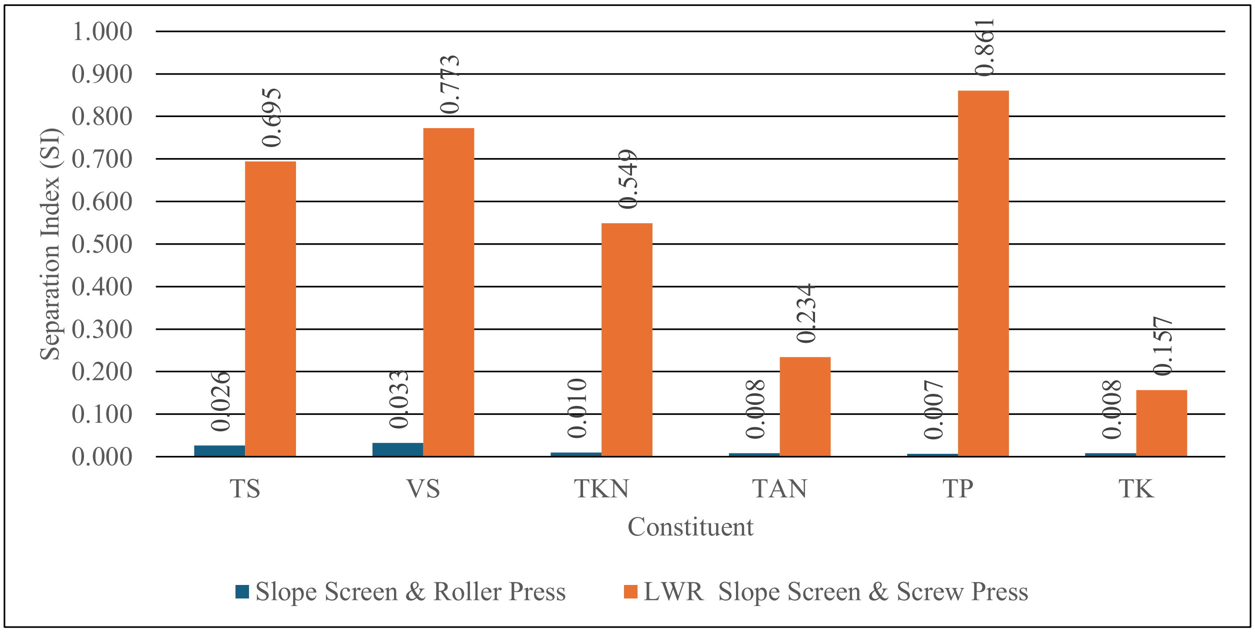


Figure 5. Separation index (SI) for total solids (TS), volatile solids (VS), total Kjeldahl nitrogen (TKN), total ammonium nitrogen (TAN), total phosphorus (TP), and total potassium (TK).

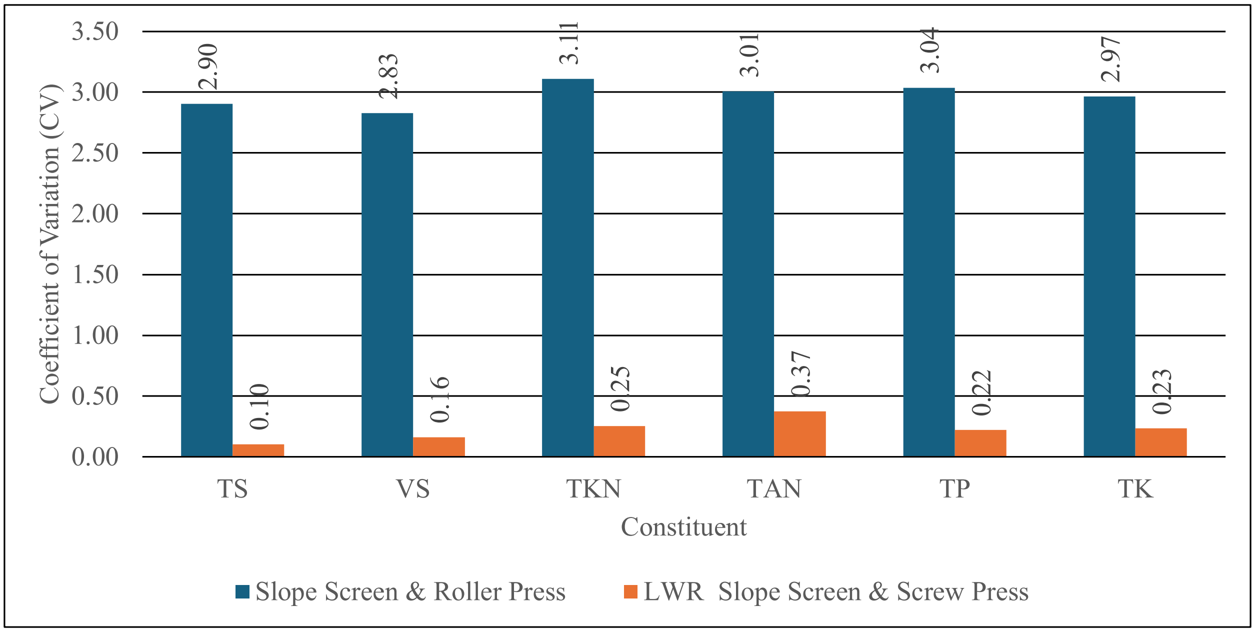


Figure 6. Coefficient of variation (CV) for the separation index for total solids (TS), volatile solids (VS), total Kjeldahl nitrogen (TKN), total ammonium nitrogen (TAN), total phosphorus (TP), and total potassium (TK).

The separation index (SI) for TS, TKN, TAN, TP, and K across the 45 sampling events is presented in Figures 7 and 8 below. The SI was consistently low for all constituents when evaluating the performance of the slope screen and roller press (Figure 7). However, the SI was higher in the LWR slope screen and screw press, particularly for TS, VS, and TP. Daily oversight, maintenance, and cleaning are required to keep the screens operational, which accounts for some variability in the SI throughout the sampling events.

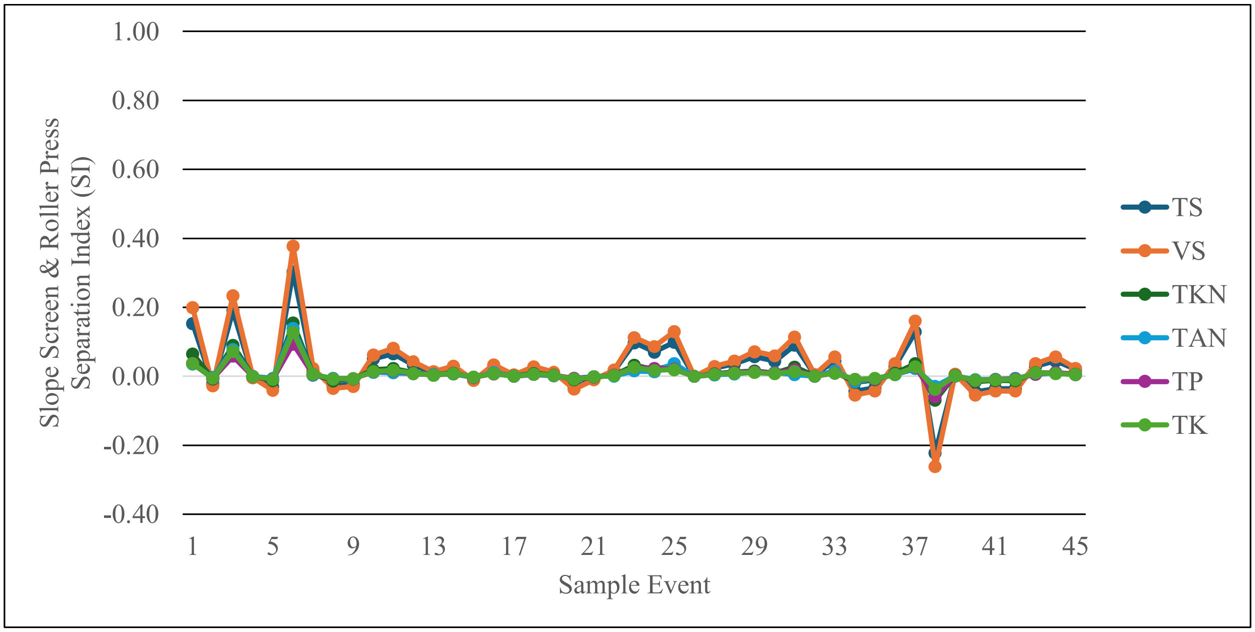


Figure 7. Separation index (SI) over time for total solids (TS, top), total Kjeldahl nitrogen (TKN), total ammonium nitrogen (TAN), total phosphorus (TP), and potassium (TK, bottom) for the slope screen and roller press.

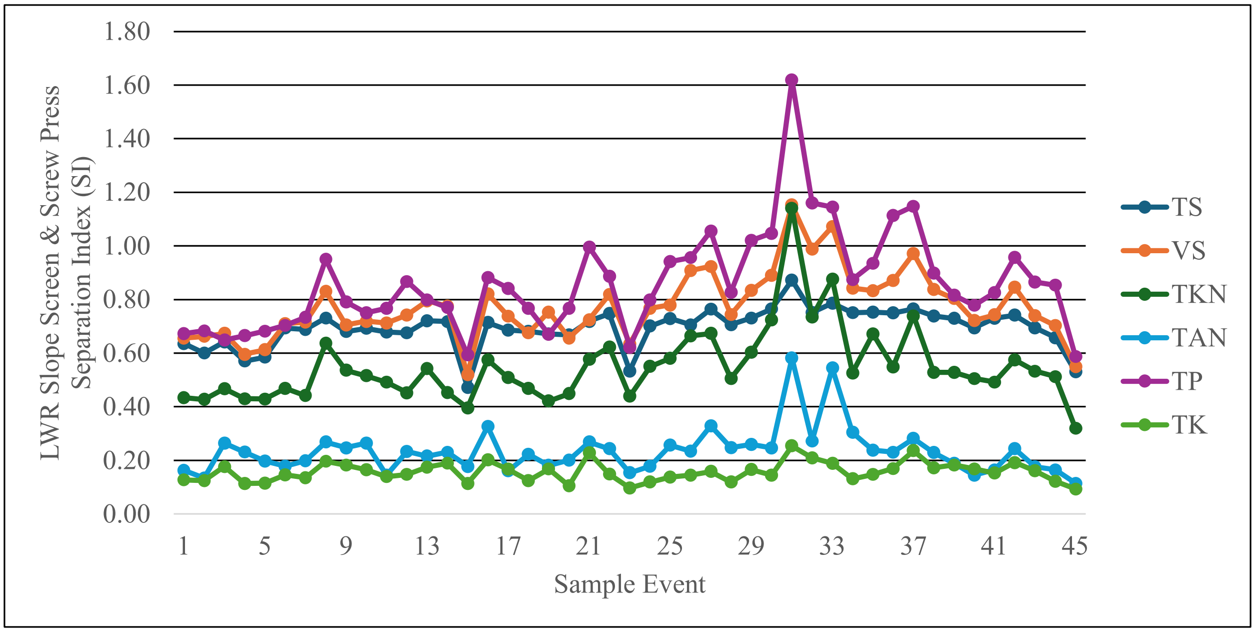


Figure 8. Separation index (SI) over time for total solids (TS, top), total Kjeldahl nitrogen (TKN), total ammonium nitrogen (TAN), total phosphorus (TP), and potassium (TK, bottom) for the LWR slope screen and screw press.

Separation efficiencies as measured by removal efficiency (RE)

The LWR system had higher RE across all constituents compared to the initial slope screen & roller press (Figure 9 and 10). Previous research indicates a high efficiency RE value is above 0.53 (Guilayn et al., 2019). For the individual processing units, LWR slope screen reached a high removal efficiency for TS, VS and P, but using this metric performed with low efficiency for TKN, TAN, and K. A high efficiency RE for volatile solids is important for the reduction in methane production during storage. Removal of P is generally considered important for producers as it can improve the N to P ratio that is useful in land application. In addition, some producers have a land base with high soil P levels due to ongoing manure applications and this processing can provide management flexibility to meet nutrient management goals.

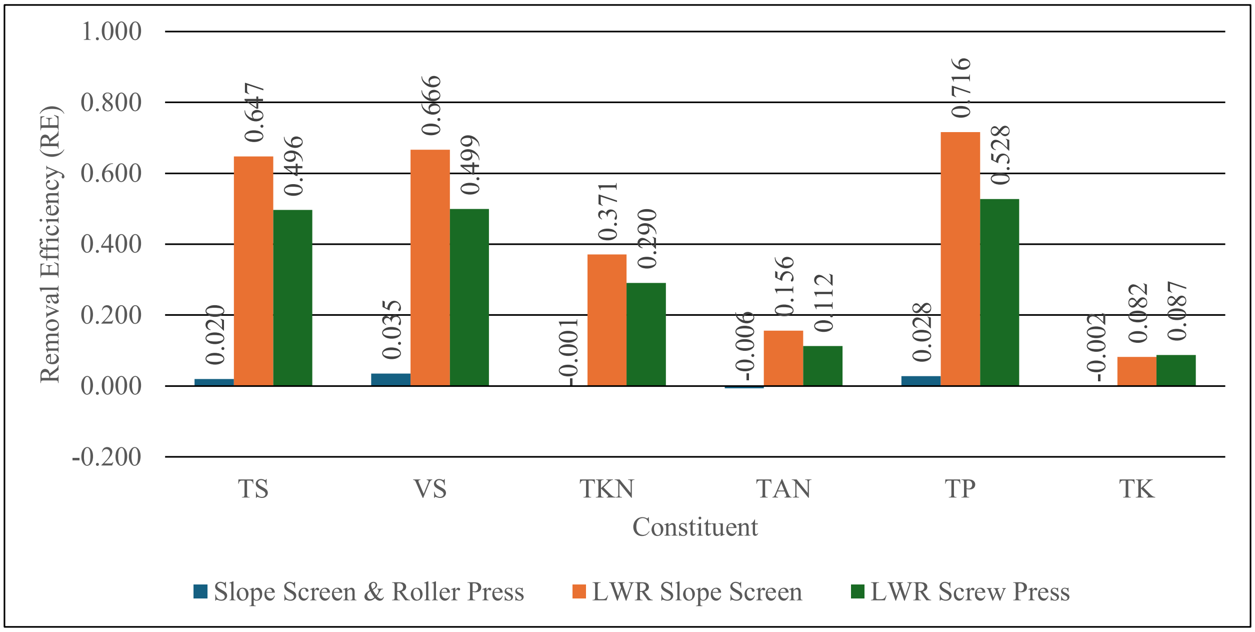


Figure 9. Removal efficiency (RE) for total solids (TS), volatile solids (VS), total Kjeldahl nitrogen (TKN), total ammonium nitrogen (TAN), total phosphorus (TP), and total potassium (TK) for the slope screen & roller press, LWR slope screen and the LWR screw press.

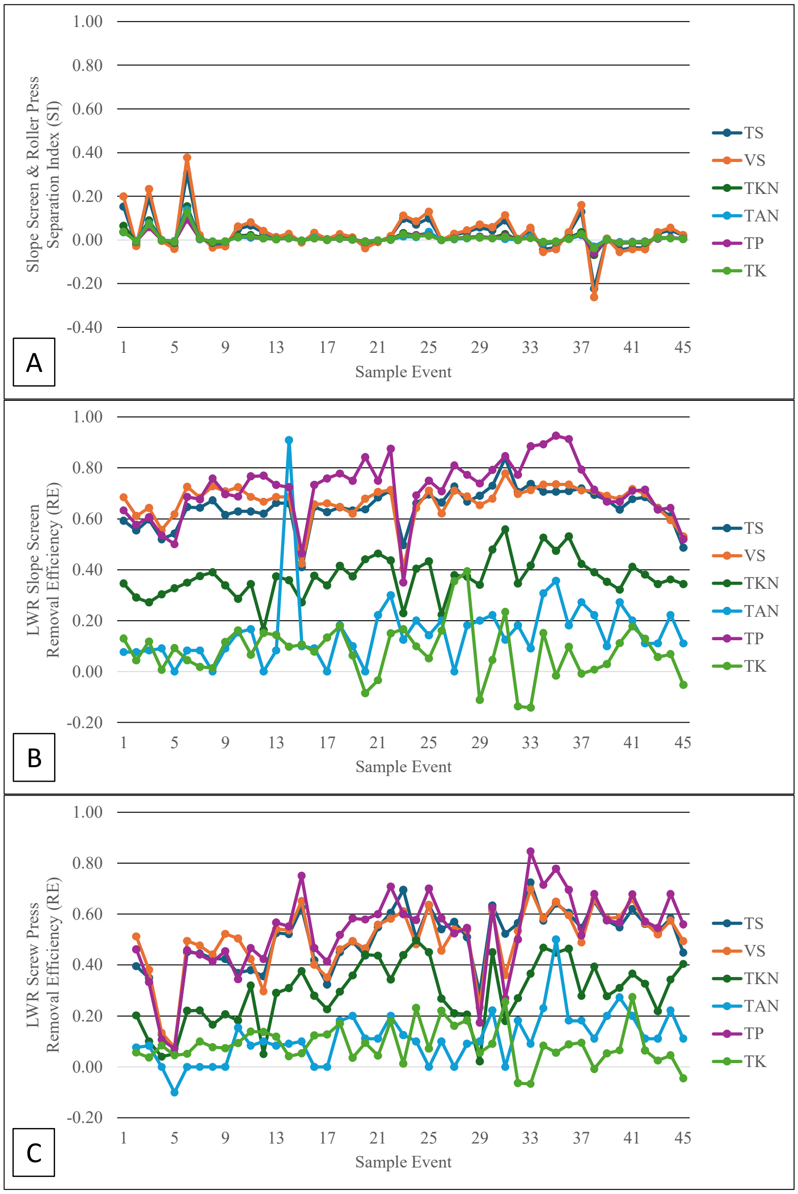


Figure 10. Removal efficiency (RE) over time for total solids (TS,), total Kjeldahl nitrogen (TKN), total ammonium nitrogen (TAN), total phosphorus (TP), and potassium (TK,) for the A) slope screen and roller press B) LWR slope screen and C) LWR screw press.

In Summary

- A dairy farm in Northeastern Wisconsin was selected to evaluate manure characteristics from a sand separation system down stream of the sand recovery focusing on the system components comprised of a slope screen and roller press followed by an LWR slope screen and screw press.
- The separation system of focus processes around 230,000 gallons per day (160 GPM) of diluted manure with a total solids around 4% TS.
- The farm captures approximately 9,477 tons per year of fiber from the initial slope screen and roller press, with an average total solids content of 18% TS.
- The farm captures approximately 2,100 tons per year of solids post LWR system with an average total solids content of 22%.
- Over a 49-week period, 45 sample events were conducted, collecting 7 samples per event. Five liquid samples and two solid samples were collected at each event.
- Samples were analyzed for moisture, total solids, total Kjeldahl nitrogen (TKN), phosphorus (P), potassium (K), sulfur, calcium, magnesium, sodium, iron, aluminum, manganese, copper, zinc, ash, organic carbon, volatile solids, carbon to nitrogen ratio (C:N), ammonium-nitrogen (TAN), and pH.
- On average, the liquid samples showed higher levels of total nitrogen (N) and potassium (K) compared to the solid samples, while total phosphorus (P) was higher in the solid samples.
- The separation index (SI) and removal efficiency (RE) for the slope screen and roller press system were low, indicating that the majority of the nutrient constituents remained in the liquid manure stream to be managed further downstream in the manure management system.
- The SI and RE performed better for all constituents for the LWR system compared to the slope screen and roller press indicating that the combination of slope screen with polymer and screw press are more effective at removal. The highest RE and SI occurred with TS, VS, TP and TKN with poor removal of N and K.

References

2020 National Emissions Inventory Data. (2023). Office of Air Quality Planning and Standards Retrieved from https://www.epa.gov/air-emissions-inventories/2020-national-emissions-inventory-nei-data

Aguirre-Villegas, H. A., & Larson, R. A. (2017). Evaluating greenhouse gas emissions from dairy manure management practices using survey data and lifecycle tools. *Journal of Cleaner Production*, *143*, 169-179. https://doi.org/https://doi.org/10.1016/j.jclepro.2016.12.133

Aguirre-Villegas, H. A., Larson, R. A., & Sharara, M. A. (2019). Anaerobic digestion, solid-liquid separation, and drying of dairy manure: Measuring constituents and modeling emission. *Science of The Total Environment*, *696*, 134059. https://doi.org/https://doi.org/10.1016/j.scitotenv.2019.134059

Guilayn, F., Jimenez, J., Rouez, M., Crest, M., & Patureau, D. (2019). Digestate mechanical separation: Efficiency profiles based on anaerobic digestion feedstock and equipment choice. *Bioresource Technology*, *274*, 180-189. https://doi.org/https://doi.org/10.1016/j.biortech.2018.11.090

Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2021. (2023). Retrieved from https://www.epa.gov/ghgemissions/inventory-us-greenhouse-gas-emissions-and-sinks-1990-2021

Lorimor, J., Powers, W., & Sutton, A. (2004). Manure Characteristics. In (Second ed., Vol. MWPS-18 Section 1). Ames, IA: MidWest Plan Service (MWPS).

Sharara, M., Kolesch, R. K., Cortus, E. L., Larson, R. A., Classen, J. J., & Janni, K. A. (2022). Addressing Nutrient Imbalances in Animal Agriculture Systems. *Journal of the ASABE*, *65*(2), 235-249. https://doi.org/https://doi.org/10.13031/ja.14661

Spiegal, S., Kleinman, P. J. A., Endale, D. M., Bryant, R. B., Dell, C., Goslee, S., Meinen, R. J., Flynn, K. C., Baker, J. M., Browning, D. M., McCarty, G., Bittman, S., Carter, J., Cavigelli, M., Duncan, E., Gowda, P., Li, X., Ponce-Campos, G. E., Cibin, R.,…Yang, Q. (2020). Manuresheds: Advancing nutrient recycling in US agriculture. *Agricultural Systems*, *182*, 102813. https://doi.org/https://doi.org/10.1016/j.agsy.2020.102813

Wisconet. *Wisconet, Wisconsin's Environmental Mesonet*. University of Wisconsin-Madison. https://wisconet.wisc.edu/

Appendix A

Table A1. Additional manure characteristics measured by sampling location

		Moisture [%]	**Ash @ 550C [%]**	**Organic Carbon (LOI @ 550C) [%]**	**S [%]**	**Mg [%]**	**Ca [%]**	**Na [%]**	**Al [ppm]**	**Cu [ppm]**	**Fe [ppm]**	**Mn [ppm]**	**Zn [ppm]**	**pH**
Manure Liquid Pre Slope Screen	Average	95.93	1.08	1.73	0.02	0.11	0.42	0.07	18	23.5	49	5.4	7.8	7.1
	Max	97.48	1.93	3.06	0.04	0.18	12.00	0.11	51	64.0	96	9.9	12.0	7.6
	Min	92.79	0.61	1.11	0.01	0.07	0.11	0.04	11	1.4	28	3.2	4.4	6.7
	Standard Deviation	0.87	0.25	0.37	0.01	0.02	1.77	0.01	7	20.6	13	1.1	1.8	0.2
Manure Liquid Post Slope Screen & Roller Press	Average	96.03	1.07	1.68	0.02	0.10	0.15	0.09	17	22.2	47	5.2	7.3	7.1
	Max	97.68	1.73	2.42	0.03	0.17	0.26	0.90	29	63.0	97	7.4	12.0	7.6
	Min	94.19	0.62	0.98	0.01	0.07	0.02	0.04	11	1.3	32	3.2	4.4	6.7
	Standard Deviation	0.77	0.23	0.33	0.01	0.02	0.04	0.12	4	19.7	12	0.9	1.4	0.2
Manure Solids Post Slope Screen & Roller Press	Average	82.25	1.60	9.35	0.04	0.13	0.24	0.07	31	22.2	83	6.5	12.1	8.1
	Max	84.78	2.96	11.56	0.05	0.21	0.40	0.11	58	59.0	160	8.1	14.0	9.2
	Min	79.83	0.06	7.99	0.03	0.08	0.16	0.04	17	2.2	53	4.9	9.1	5.8
	Standard Deviation	1.12	0.52	0.67	0.01	0.03	0.05	0.01	8	18.0	22	0.8	1.3	0.7
	Average	95.75	1.37	1.66	0.02	0.14	0.21	0.07	20	18.1	65	5.4	6.7	7.1

Manure Liquid Pre LWR Screen	Max	97.30	2.97	2.27	0.03	0.26	0.50	0.11	42	52.0	150	6.8	8.6	7.6
	Min	94.01	0.83	1.08	0.01	0.09	0.13	0.04	12	1.6	32	3.8	4.7	6.8
	Standard Deviation	0.75	0.34	0.33	0.01	0.03	0.06	0.02	5	16.5	21	0.8	1.0	0.2
Manure Liquid Post LWR Screen & Polymer	Average	98.51	0.54	0.55	0.01	0.05	0.03	0.19	3	3.4	5	1.1	1.2	7.5
	Max	99.03	0.88	1.02	0.02	0.08	0.10	6.00	10	20.0	27	3.0	3.6	7.8
	Min	97.37	0.30	0.35	0.00	0.03	0.02	0.04	0	0.1	1	0.3	0.2	7.1
	Standard Deviation	0.35	0.16	0.14	0.01	0.01	0.01	0.89	2	4.5	5	0.6	0.7	0.1
Manure Liquid Pose LWR Screw Press	Average	95.88	0.70	0.82	0.01	0.06	0.07	0.06	7	8.7	18	2.3	2.7	7.3
	Max	98.98	1.39	1.40	0.02	0.11	0.19	0.10	16	43.0	54	5.2	6.6	7.8
	Min	9.15	0.21	0.43	0.01	0.03	0.02	0.03	1	0.3	3	0.6	0.5	7.0
	Standard Deviation	13.39	0.23	0.26	0.01	0.02	0.04	0.01	3	11.2	11	1.1	1.4	0.2
Manure Solids Post LWR Screw Press	Average	78.34	5.54	9.35	0.08	0.53	1.16	0.07	129	137.4	373	35.0	53.7	7.7
	Max	81.94	8.24	12.65	0.11	0.81	1.75	0.11	187	506.0	553	44.0	69.0	8.7
	Min	71.51	3.53	7.70	0.06	0.39	0.89	0.05	90	9.3	274	27.0	37.0	6.8
	Standard Deviation	2.26	0.93	1.06	0.01	0.11	0.21	0.01	23	127.2	73	4.6	8.5	0.5

Appendix B

Report Number
F24184-6501
Account Number
63570

a&lgreatlakes LABORATORIES
Scientists who don't mind getting dirty.™

3505 Conestoga Dr.
Fort Wayne, IN 46808
260.483.4759
algreatlakes.com

To: NEWTRIENT LLC - SIG GRANT
11510 LAURIE DR
WHEATFIELD, IN 46392-7364

For: UW-MADISON

Attn: MARK STOERMAN

Purchase Order: UW-MADISON

Lab Number: 66795
Sample ID: 1
Manure Type: DAIRY, LIQUID PIT (20)

Date Sampled: 6/27/2024
Date Received: 7/2/2024
Date Reported: 7/9/2024

Page: 1 of 14

MANURE ANALYSIS

Analysis	Unit	Analysis Result (As Received)	Pounds Per 1,000 Gal **	First Year Availability @ Pounds Per 1,000 Gal
Moisture	%	96.48	8037	
Solids	%	3.52	293	
Ash @ 550 C	%	0.91	76.1	
Organic Matter (LOI @ 550 C)	%	2.61	217.1	
Organic Carbon (LOI @ 550 C)	%	1.51	125.9	
Carbon:Nitrogen Ratio (C:N)	-		7.1:1	
Nitrogen, Total Kjeldahl (TKN)	%	0.214	17.8	11.8 *
Nitrogen, Ammonium (NH_4-N)	%	0.110	9.2	9.2 *
Nitrogen, Organic (N)	%	0.104	8.7	2.6 *
Phosphorus (P)	%	0.022	4.2 (as P_2O_5)	4.2 * (as P_2O_5)
Potassium (K)	%	0.104	10.4 (as K_2O)	10.4 * (as K_2O)
Sulfur (S)	%	0.01	1.2	0.5 #

@ Estimate of first-year availability does not account for incorporation losses. Consult MWPS-18, "Livestock Waste Facilities Handbook" for additional information.
* Source: MWPS-18, Livestock Waste Facilities Handbook, 1993 # Source: A3411, "Manure Nutrient Credit Worksheet", University of Wisconsin
** Manure density assumed to be 8.33 lb/gallon

Report Approved By: [signature] Approval Date: 7/09/2024
David Henry - Agronomist / Technical Services - CCA

Report Number
F24184-6501
Account Number
63570

a&lgreatlakes LABORATORIES
Scientists who don't mind getting dirty.™

3505 Conestoga Dr.
Fort Wayne, IN 46808
260.483.4759
algreatlakes.com

To: NEWTRIENT LLC - SIG GRANT
11510 LAURIE DR
WHEATFIELD, IN 46392-7364

For: UW-MADISON

Attn: MARK STOERMAN

Purchase Order: UW-MADISON

Lab Number: 66795
Sample ID: 1
Manure Type: DAIRY, LIQUID PIT (20)

Date Sampled: 6/27/2024
Date Received: 7/2/2024
Date Reported: 7/9/2024

MANURE ANALYSIS

Analysis	Unit	Analysis Result (As Received)	Pounds Per 1,000 Gal **	First Year Availability @ Pounds Per 1,000 Gal
Magnesium (Mg)	%	0.09	7.7	4.1 #
Calcium (Ca)	%	0.13	11.1	6.0 #
Sodium (Na)	%	0.06	4.8	
Aluminum (Al)	ppm	15	0.1	
Copper (Cu)	ppm	5.8	<0.1	<0.1 #
Iron (Fe)	ppm	43	0.4	0.2 #
Manganese (Mn)	ppm	4.2	<0.1	<0.1 #
Zinc (Zn)	ppm	5.7	<0.1	<0.1 #
pH	-	6.8		

@ Estimate of first-year availability does not account for incorporation losses. Consult MWPS-18, "Livestock Waste Facilities Handbook" for additional information.
* Source: MWPS-18, Livestock Waste Facilities Handbook, 1993 # Source: A3411, "Manure Nutrient Credit Worksheet", University of Wisconsin
** Manure density assumed to be 8.33 lb/gallon

Report Number
F24184-6501
Account Number
63570

a&lgreatlakes LABORATORIES
Scientists who don't mind getting dirty.™

3505 Conestoga Dr.
Fort Wayne, IN 46808
260.483.4759
algreatlakes.com

To: NEWTRIENT LLC - SIG GRANT
11510 LAURIE DR
WHEATFIELD, IN 46392-7364

For: UW-MADISON

Attn: MARK STOERMAN

Purchase Order: UW-MADISON

Lab Number: 66796
Sample ID: 2
Manure Type: DAIRY, LIQUID PIT (20)

Date Sampled: 6/27/2024
Date Received: 7/2/2024
Date Reported: 7/9/2024 **Page:** 3 of 14

MANURE ANALYSIS

Analysis	Unit	Analysis Result (As Received)	Pounds Per 1,000 Gal **	First Year Availability @ Pounds Per 1,000 Gal
Moisture	%	96.58	8045	
Solids	%	3.42	285	
Ash @ 550 C	%	0.92	76.8	
Organic Matter (LOI @ 550 C)	%	2.50	208.0	
Organic Carbon (LOI @ 550 C)	%	1.45	120.7	
Carbon:Nitrogen Ratio (C:N)	-		6.7:1	
Nitrogen, Total Kjeldahl (TKN)	%	0.217	18.1	12.4 *
Nitrogen, Ammonium (NH_4-N)	%	0.120	10.0	10.0 *
Nitrogen, Organic (N)	%	0.097	8.1	2.4 *
Phosphorus (P)	%	0.023	4.4 (as P_2O_5)	4.4 * (as P_2O_5)
Potassium (K)	%	0.104	10.4 (as K_2O)	10.4 * (as K_2O)
Sulfur (S)	%	0.01	1.1	0.5 #

@ Estimate of first-year availability does not account for incorporation losses. Consult MWPS-18, "Livestock Waste Facilities Handbook" for additional information.
* Source: MWPS-18, Livestock Waste Facilities Handbook, 1993 # Source: A3411, "Manure Nutrient Credit Worksheet", University of Wisconsin
** Manure density assumed to be 8.33 lb/gallon

Report Number
F24184-6501
Account Number
63570

a&lgreatlakes LABORATORIES
Scientists who don't mind getting dirty.™

3505 Conestoga Dr.
Fort Wayne, IN 46808
260.483.4759
algreatlakes.com

To: NEWTRIENT LLC - SIG GRANT
11510 LAURIE DR
WHEATFIELD, IN 46392-7364

For: UW-MADISON

Attn: MARK STOERMAN

Purchase Order: UW-MADISON

Lab Number: 66796
Sample ID: 2
Manure Type: DAIRY, LIQUID PIT (20)

Date Sampled: 6/27/2024
Date Received: 7/2/2024
Date Reported: 7/9/2024

MANURE ANALYSIS

Analysis	Unit	Analysis Result (As Received)	Pounds Per 1,000 Gal **	First Year Availability @ Pounds Per 1,000 Gal
Magnesium (Mg)	%	0.09	7.6	4.1 #
Calcium (Ca)	%	0.14	11.4	6.4 #
Sodium (Na)	%	0.06	4.8	
Aluminum (Al)	ppm	15	0.1	
Copper (Cu)	ppm	6.3	0.1	<0.1 #
Iron (Fe)	ppm	41	0.3	0.2 #
Manganese (Mn)	ppm	4.5	<0.1	<0.1 #
Zinc (Zn)	ppm	6.0	<0.1	<0.1 #
pH	-	6.9		

@ Estimate of first-year availability does not account for incorporation losses. Consult MWPS-18, "Livestock Waste Facilities Handbook" for additional information.
* Source: MWPS-18, Livestock Waste Facilities Handbook, 1993 # Source: A3411, "Manure Nutrient Credit Worksheet", University of Wisconsin
** Manure density assumed to be 8.33 lb/gallon

Report Number
F24184-6501
Account Number
63570

a&lgreatlakes LABORATORIES
Scientists who don't mind getting dirty.™

3505 Conestoga Dr.
Fort Wayne, IN 46808
260.483.4759
algreatlakes.com

To: NEWTRIENT LLC - SIG GRANT
11510 LAURIE DR
WHEATFIELD, IN 46392-7364

For: UW-MADISON

Attn: MARK STOERMAN

Purchase Order: UW-MADISON

Lab Number: 66797
Sample ID: 3
Manure Type: DAIRY, SOLID W/O BEDDING (6)

Date Sampled: 6/27/2024
Date Received: 7/2/2024
Date Reported: 7/9/2024 **Page:** 5 of 14

MANURE ANALYSIS

Analysis	Unit	Analysis Result (As Received)	Pounds Per Ton	First Year Availability @ Pounds Per Ton
Moisture	%	83.81	1676	
Solids	%	16.19	324	
Ash @ 550 C	%	1.44	28.8	
Organic Matter (LOI @ 550 C)	%	14.75	295.0	
Organic Carbon (LOI @ 550 C)	%	8.56	171.1	
Carbon:Nitrogen Ratio (C:N)	-		25.1:1	
Nitrogen, Total Kjeldahl (TKN)	%	0.341	6.8	3.7 *
Nitrogen, Ammonium (NH_4-N)	%	0.100	2.0	2.0 *
Nitrogen, Organic (N)	%	0.241	4.8	1.7 *
Phosphorus (P)	%	0.031	1.4 (as P_2O_5)	1.4 * (as P_2O_5)
Potassium (K)	%	0.121	2.9 (as K_2O)	2.9 * (as K_2O)
Sulfur (S)	%	0.03	0.6	0.3 #

@ Estimate of first-year availability does not account for incorporation losses. Consult MWPS-18, "Livestock Waste Facilities Handbook" for additional information.
* Source: MWPS-18, Livestock Waste Facilities Handbook, 1993 # Source: A3411, "Manure Nutrient Credit Worksheet", University of Wisconsin

Report Number
F24184-6501
Account Number
63570

a&lgreatlakes LABORATORIES
Scientists who don't mind getting dirty.™

3505 Conestoga Dr.
Fort Wayne, IN 46808
260.483.4759
algreatlakes.com

To: NEWTRIENT LLC - SIG GRANT
11510 LAURIE DR
WHEATFIELD, IN 46392-7364

For: UW-MADISON

Attn: MARK STOERMAN

Purchase Order: UW-MADISON

Lab Number: 66797
Sample ID: 3
Manure Type: DAIRY, SOLID W/O BEDDING (6)

Date Sampled: 6/27/2024
Date Received: 7/2/2024
Date Reported: 7/9/2024

MANURE ANALYSIS

Analysis	Unit	Analysis Result (As Received)	Pounds Per Ton	First Year Availability @ Pounds Per Ton
Magnesium (Mg)	%	0.14	2.8	1.5 #
Calcium (Ca)	%	0.28	5.6	3.1 #
Sodium (Na)	%	0.06	1.3	
Aluminum (Al)	ppm	38	0.1	
Copper (Cu)	ppm	6.4	<0.1	<0.1 #
Iron (Fe)	ppm	94	0.2	0.1 #
Manganese (Mn)	ppm	6.0	<0.1	<0.1 #
Zinc (Zn)	ppm	11	<0.1	<0.1 #
pH	-	7.1		

@ Estimate of first-year availability does not account for incorporation losses. Consult MWPS-18, "Livestock Waste Facilities Handbook" for additional information.
* Source: MWPS-18, Livestock Waste Facilities Handbook, 1993 # Source: A3411, "Manure Nutrient Credit Worksheet", University of Wisconsin

Report Number
F24184-6501
Account Number
63570

a&lgreatlakes LABORATORIES
Scientists who don't mind getting dirty.™

3505 Conestoga Dr.
Fort Wayne, IN 46808
260.483.4759
algreatlakes.com

To: NEWTRIENT LLC - SIG GRANT
11510 LAURIE DR
WHEATFIELD, IN 46392-7364

For: UW-MADISON

Attn: MARK STOERMAN

Purchase Order: UW-MADISON

Lab Number: 66798
Sample ID: 4
Manure Type: DAIRY, LIQUID PIT (20)

Date Sampled: 6/27/2024
Date Received: 7/2/2024
Date Reported: 7/9/2024 **Page:** 7 of 14

MANURE ANALYSIS

Analysis	Unit	Analysis Result (As Received)	Pounds Per 1,000 Gal **	First Year Availability @ Pounds Per 1,000 Gal
Moisture	%	96.31	8023	
Solids	%	3.69	307	
Ash @ 550 C	%	1.03	85.7	
Organic Matter (LOI @ 550 C)	%	2.66	221.7	
Organic Carbon (LOI @ 550 C)	%	1.54	128.6	
Carbon:Nitrogen Ratio (C:N)	-		7.6:1	
Nitrogen, Total Kjeldahl (TKN)	%	0.204	17.0	11.5 *
Nitrogen, Ammonium (NH_4-N)	%	0.110	9.2	9.2 *
Nitrogen, Organic (N)	%	0.094	7.8	2.3 *
Phosphorus (P)	%	0.022	4.1 (as P_2O_5)	4.1 * (as P_2O_5)
Potassium (K)	%	0.104	10.4 (as K_2O)	10.4 * (as K_2O)
Sulfur (S)	%	0.01	1.1	0.5 #

@ Estimate of first-year availability does not account for incorporation losses. Consult MWPS-18, "Livestock Waste Facilities Handbook" for additional information.
* Source: MWPS-18, Livestock Waste Facilities Handbook, 1993 # Source: A3411, "Manure Nutrient Credit Worksheet", University of Wisconsin
** Manure density assumed to be 8.33 lb/gallon

Report Number
F24184-6501
Account Number
63570

a&lgreatlakes LABORATORIES
Scientists who don't mind getting dirty.™

3505 Conestoga Dr.
Fort Wayne, IN 46808
260.483.4759
algreatlakes.com

To: NEWTRIENT LLC - SIG GRANT
11510 LAURIE DR
WHEATFIELD, IN 46392-7364

For: UW-MADISON

Attn: MARK STOERMAN

Purchase Order: UW-MADISON

Lab Number: 66798
Sample ID: 4
Manure Type: DAIRY, LIQUID PIT (20)

Date Sampled: 6/27/2024
Date Received: 7/2/2024
Date Reported: 7/9/2024

MANURE ANALYSIS

Analysis	Unit	Analysis Result (As Received)	Pounds Per 1,000 Gal **	First Year Availability @ Pounds Per 1,000 Gal
Magnesium (Mg)	%	0.13	10.6	6.0 #
Calcium (Ca)	%	0.19	16.2	8.7 #
Sodium (Na)	%	0.05	4.6	
Aluminum (Al)	ppm	19	0.2	
Copper (Cu)	ppm	5.9	<0.1	<0.1 #
Iron (Fe)	ppm	56	0.5	0.3 #
Manganese (Mn)	ppm	4.6	<0.1	<0.1 #
Zinc (Zn)	ppm	5.5	<0.1	<0.1 #
pH	-	6.8		

@ Estimate of first-year availability does not account for incorporation losses. Consult MWPS-18, "Livestock Waste Facilities Handbook" for additional information.
* Source: MWPS-18, Livestock Waste Facilities Handbook, 1993 # Source: A3411, "Manure Nutrient Credit Worksheet", University of Wisconsin
** Manure density assumed to be 8.33 lb/gallon

Report Number
F24184-6501
Account Number
63570

a&lgreatlakes LABORATORIES
Scientists who don't mind getting dirty.™

3505 Conestoga Dr.
Fort Wayne, IN 46808
260.483.4759
algreatlakes.com

To: NEWTRIENT LLC - SIG GRANT
11510 LAURIE DR
WHEATFIELD, IN 46392-7364

For: UW-MADISON

Attn: MARK STOERMAN

Purchase Order: UW-MADISON

Lab Number: 66799
Sample ID: 5A
Manure Type: DAIRY, LIQUID PIT (20)

Date Sampled: 6/27/2024
Date Received: 7/2/2024
Date Reported: 7/9/2024

MANURE ANALYSIS

Analysis	Unit	Analysis Result (As Received)	Pounds Per 1,000 Gal **	First Year Availability @ Pounds Per 1,000 Gal
Moisture	%	98.77	8228	
Solids	%	1.23	102	
Ash @ 550 C	%	0.40	32.9	
Organic Matter (LOI @ 550 C)	%	0.83	69.5	
Organic Carbon (LOI @ 550 C)	%	0.48	40.3	
Carbon:Nitrogen Ratio (C:N)	-		3.8:1	
Nitrogen, Total Kjeldahl (TKN)	%	0.128	10.7	8.5 *
Nitrogen, Ammonium (NH_4-N)	%	0.090	7.5	7.5 *
Nitrogen, Organic (N)	%	0.038	3.2	1.0 *
Phosphorus (P)	%	0.005	1.0 (as P_2O_5)	1.0 * (as P_2O_5)
Potassium (K)	%	0.063	6.3 (as K_2O)	6.3 * (as K_2O)
Sulfur (S)	%	0.00	0.4	<0.1 #

@ Estimate of first-year availability does not account for incorporation losses. Consult MWPS-18, "Livestock Waste Facilities Handbook" for additional information.
* Source: MWPS-18, Livestock Waste Facilities Handbook, 1993 # Source: A3411, "Manure Nutrient Credit Worksheet", University of Wisconsin
** Manure density assumed to be 8.33 lb/gallon

Report Number
F24184-6501
Account Number
63570

a&lgreatlakes LABORATORIES
Scientists who don't mind getting dirty.™

3505 Conestoga Dr.
Fort Wayne, IN 46808
260.483.4759
algreatlakes.com

To: NEWTRIENT LLC - SIG GRANT
11510 LAURIE DR
WHEATFIELD, IN 46392-7364

For: UW-MADISON

Attn: MARK STOERMAN

Purchase Order: UW-MADISON

Lab Number: 66799
Sample ID: 5A
Manure Type: DAIRY, LIQUID PIT (20)

Date Sampled: 6/27/2024
Date Received: 7/2/2024
Date Reported: 7/9/2024

MANURE ANALYSIS

Analysis	Unit	Analysis Result (As Received)	Pounds Per 1,000 Gal **	First Year Availability @ Pounds Per 1,000 Gal
Magnesium (Mg)	%	0.04	3.1	1.8 #
Calcium (Ca)	%	0.02	1.4	0.9 #
Sodium (Na)	%	0.05	4.1	
Aluminum (Al)	ppm	2.5	<0.1	
Copper (Cu)	ppm	0.7	<0.1	<0.1 #
Iron (Fe)	ppm	3.2	<0.1	<0.1 #
Manganese (Mn)	ppm	0.5	<0.1	<0.1 #
Zinc (Zn)	ppm	0.7	<0.1	<0.1 #
pH	-	7.4		

@ Estimate of first-year availability does not account for incorporation losses. Consult MWPS-18, "Livestock Waste Facilities Handbook" for additional information.
* Source: MWPS-18, Livestock Waste Facilities Handbook, 1993 # Source: A3411, "Manure Nutrient Credit Worksheet", University of Wisconsin
** Manure density assumed to be 8.33 lb/gallon

Report Number
F24184-6501
Account Number
63570

a&lgreatlakes LABORATORIES
Scientists who don't mind getting dirty.™

3505 Conestoga Dr.
Fort Wayne, IN 46808
260.483.4759
algreatlakes.com

To: NEWTRIENT LLC - SIG GRANT
11510 LAURIE DR
WHEATFIELD, IN 46392-7364

For: UW-MADISON

Attn: MARK STOERMAN

Purchase Order: UW-MADISON

Lab Number: 66800
Sample ID: 5B
Manure Type: DAIRY, LIQUID PIT (20)

Date Sampled: 6/27/2024
Date Received: 7/2/2024
Date Reported: 7/9/2024

MANURE ANALYSIS

Analysis	Unit	Analysis Result (As Received)	Pounds Per 1,000 Gal **	First Year Availability @ Pounds Per 1,000 Gal
Moisture	%	98.19	8179	
Solids	%	1.81	151	
Ash @ 550 C	%	0.58	48.1	
Organic Matter (LOI @ 550 C)	%	1.23	102.7	
Organic Carbon (LOI @ 550 C)	%	0.71	59.6	
Carbon:Nitrogen Ratio (C:N)	-		4.4:1	
Nitrogen, Total Kjeldahl (TKN)	%	0.162	13.5	9.9 *
Nitrogen, Ammonium (NH_4-N)	%	0.100	8.3	8.3 *
Nitrogen, Organic (N)	%	0.062	5.2	1.6 *
Phosphorus (P)	%	0.010	1.8 (as P_2O_5)	1.8 * (as P_2O_5)
Potassium (K)	%	0.085	8.5 (as K_2O)	8.5 * (as K_2O)
Sulfur (S)	%	0.01	0.6	0.5 #

@ Estimate of first-year availability does not account for incorporation losses. Consult MWPS-18, "Livestock Waste Facilities Handbook" for additional information.
* Source: MWPS-18, Livestock Waste Facilities Handbook, 1993 # Source: A3411, "Manure Nutrient Credit Worksheet", University of Wisconsin
** Manure density assumed to be 8.33 lb/gallon

Report Number
F24184-6501
Account Number
63570

a&lgreatlakes LABORATORIES
Scientists who don't mind getting dirty.™

3505 Conestoga Dr.
Fort Wayne, IN 46808
260.483.4759
algreatlakes.com

To: NEWTRIENT LLC - SIG GRANT
11510 LAURIE DR
WHEATFIELD, IN 46392-7364

For: UW-MADISON

Attn: MARK STOERMAN

Purchase Order: UW-MADISON

Lab Number: 66800
Sample ID: 5B
Manure Type: DAIRY, LIQUID PIT (20)

Date Sampled: 6/27/2024
Date Received: 7/2/2024
Date Reported: 7/9/2024

Page: 12 of 14

MANURE ANALYSIS

Analysis	Unit	Analysis Result (As Received)	Pounds Per 1,000 Gal **	First Year Availability @ Pounds Per 1,000 Gal
Magnesium (Mg)	%	0.05	4.5	2.3 #
Calcium (Ca)	%	0.06	4.7	2.7 #
Sodium (Na)	%	0.05	4.3	
Aluminum (Al)	ppm	7.2	0.1	
Copper (Cu)	ppm	2.4	<0.1	<0.1 #
Iron (Fe)	ppm	15	0.1	0.1 #
Manganese (Mn)	ppm	1.7	<0.1	<0.1 #
Zinc (Zn)	ppm	2.1	<0.1	<0.1 #
pH	-	7.1		

@ Estimate of first-year availability does not account for incorporation losses. Consult MWPS-18, "Livestock Waste Facilities Handbook" for additional information.
* Source: MWPS-18, Livestock Waste Facilities Handbook, 1993 # Source: A3411, "Manure Nutrient Credit Worksheet", University of Wisconsin
** Manure density assumed to be 8.33 lb/gallon

Report Number
F24184-6501
Account Number
63570

a&lgreatlakes LABORATORIES
Scientists who don't mind getting dirty.™

3505 Conestoga Dr.
Fort Wayne, IN 46808
260.483.4759
algreatlakes.com

To: NEWTRIENT LLC - SIG GRANT
11510 LAURIE DR
WHEATFIELD, IN 46392-7364

For: UW-MADISON

Attn: MARK STOERMAN

Purchase Order: UW-MADISON

Lab Number: 66801
Sample ID: 9
Manure Type: DAIRY, SOLID W/O BEDDING (6)

Date Sampled: 6/27/2024
Date Received: 7/2/2024
Date Reported: 7/9/2024
Page: 13 of 14

MANURE ANALYSIS

Analysis	Unit	Analysis Result (As Received)	Pounds Per Ton	First Year Availability @ Pounds Per Ton
Moisture	%	77.95	1559	
Solids	%	22.05	441	
Ash @ 550 C	%	5.31	106.1	
Organic Matter (LOI @ 550 C)	%	16.74	334.9	
Organic Carbon (LOI @ 550 C)	%	9.71	194.2	
Carbon:Nitrogen Ratio (C:N)	-		11.1:1	
Nitrogen, Total Kjeldahl (TKN)	%	0.873	17.5	9.1 *
Nitrogen, Ammonium (NH_4-N)	%	0.230	4.6	4.6 *
Nitrogen, Organic (N)	%	0.643	12.9	4.5 *
Phosphorus (P)	%	0.154	7.1 (as P_2O_5)	7.1 * (as P_2O_5)
Potassium (K)	%	0.105	2.5 (as K_2O)	2.5 * (as K_2O)
Sulfur (S)	%	0.07	1.4	0.8 #

@ Estimate of first-year availability does not account for incorporation losses. Consult MWPS-18, "Livestock Waste Facilities Handbook" for additional information.
* Source: MWPS-18, Livestock Waste Facilities Handbook, 1993 # Source: A3411, "Manure Nutrient Credit Worksheet", University of Wisconsin

Report Number
F24184-6501
Account Number
63570

a&lgreatlakes LABORATORIES
Scientists who don't mind getting dirty.™

3505 Conestoga Dr.
Fort Wayne, IN 46808
260.483.4759
algreatlakes.com

To: NEWTRIENT LLC - SIG GRANT
11510 LAURIE DR
WHEATFIELD, IN 46392-7364

For: UW-MADISON

Attn: MARK STOERMAN

Purchase Order: UW-MADISON

Lab Number: 66801
Sample ID: 9
Manure Type: DAIRY, SOLID W/O BEDDING (6)

Date Sampled: 6/27/2024
Date Received: 7/2/2024
Date Reported: 7/9/2024

MANURE ANALYSIS

Analysis	Unit	Analysis Result (As Received)	Pounds Per Ton	First Year Availability @ Pounds Per Ton
Magnesium (Mg)	%	0.55	11.0	6.1 #
Calcium (Ca)	%	1.10	21.9	12.1 #
Sodium (Na)	%	0.06	1.3	
Aluminum (Al)	ppm	122	0.2	
Copper (Cu)	ppm	55	0.1	0.1 #
Iron (Fe)	ppm	398	0.8	0.5 #
Manganese (Mn)	ppm	34	0.1	<0.1 #
Zinc (Zn)	ppm	47	0.1	0.1 #
pH	-	7.0		

@ Estimate of first-year availability does not account for incorporation losses. Consult MWPS-18, "Livestock Waste Facilities Handbook" for additional information.
* Source: MWPS-18, Livestock Waste Facilities Handbook, 1993 # Source: A3411, "Manure Nutrient Credit Worksheet", University of Wisconsin