NEWTRIENT EVALUATION SUMMARY

CONSERVATION INNOVATION GRANT (CIG):

Coarse Solids Separation

Dairy Manure Treatment Innovations – Enhancing Water Quality and Sustainability

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BACKGROUND

As dairy farms have expanded in size and herd density, manure management has become increasingly complex, particularly for operations that rely on liquid manure systems. Traditional approaches such as settling basins or lagoons are limited by the large volumes produced and the need to maintain appropriate nutrient balances. Coarse solids separation (CSS) has emerged as a practical strategy to divide manure into distinct liquid and solid fractions that can each be managed more efficiently. Separating manure into liquid and solid waste streams helps address these pressures by improving manure transport efficiency, reducing lagoon loading rates, applying precise nutrients, and allowing targeted reuse of solids and liquids.

Mechanical separators—such as screw presses, slope screens, and vibratory screens—provide farms with ways to quickly remove coarse solids before storage or further downstream treatment. Solid fractions can be used as bedding, compost ingredients, digester feedstock, or soil amendments. Liquid fractions typically maintain a nutrient profile well-suited for agronomic land application. As farms pursue more sustainable manure strategies, CSS technologies offer important benefits across nutrient management, environmental protection, and on-farm resource circularity.

This evaluation summarizes performance outcomes from a multi-site review of three CSS technologies and examines how each performs under real-world dairy conditions.

INTRODUCTION

This assessment reviewed the performance of screw press, slope screen, and vibratory screen technologies (Figure 1) as documented across five commercial dairy operations in a multi-site white paper. Unlike controlled field trials that follow a consistent treatment protocol, this evaluation synthesizes existing operational data from farms already using these systems under normal working conditions.

The goal of the assessment is to understand how CSS technologies influence the distribution of moisture, organic material, and nutrients between the liquid and solid fractions of manure. By examining general patterns in solids dryness, carbon content, nitrogen (N) and phosphorus (P) behavior, and overall separation consistency, the evaluation provides insight into the practical advantages and limitations of each technology. This broader perspective helps clarify how CSS fits into a farm's manure management strategy and how technology differences may affect downstream use options and nutrient planning.

FIGURE 1: COARSE SOLIDS SEPARATION TECHNIQUES EXAMINED IN THIS STUDY.

A. **Slope Screen**
Robinway Dairy

B. **Screw Press**
Middleton project

C. **Vibratory Screen**
Kilby Dairy

METHODOLOGY

The evaluation is based on a 15-week dataset in which independent researchers collected manure samples from three points in the separation process—inflow, solids, and outflow—at farms operating three different coarse separation systems (slope screen, screw press, and vibratory screen). Samples were collected three times per week and analyzed at A&L Great Lakes Laboratories using standard M7 procedures for moisture, organic carbon, total Kjeldahl nitrogen (TKN), ammonium nitrogen (NH_4^+-N), potassium (K), P, and calculated N:P ratios. Data were drawn from screw press systems at Fessenden Farms (NY) and the Middleton regional digester project (WI); slope screen systems at Deer Valley Dairy (CO) and Robinway Dairy (WI); and a vibratory screen system at Kilby Dairy (MD). Analysis of variance (ANOVA) models (SYSTAT v13) were used to assess differences among farms and technologies. Results were interpreted by comparing averaged values for each farm and separation point to identify general trends in moisture removal, nutrient partitioning, and solids characteristics.

DISCUSSION OF RESULTS

The evaluation of CSS technologies across five commercial dairy operations demonstrates clear trends in moisture reduction, nutrient distribution, and solids quality. While the study was not a controlled field trial, the consistent patterns observed across Table 1 and Figure 2 illustrate how screw presses, slope screens, and vibratory screens influence the characteristics of separated solids and liquids under real farm conditions. The results show that all systems effectively reduce moisture in the solids, concentrate carbon and nutrients to varying degrees, and create liquid fractions that retain a relatively stable nutrient profile, suitable for land application. These outcomes form the basis for understanding the operational strengths and limitations of each CSS technology.

Key Benefits of Coarse Solids Separation

Reliable Moisture Reduction Across All CSS Technologies: Across all participating farms, each CSS system reduced moisture in the solids relative to the inflow, creating a more manageable and transportable material.

As shown in Table 1, solids moisture decreased from inflow values above 91%-96% to post-separation values ranging from 61%-91%. Screw presses demonstrated the greatest effectiveness in moisture reduction, with Fessenden Farms producing solids at 61.30% moisture and Middleton producing solids at 73.98%. Slope screens achieved reductions to 82.43% (Robinway) and 83.08% (Deer Valley), while the vibratory system exhibited the smallest reduction, generating solids at 91.06% (Kilby). Both inclined screens also incorporated roller presses at the bottom of the screen to remove additional moisture from the separated solids. Inclined screens without the roller presses would result in higher moisture content in the solids which could lead to potential leaching issues from the solids and reduced ability to stack. These patterns for the three systems, visually reinforced in Figure 2, confirm that all technologies provide measurable moisture reduction, with screw presses offering the most pronounced improvement.

TABLE 1: PERCENT OF EACH TYPE OF ANALYSIS FOR EACH FARM AND SAMPLE TYPE.

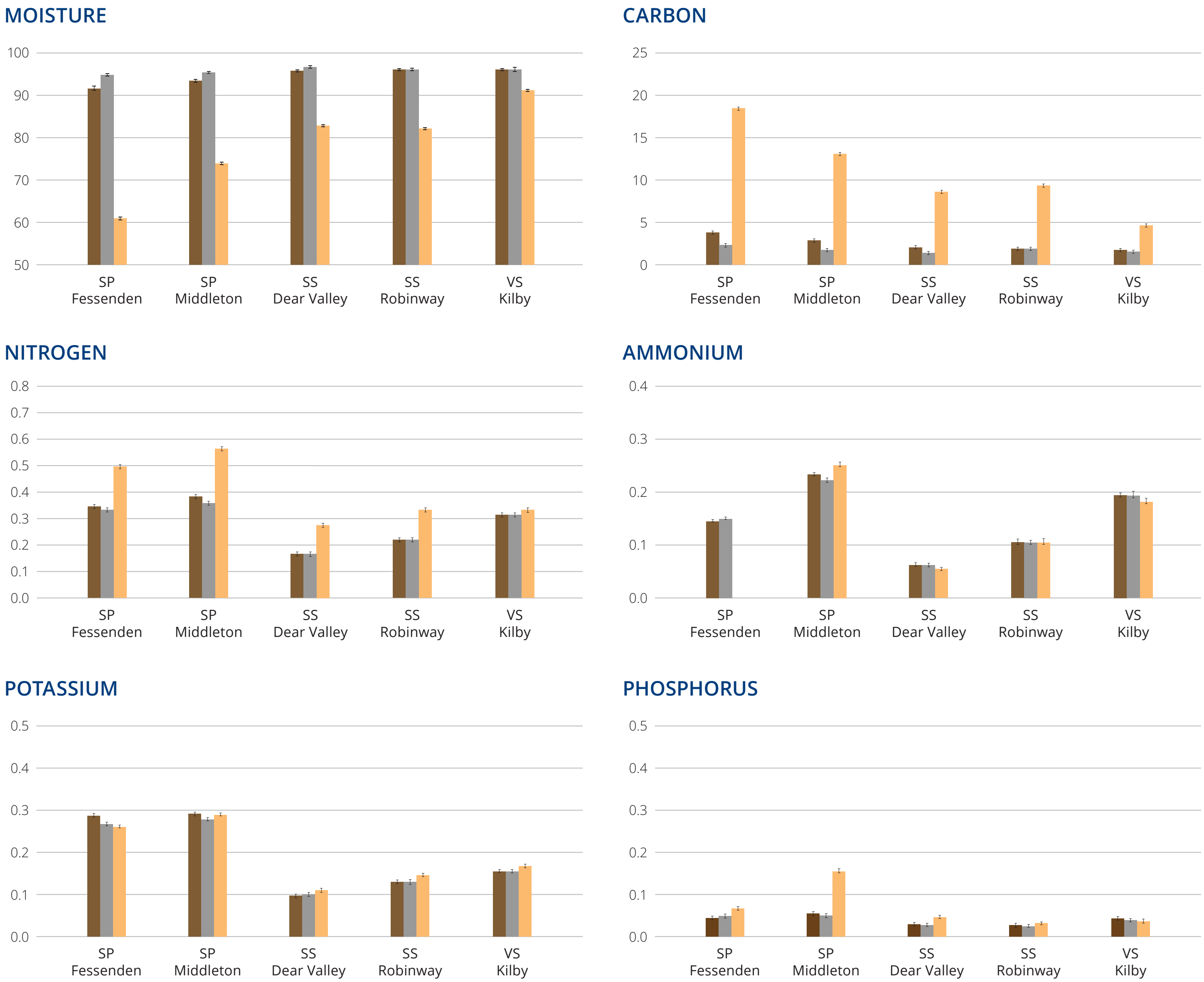
Most comparisons were significant at the P<0.001 level using Analysis of Variance; exceptions are explained in the text.

	MOISTURE	CARBON	NITROGEN	AMMONIUM	POTASSIUM	PHOSPHORUS	N:P
SCREW PRESS (MIDDLETON)							
INFLOW	93.56	2.77	0.38	0.23	0.29	0.06	6:1
SOLIDS	73.98	12.99	0.56	0.25	0.29	0.16	3.5:1
OUTFLOW	95.46	1.72	0.36	0.22	0.28	0.05	7:1
SCREW PRESS (FESSENDEN)							
INFLOW	91.45	3.68	0.35	0.15	0.29	0.05	7:1
SOLIDS	61.30	18.38	0.49	—	0.26	0.07	7:1
OUTFLOW	94.73	2.32	0.34	0.15	0.27	0.05	7:1
SLOPE SCREEN (DEER VALLEY)							
INFLOW	95.82	1.83	0.17	0.06	0.10	0.03	5:1
SOLIDS	83.08	8.53	0.28	0.06	0.11	0.05	5:1
OUTFLOW	96.81	1.30	0.16	0.06	0.10	0.03	5:1
SLOPE SCREEN (ROBINWAY)							
INFLOW	96.13	1.66	0.22	0.11	0.13	0.03	7:1
SOLIDS	82.43	9.21	0.33	0.11	0.15	0.03	11:1
OUTFLOW	96.20	1.62	0.22	0.11	0.13	0.03	7:1
VIBRATORY SCREEN (KILBY)							
INFLOW	96.20	1.62	0.31	0.20	0.15	0.04	8:1
SOLIDS	91.06	4.60	0.33	0.19	0.17	0.04	8:1
OUTFLOW	96.15	1.43	0.31	0.20	0.16	0.04	8:1

Improved Carbon and Organic Matter Concentration in Solids: All CSS technologies concentrated organic carbon in the solids fraction, enhancing their composting potential, bedding dryness, and soil amendment value. Table 1 illustrates substantial increases in carbon across all farms, particularly in the screw press systems: Fessenden's solids increased to 18.38% carbon compared to 3.68% inflow, and Middleton's solids rose to 12.99% from 2.77% inflow. Slope screen systems also increased carbon to 8.53% (Deer Valley) and 9.21% (Robinway), while vibratory screen solids increased more modestly to 4.60% (Kilby). Figure 2 displays these increases clearly, with solids consistently showing higher carbon levels than both inflow and outflow streams. This data confirms that CSS reliably captures organic matter in the solids fraction, creating a concentrated material suitable for multiple farm uses.

FIGURE 2: PERCENTAGES OF MOISTURE AND NUTRIENTS FOR EACH FARM, ARRANGED BY COARSE SEPARATION TECHNIQUE.

SP = Screw Press; SS = Slope Screen; VS = Vibratory Screen. INFLOW OUTFLOW SOLIDS **Error bars are + standard error**



Flexible Technology Options to Meet Farm-Specific Goals: The performance profiles shown in Table 1 and Figure 2 demonstrate that each CSS technology offers distinct advantages, enabling farms to select the system best aligned with their operational objectives. Screw presses provide the driest and most nutrient-dense solids, making them ideal for bedding recovery, composting, or long-distance nutrient export. Slope screens offer moderate nutrient retention with lower capital costs, making them practical for farms prioritizing basic solids removal and a lower infrastructure investment. Vibratory screens, while producing wetter solids (91.06% moisture at Kilby), offer reduced space requirements and interchangeable screens that enable targeted separation and compatibility with pretreatment for anaerobic digestion and other practices. The diversity of performance outcomes across technologies gives farms the flexibility to match CSS capabilities with manure characteristics, climate, available space, and downstream nutrient management strategies.

Evaluation Key Challenges and Issues

High Variability in Performance Across Farms: Table 1 shows substantial variation in moisture, carbon, N, and P values across farms using the same technology, highlighting one of the most significant challenges in CSS implementation. For example, screw press moisture levels ranged from 61.30% at Fessenden to 73.98% at Middleton, despite similar mechanical separation methods. Likewise, N levels in solids for slope screens differed between Deer Valley (0.28%) and Robinway (0.33%). These disparities reflect differences in manure dilution, anaerobic digestion status, bedding composition, screen size, and other farm-specific factors. Figure 2 reinforces this variability, demonstrating wide nutrient and moisture distributions across farms. This underscores the need for site-specific evaluations when selecting or optimizing CSS technologies.

Differences in Moisture Removal Affect Downstream Use Options: While all CSS systems reduce moisture, the extent of reduction varies dramatically, impacting how solids can be used on the farm. Screw press solids at Fessenden reached 61.30% moisture—appropriate for bedding or compost feedstock—while solids at Kilby remained at 91.06%, which may require further drying before use. Slope screens produced intermediate values in the 82%-83% range. As reflected in Table 1 and illustrated in Figure 2, this variability directly influences bedding suitability, composting efficiency, storage space, hauling costs, and potential equipment or infrastructure needs for further drying or processing. Farms relying on CSS for bedding production or solids export must account for these differences during equipment selection.

P Enrichment in Solids Can Limit Land Application Options: Several separation systems showed considerable P concentration in the solids relative to the inflow. Table 1 highlights dramatic increases from the screw presses at Middleton (0.06% to 0.16%) and smaller but meaningful rises at Fessenden (screw press) and Deer Valley (slope screen). For systems with anaerobic digesters, some operations add iron-based additives to reduce hydrogen sulfide (H_2S) generation. When utilized, the iron also allows more of the P to be captured in the solids. While nutrient-rich solids can be beneficial as soil amendments, P accumulation can also restrict flexibility for land application in regions with P-limited fields or regulatory constraints. Figure 2 demonstrates these differences visually, showing pronounced P elevation in some solid streams. Farms aiming to manage P surpluses must consider whether CSS will concentrate P beyond workable thresholds or require alternative nutrient export pathways.

Operational Limitations of Certain Separation Technologies: The study analysis showed that slope screens require highly dilute manure and continuous flow to prevent solids build up or drying on the screen surface, limiting their use in intermittent-flow or cold-weather environments. Vibratory screens, while compact and adjustable, produced the wettest solids, as shown by Kilby's 91.06% moisture in Table 1, which may hinder downstream handling. Figure 2 further illustrates this moisture challenge. These technological limitations mean that CSS systems cannot be selected based solely on nutrient performance; they must be evaluated in the context of climate, manure dilution level, manure consistency, and integration with farm infrastructure such as digesters, storage tanks, or bedding management systems.

IMPLICATIONS

The evaluation of CSS technologies shows they can serve as an effective foundation for improving manure handling, storage efficiency, and nutrient distribution on dairy operations. By producing more manageable solid and liquid fractions, these systems support flexibility in how farms apply nutrients, reuse solids, and plan long-term manure strategies. CSS also enhances the ability of farms to match nutrient forms with agronomic needs, enabling producers to direct solid and liquid streams where they can be used most effectively. This separation helps reduce pressure on storage systems, improves opportunities for transport or export of nutrients, and contributes to more controlled land application practices.

At the same time, the evaluation highlights the importance of selecting technologies that align with a farm's specific operational goals, manure characteristics, and downstream uses. Differences among systems in the dryness, consistency, and characteristics of the separated solids mean that equipment choice influences how easily solids can be incorporated into bedding recovery, composting, anaerobic digestion, or off-site hauling management. Because performance can also vary under different farm conditions, CSS is most effective when integrated into a broader manure management approach that accounts for the farm's storage capacity, field base, climate, and nutrient management plan.

Overall, CSS technologies can play an important role in advancing the sustainability of dairy operations by enhancing nutrient stewardship, improving manure flow efficiencies, and supporting more resilient long-term management strategies. Continued evaluation across diverse farm types and operational conditions will help refine technology selection, identify best-fit systems, and guide producers in adopting approaches that meet both agronomic and environmental objectives.

Information on these, and other solid-liquid separation technologies can be found in the Newtrient's Solutions Catalog at **Newtrient website**.

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

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