Manure Processing for Discharge Water Quality - Technical Performance

Livestock and Poultry Environmental Learning Center (LPELC) June 2025 Webinar
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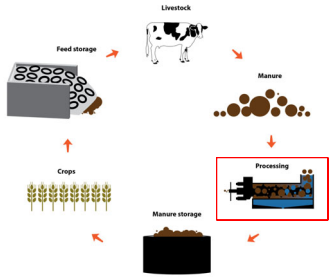
Sustainability and Manure Cycling



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Manure Processing

- Composting
- Anaerobic digestion
- Solid liquid separation
- Sand separation
- Pelleting/Granulation
- Drying
- Pyrolysis – biochar
- Membrane treatment
- Advanced processing to clean water

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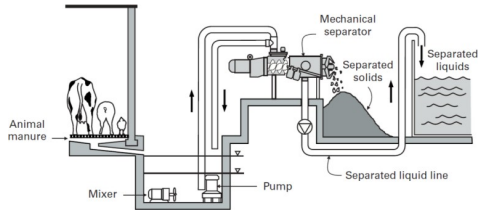
Solid Liquid Separation



Midwest Plan Service, 2001

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Manure Treatment to Clean Water Systems

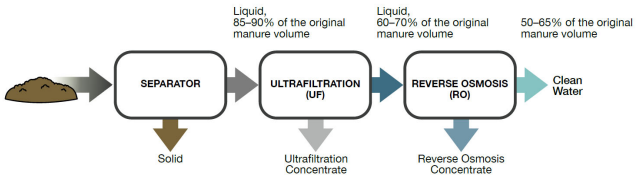

Figure 3. Common processing steps involved in a manure-to-clean water system.

Larson, R.A., & H. Aguirre-Villegas. Treating Manure to Produce Clean Water. University of Wisconsin-Extension, Publication No. A4192-09

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Screw Press

Centrifuge

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Mass Separator Efficiency

Component	Mass separation efficiency (%)[1]
Total solids	45
Total nitrogen	18
Organic nitrogen	20
Inorganic nitrogen	15
Total phosphorous	21

[1]From Chastain (2013) based on (Gooch, Inglis, and Czymmek 2005; Chastain, Vanotti, and Wingfield 2001)

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Removal Efficiency

$$\%\ removal\ effciency = \frac{C_{influent} - C_{effluent}}{C_{influent}}\ x\ 100$$

- Removal Efficiency (RE) of a compound as calculated refers to the purification of the liquid fraction
- Can also be written as:

$$RE = 1 - \frac{C_{effluent}}{C_{influent}}$$

Example: Influent BOD_5 of a wastewater treatment system is 780 mg/L DO. After the treatment system the concentration is 10 mg/L DO. What is the removal efficiency?

$$\%\ removal\ effciency = \frac{780\frac{mg}{L}DO - 10\frac{mg}{L}DO}{780\frac{mg}{L}DO}\ x\ 100 = \ 98.7\%$$

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Separation Index

Separation Index of a compound is the mass distribution into the solid fraction

$$SI_X = R_{SF} * \frac{X_{SolidFraction}}{X_{IN}}$$

$$R_{SF} = \frac{DM_{influent} - DM_{liquidfraction}}{DM_{solidfraction} - DM_{liquidfraction}}$$

$$SI_X = \frac{DM_{influent} - DM_{liquidfraction}}{DM_{solidfraction} - DM_{liquidfraction}} * \frac{X_{SolidFraction}}{X_{IN}}$$

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Low vs. High Efficiency Systems

RE_{DM}=0.53

SI_{DM}=0.62

- Systems with calculated values below these numbers are considered low efficiency
- Systems with calculated values above these numbers are considered high efficiency

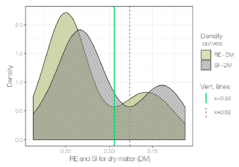

Fig. 4. Density curves for dry matter (DM) removal efficiency (RE) and separation index (SI).

Guilayn, F., Jimeneza, J., Rouezb, M., Crestb, M., & Patureaua, D. 2019. Digestate mechanical separation: Efficiency profiles based on anaerobic digestion feedstock and equipment choice. *Bioresource Technology*, 274, 180-189.

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Separation Efficiency

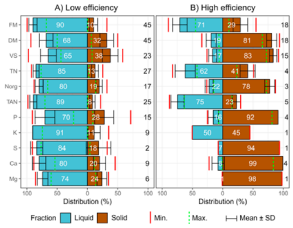

Fig. 5. Mass distributions profiles of digestate mechanical separation according to low (a) and high (b) efficiency categories. The solid fraction distribution correspond to the separation index. The numbers in the right indicate the number of observations. FM: fresh matter. DM: dry matter. VS: volatile solids. TN: total nitrogen. Norg: organic nitrogen. TAN: total ammoniacal nitrogen. P: total phosphorus. K: total potassium. S: total sulfur. Ca: total calcium. Mg: total magnesium.

Guilayn, F., J. Jimenez, M. Rouez, M. Crest, D. Patureau. 2019. Digestate mechanical separation: Efficiency profiles based on anaerobic digestion feedstock and equipment choice. *Bioresource Technology*, 274:180-189.

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Separation Efficiency

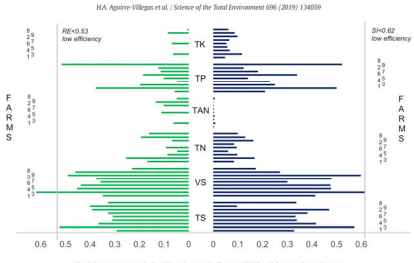

Fig. 5. Mean separation index (SI) and removal efficiency (RE) for all farms and constituents.

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Separated Manure Products

Separated Liquids
- Increase N:P
- In these low efficiency systems range was from 2.7 to 6.3

Separated solids
- Most nitrogen in organic form (over 90%), slow release

	TS (%)	N (g/kg)	P_2O_5 (g/kg)	K_2O (g/kg)	N:P_2O_5
Manure	6.3	50	18	41	3
Separated Liquids	3.9	101	27	75	4
Separated Solids	30.6	15	14	8	1

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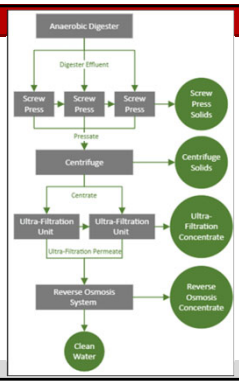

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Ultrafiltration and Reverse Osmosis

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Products

- Variety of separated products
  - Separated solids (25-30% solids)
  - Ultrafiltration concentrate (4% solids)
  - Reverse osmosis concentrate (2% solids)
  - Clean water
    - Manure is treated to water quality standards
    - Discharge (requires permits)
    - Animal drinking water
    - Irrigation
    - Other uses

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Separated Manure Characteristics

Sample	Solids [%]	Volatile Solids [%]	Total Kjeldahl Nitrogen [%]	Ammonium Nitrogen as NH_4-N [%]	Phosphorus as P_2O_5 [%]	Potassium as K_2O [%]
Manure	11.7	8.69	0.41	0.17	0.07	0.29
Digestate	6.44	4.76	0.38	0.23	0.06	0.29
Screw Press Separated Solids	26.05	22.17	0.57	0.26	0.16	0.29
Screw Press Separated Liquids	4.52	2.96	0.36	0.22	0.05	0.28
Centrifuge Separated Solids	28.28	18.35	0.78	0.37	0.46	0.30
Centrifuge Separated Liquids	2.63	1.38	0.29	0.18	0.03	0.24
Ultra Filtration Concentrate	4.01	2.73	0.37	0.18	0.05	0.22
Ultra Filtration Permeate	1.06	0.27	0.19	0.17	0.00	0.17
Reverse Osmosis Concentrate	1.74	0.42	0.30	0.27	0.00	0.23

Sample	pH	Conductivity [mmho/cm]	Total Dissolved Solids (estimated) [mg/L]	Ammonium Nitrogen [mg NH4-N/L]	Nitrate Nitrogen [mg NO3-N/L]	Phosphorus [mg P/L]	Potassium [mg/L]	Chloride [mg/L]	Manganese [mg/L]
Treated Water	6.8	0.14	62.7	12.10	0.022	0.094	5.78	5.11	0.058

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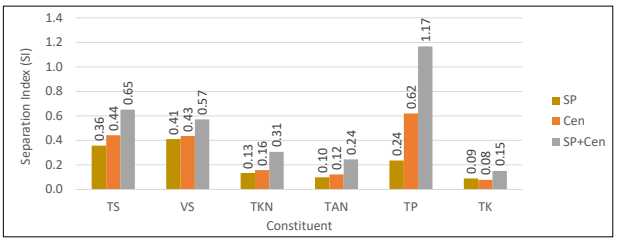
Separation Index



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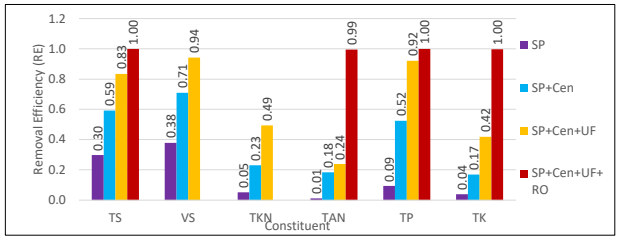
Cumulative Removal Efficiency



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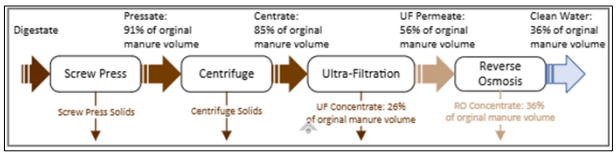
Volume



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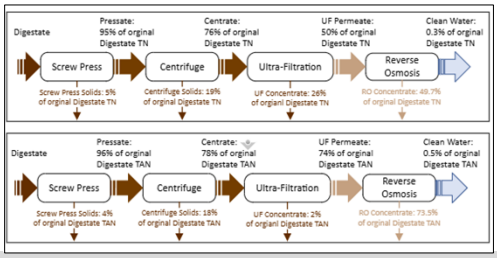
Nitrogen



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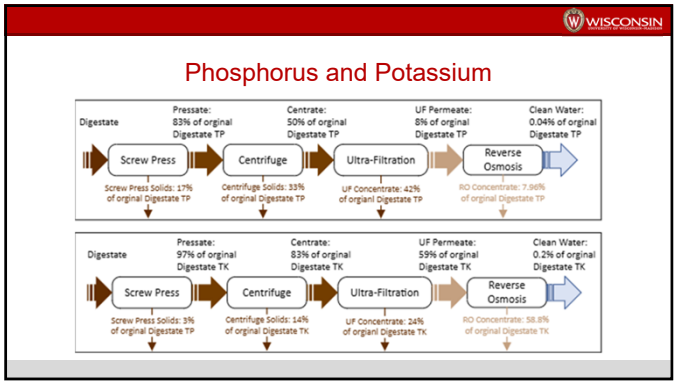

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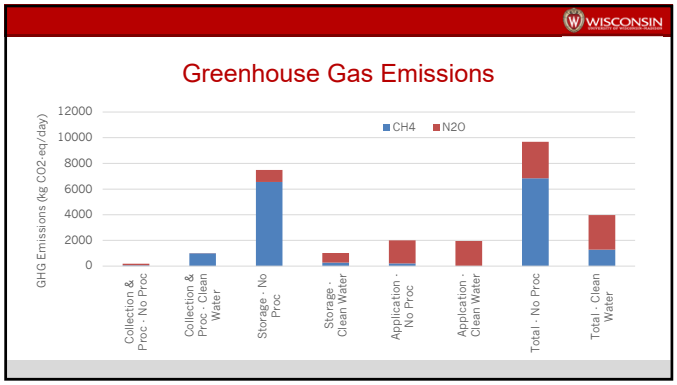

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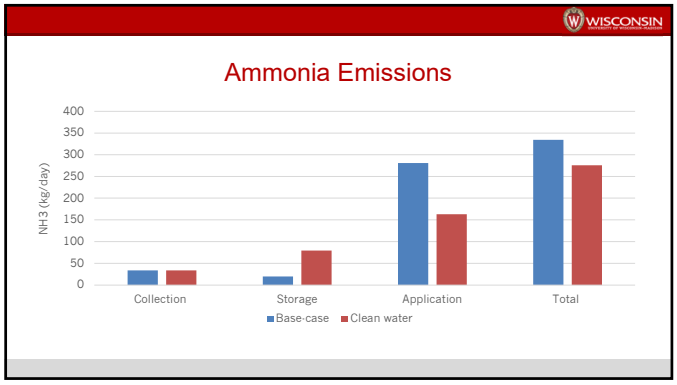

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Costs

- Capital costs are in the millions of dollars
- Capital costs of $290 to $2,225 per cow
  - Costs reduce with increasing number of animals (minimum size 50,000 gallons per day)
  - $15 to $120 per gallon manure treated per day
  - Costs increase with ammonia capture
- Operating costs are 10 to 20% of capital costs
- Capital and operational costs over 15 years from $0.01 to $0.03 per gallon of manure treated
- System reduces hauling costs by at least 35%

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Manure Processing Fact Sheets

- Struvite Recovery from Manure
- Composting Animal Manure
- Biochar Production through Slow Pyrolysis of Animal Manure
- Screw Press Separation of Manure
- Sloped Screen Separator for Manure
- Pelleting Animal Manure
- Anaerobic Digestion from Animal Manure
- Treating Manure to Produce Clean Water
- Systems Approaches to Managing Manure using Coordinated Markets

https://learningstore.extension.wisc.edu/
Agriculture – Animals – Manure

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Acknowledgements

Funded by Newtrient through a subaward from the United States Department of Agriculture (USDA) Natural Resources Conservation Service (NRCS) Conservation Innovation Grant (CIG)

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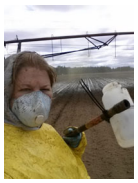
Take Away

- Manure can be treated to discharge quality
- Systems in series reduces variability in separation efficiency
- Reverse osmosis removes most TAN and TK

Thank You!



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