

# Managing Solids in Liquid Manure

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Liquid manure is a mixture of animal feces, urine, flush water, wash water, and sometimes bedding material from animal feeding operations such as dairy and swine farms. If solids are not managed properly, they can reduce storage volume, make pumping and land application more difficult, plug irrigation equipment, increase odor, and raise the risk of runoff or overflow. This publication explains how solids can be managed or separated from liquid manure to improve pumping, support nutrient management, reduce odor concerns, and protect water quality.

## Identifying Problems

Several situations may indicate that better storage management is needed, including the following:

- Solids building up in liquid manure storage units.
- More frequent pumping requirements.
- Increased chances of freeboard violations and overflows.
- Clogging of liquid manure land application systems.
- Increased chance of land application under poor conditions.
- Difficulty recycling sand bedding.

- Need to separate liquid manure for reuse or easier handling.
- Odor complaints.

## Manage Storage Systems

The primary liquid manure storage options are in-house pits, tanks, settling basins, holding ponds and lagoons. The in-house pits and tanks are usually constructed of concrete. Settling basins, holding ponds and lagoons are earthen structures in which the liquid manure is stored until it is utilized. Clay liners are used as needed to prevent excessive leakage to the groundwater. The storage period depends on the type of unit and the needs of the farming operation. In addition to the defined storage period, additional unfilled room for open-air storage systems is needed to handle large precipitation events designed for a 25-year, 24-hour storm and a minimum freeboard of 12 inches. Typically for warm climates, liquid manure storage is designed to contain 120 to 180 days of manure. In cold climates, a storage period of one year is common.

All liquid manure storage systems have a design storage volume that matches the number of animals being housed. This means each system has an

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expected cleanout and solids removal schedule, including floating crust, suspended solids, and settled solids. Agitation during pump-out is critical so that settled solids do not remain in the storage unit. Planned cleanout frequency is also needed to maintain the designed storage volume. With all storages except lagoons, the basic premise of proper management is to thoroughly mix floating crusts and settled solids before pumping so the manure removed is representative of what is in the storage. For in-house pits and concrete tanks, this premise should be followed each time the unit is pumped, meaning manure is thoroughly agitated and removed at an appropriate frequency.

The traditional recommendation for holding ponds is also to thoroughly agitate the manure and completely empty the pond at every pumping. However, an acceptable alternative is to land apply the top water to fields near the pond at every pump down. Then once a year, after land applying most of the top water, agitate the settled solids and use a tank spreader to apply the resulting slurry to fields at some distance from the pond.

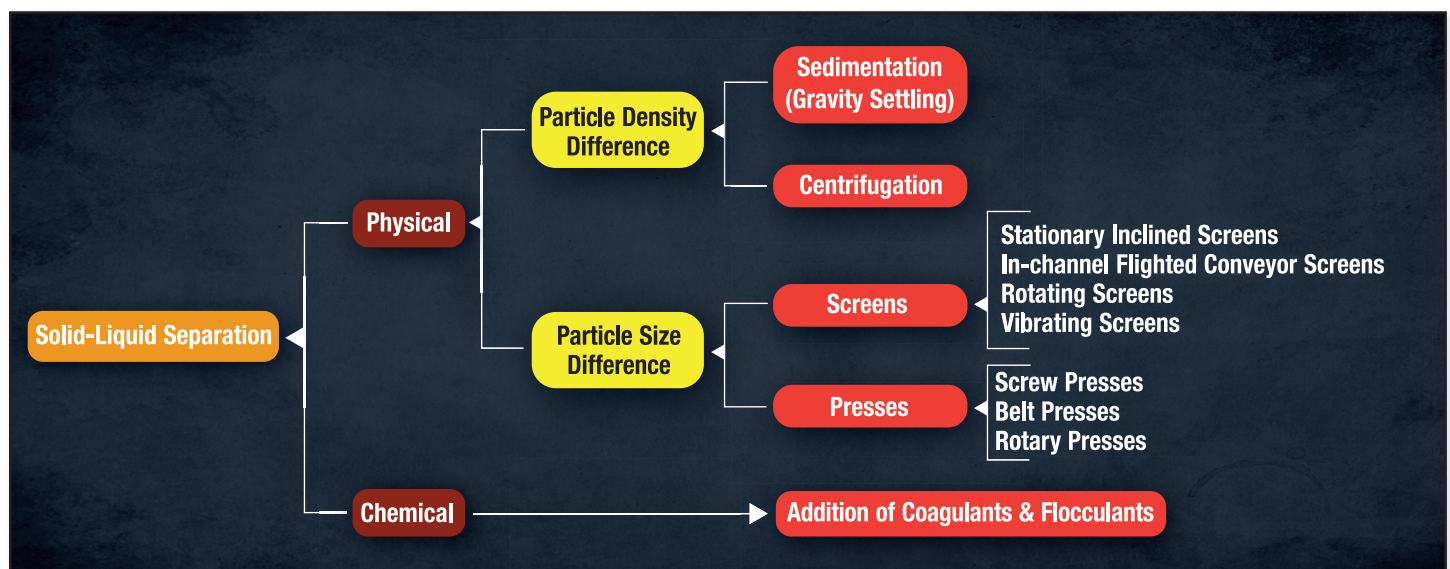
This approach has the advantage of moving the solids with their higher nutrient concentrations, especially phosphorus, to fields that have not routinely received as many nutrients. If a custom applicator service is used, it also has the advantage of allowing the producer to pump the easily managed liquids with irrigation equipment without agitation, while leaving the more difficult solids for the custom applicator. In Arkansas,

liquid animal waste management systems are regulated under 8 CAR pt. 24, Liquid Animal Waste Management Systems, formerly known as Regulation 5. Producers should follow their permit, approved waste management plan, and nutrient management plan. Liquid manure should be tested for nutrients before land application.

While it is also possible to reduce the cleanout frequency of settling basins to once a year, there are some significant drawbacks. The ability of settling basins to concentrate manure solids in a smaller and more easily agitated unit will be significantly reduced after the basin is full because most of the solids will flow through to the larger holding pond. If the settling basin precedes a lagoon, the lagoon will be overloaded. This will quite likely result in reduced treatment efficiency, more odors, and increased solids accumulation.

The traditional recommendation for lagoons has been to remove the liquid storage volume twice a year without agitating the solids. Then about every five years (when the settled solids or sludge volume is full), remove the solids as well. An issue with this approach that must be addressed is that an accumulation of several years of sludge also builds up several years of nutrients. Since the sludge is land applied at agronomic nutrient rates, the required application area for a sludge application is significantly greater than normal. An alternative is to perform more frequent partial cleanouts of sludge. Some experts recommend leaving some sludge so that the lagoon remains biologically active.

Figure 1. Solid-liquid separation methods.



## Selecting Solid-Liquid Separation Methods

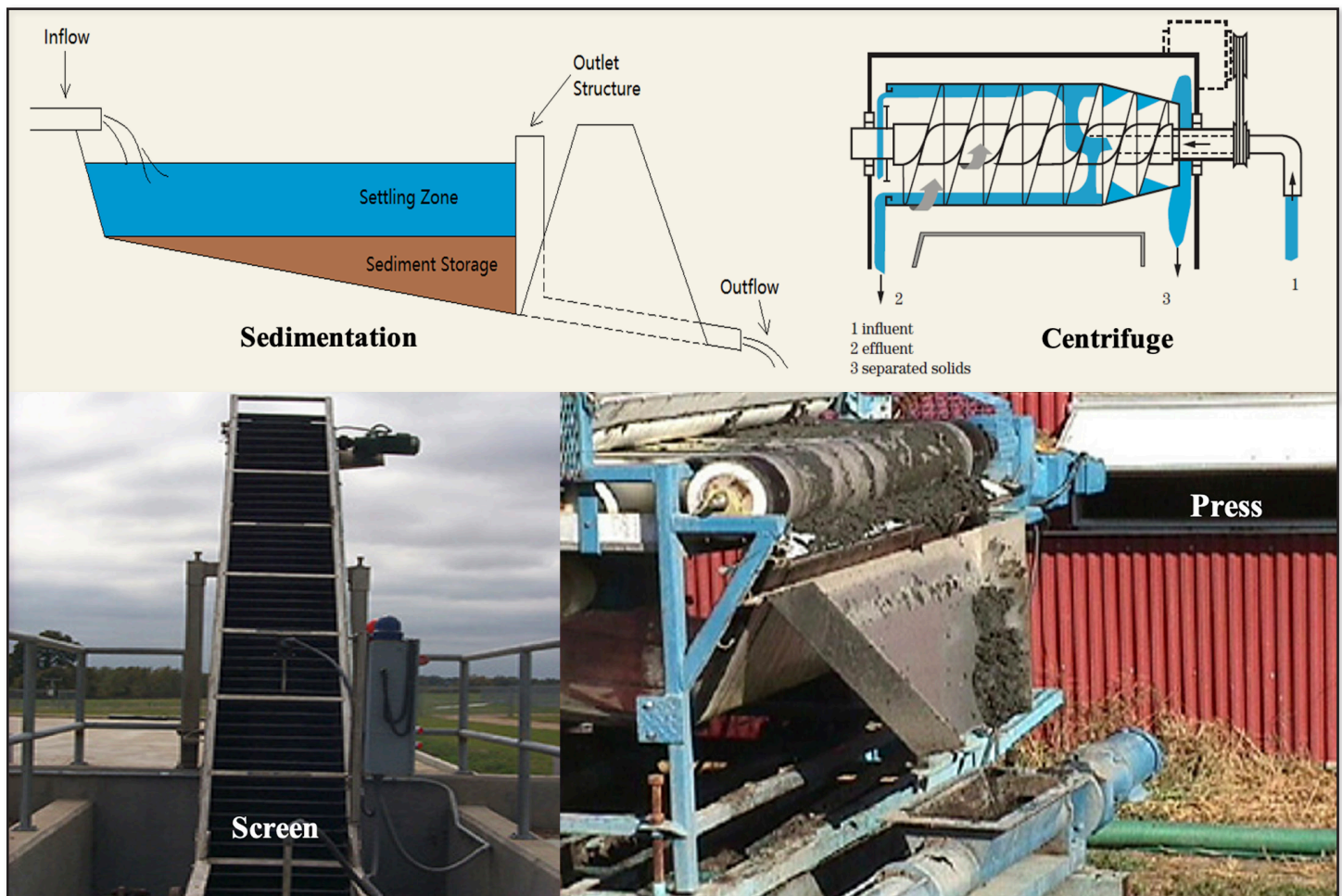
Solid-liquid separation can be used in liquid manure systems to achieve a variety of objectives, including but not limited to excluding solids build-up from a storage structure or lagoon, improving the pumping performance, reducing organic loading into a treatment lagoon, and providing treatment for runoff from outdoor feedlots. A wide range of solid-liquid separation methods are available (shown in Figure 1). Some photos of different separation methods are also shown in Figure 2. To achieve optimal solid-removal performance, some options may use a combination of methods or multiple stages.

Each solid-liquid separation method can be best suited for certain types of animal feeding operations. Each system is designed to separate a range of particle sizes, and its efficiency depends on the flow rate of liquid manure, the shape and size distribution of the particles and their

chemical nature. Table 1 summarizes the application scenarios for each solid-liquid separation system. Producers should confirm equipment selection with manure testing, flow rate, bedding type, solids content, and vendor specifications.

Generally speaking, sedimentation is commonly used if the site has abundant land/space and receives slow flow of liquid manure with low solids content, which is simple in design and operation with low cost and energy inputs. For more compact systems, mechanical separation systems can be employed. For primary treatment with low solid content, screens are a good option due to their relatively simple operation and easy maintenance for fewer moving parts. For secondary treatment with higher solids content and more complete solid-liquid separation, centrifuges and presses are recommended. Both types of separators can provide high efficiency solid removal and produce drier separated solids and cleaner effluent liquids. However, they

Figure 2. Typical examples of different solid-liquid separation methods (left-top: sedimentation, right-top: centrifuge, left-bottom: screen, right-bottom: press)



also require greater capital and operating costs, higher energy input and more complicated operation and maintenance. If desired or needed, chemical enhancement can be applied for solid removal and nutrient management (such as phosphorus and nitrogen). Better and faster separation will be achieved with addition of coagulants and flocculants, generating more condensed solid sludge and cleaner effluents. However, chemical addition requires well-trained operators to determine optimum dosing, adjust pH, and provide careful handling of chemicals with hazardous concerns. Cost and energy inputs of chemically enhanced separation are also higher compared to physical separation methods.

## Benefits of Solid-Liquid Separation

Solid-liquid separation has traditionally been viewed as a method to improve the

pumping and irrigation characteristics of liquid manure and to generate solids for composting or land application. More recently, solid-liquid separation has been used to facilitate implementation of secondary biological treatment, reduce sludge build-up in lagoons, facilitate better nutrient management practices, and facilitate the use of the organic portion of manure as an energy source.

### Benefits for Storage

The benefits of providing solid-liquid separation of manure prior to storage include improved pumping and handling characteristics of the manure, reduction in agitation requirements, and reduction in storage volume.

### Benefits for Lagoon

Lagoons are the most common biological method used to treat and store liquid manure from

METHOD	BEST-FIT SCENARIO	EXPECTED BENEFITS	OPERATION AND MAINTENANCE NEEDS
Sedimentation	<ul style="list-style-type: none"> <li>Primary treatment</li> <li>Highly diluted liquid manure (&lt;3% total solids)</li> <li>Slow flow velocities (&lt;0.5 ft/sec)</li> <li>Long retention time (&gt;20 min)</li> <li>Large treatment volume</li> </ul>	<ul style="list-style-type: none"> <li>Simple design with fewer moving parts</li> <li>Lower initial &amp; operational costs</li> <li>Lower energy inputs</li> </ul>	<ul style="list-style-type: none"> <li>Remove the settled solids periodically</li> <li>Ineffective for fine particles capture</li> <li>Potential algal growth for long retention period</li> </ul>
Centrifugation	<ul style="list-style-type: none"> <li>Secondary treatment</li> <li>Slurry with 5-8% total solids</li> <li>Dewater the sludge</li> </ul>	<ul style="list-style-type: none"> <li>High efficiency (up to 85% solids removal)</li> <li>Durable &amp; lower media costs</li> <li>Handle various manure types and feed rates</li> <li>Small footprints</li> </ul>	<ul style="list-style-type: none"> <li>High energy inputs</li> <li>More complex maintenance</li> <li>Trained operators for safety procedures (high rotating speed of 3,500-5,000 rpm)</li> </ul>
Screens	<ul style="list-style-type: none"> <li>Primary treatment</li> <li>Large fibrous particles removal</li> <li>Liquid manure with &lt;5 % total solids</li> <li>Slower flow rate</li> </ul>	<ul style="list-style-type: none"> <li>Simple design with fewer moving parts</li> <li>Minimal energy inputs</li> <li>Low initial cost and maintenance</li> <li>Small footprints</li> </ul>	<ul style="list-style-type: none"> <li>Pumping required</li> <li>Manually clean the screen to prevent clogging, unless an auto-cleaning feature is installed</li> <li>Inability to remove very small solids</li> </ul>
Presses	<ul style="list-style-type: none"> <li>Secondary treatment</li> <li>Thicker manure with &gt;6% total solids</li> <li>High-capacity processing</li> </ul>	<ul style="list-style-type: none"> <li>Significantly reduce liquid manure volume</li> <li>Produce dry solids for recycled bedding materials</li> <li>Improved liquid management</li> <li>Small footprints</li> </ul>	<ul style="list-style-type: none"> <li>High capital cost</li> <li>High energy inputs</li> <li>High maintenance requirements</li> <li>Requires dual management for two streams (solids and liquids)</li> </ul>
Chemical	<ul style="list-style-type: none"> <li>Liquid manure with high proportion of fine particles &amp; low total solids content (&lt;6%)</li> <li>Cleaner separated liquid needed for further treatment or approved reuse</li> <li>More complete separation between solids and liquids</li> </ul>	<ul style="list-style-type: none"> <li>High-efficiency solid removal</li> <li>Faster settling &amp; quicker separation</li> <li>Improved phosphorus and particulate organic nitrogen removal</li> <li>Improved separated liquid quality</li> <li>Reduced sludge volume</li> <li>Customizable for various manure types &amp; targeted for various contaminants</li> </ul>	<ul style="list-style-type: none"> <li>Chemical cost &amp; handling</li> <li>Operational complexity &amp; required skilled operators</li> <li>pH sensitivity &amp; need adjustment</li> <li>Generated sludge may need careful disposal</li> <li>Can leave residual metals or polymers in separated liquid</li> </ul>

**Table 1. Comparison among different solid-liquid separation methods.**

Note: Typical ranges vary by manure type, bedding, dilution, and management goals. Use these values as screening guidance and confirm with site-specific testing and vendor specifications.

animal facilities. Most lagoons are constructed as a lined earthen basin and, as a result, lagoons look similar to a storage pond. However, a treatment lagoon is designed based on anaerobic and/or facultative treatment principles. In addition to the storage volume for liquid manure (like a storage pond), lagoons also need additional volumes for the controlled biological treatment (treatment volume) and the accumulated sludge (sludge storage volume). Providing primary treatment using solid-liquid separation will reduce a significant fraction of the solids that will enter a lagoon, which can reduce the treatment volume and sludge accumulation. For new lagoons, that means smaller footprints and lower construction costs. For existing lagoons, that means greater treatment capacity, longer operation life and less frequent sludge removal.

### **Odor Control**

Research has shown that the odor occurrence near manure storage and treatment lagoons is related to the volatile solids loading rate. By reducing the volatile solid loading rates with solid-liquid separation, substantial odor reduction can be achieved.

### **Managing Separated Liquids and Solids**

Solid-liquid separation concentrates a portion of the nutrients into a smaller volume of separated solids. In general, removing solids from liquid manure also removes a significant portion of phosphorus and organic nitrogen because these components tend to associate with the solid fraction. As a result, the liquid effluent from solid-liquid separation often contains lower concentrations of total nutrients, organic matter, and suspended solids, which can reduce organic loading to downstream treatment lagoons and improve pumpability and irrigation performance. When managed correctly and verified through nutrient testing, lower nutrient concentrations in the liquid fraction may help operations meet phosphorus-based land application requirements and better match application rates to crop needs. However, separation does not eliminate the need for nutrient management planning. Both the liquid and solid fractions should be sampled and managed with

nutrient-based application rates. Separated solids may require additional land base or off-farm transport depending on farm goals and local constraints.

### **Safety Precautions**

Safety protocols should be followed during the storage, handling and separation of liquid manures.

- Avoid stepping on crusts since they can collapse. The poor buoyancy of liquid manure can create drowning hazards.
- Never enter manure storages or pits without proper training in confined-space procedures. Toxic gases such as methane, hydrogen sulfide, ammonia, and carbon dioxide can build up quickly, especially during agitation, and become lethal.
- Start agitation slowly and keep ventilation running in enclosed barns to help control gas release during mixing.
- During operation of mechanical separation, strictly follow equipment operation manuals, and use caution when operating equipment with high rotation speed or pressure.
- For chemically enhanced separation, store and handle chemicals with extra caution, to avoid chemical reactions and spills.
- Properly handle the separated solids and liquids for either further treatment or storage.
- If separated liquid is recycled for irrigation, test water quality first and follow nutrient management and water-quality guidelines. Do not allow separated liquid or runoff from land application to enter ditches, streams, ponds, or other water bodies.

### **Summary**

Effective solids management helps maintain the designed storage volume of liquid manure systems and reduces pumping, overflow, and water-quality risks. When routine agitation and pump-out are not sufficient, solid-liquid separation may be considered, but both the separated liquids and solids should be sampled and managed using nutrient-based application rates.

## References:

Arkansas Pollution Control and Ecology Commission. (2025) 8 CAR pt. 24, Liquid Animal Waste Management Systems. <https://www.adeq.state.ar.us/regs/files/car/8CARpt.24.pdf>

Hjorth M, Christensen KV, Christensen ML, Sommer SG. (2010) *Solid-liquid separation of animal slurry in theory and practice. A review. Agronomy for Sustainable Development*, 30:153–180.

Pennsylvania State University (2025) *Manure Separation Facilities*. Penn State Extension. <https://extension.psu.edu/manure-separation-facilities>

Texas A&M University. (2018) *Solid-Liquid Separation of Animal Manure and Wastewater*. University Extension Services. <https://tammi.tamu.edu/2018/03/05/solid-liquid-separation-animal-manure-wastewater/>

USDA. (2019) Part 637 *Environmental Engineering National Engineering Handbook, Chapter 4 Solid-Liquid Separation Alternatives for Manure Handling and Treatment*. Natural Resources Conservation Service. <https://directives.nrcs.usda.gov/sites/default/files2/1712930729/29499.pdf>

USDA. (2009) Part 651 *Agricultural Waste Management Field Handbook, Chapter 10 Agricultural Waste Management System Component Design*. Natural Resources Conservation Service. <https://directives.nrcs.usda.gov/sites/default/files2/1720533311/Chapter%2010%20-%20Agricultural%20Waste%20Management%20System%20Component%20Design.pdf>

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