Phosphorus Best Management Practices

Protecting Water Quality

Physical Manure Treatment (Solids Separation)

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Definition:

Physical manure treatment is the process of separating suspended solids from a liquid carrying medium. Separation is attained by trapping the particles on a mechanical screen or sieve or by centrifugation; or in the case of gravity separation, with a basin that provides the proper conditions of velocity/retention to allow particles to settle.

Purposes:

Solid separation is used to:

- reduce the frequency with which solids must be removed from a storage or treatment facility
- facilitate the operation of a sprinkler irrigation system for land application of the separated liquid fraction
- allow the utilization of separated solids for such uses as re-feeding and bedding

How Does This Practice Work?

Different physical mechanisms are involved in the separation process, and their effectiveness depends on the shape, density and size of the solids particles involved. The separation process normally involves screening, centrifugation or gravity. Sometimes pressure, such as with a series of rollers, is used to remove additional liquid from the solids.

Screening is a process where the liquid passes through the screen, and solids slide or are brushed off the screen surface. The size and shape of the opening in the screen determines the size of the particles separated. The stationary, inclined screen or a variation is the most common screening separator. The liquid waste to be separated is spread over the top of the screen. The liquid falls through the screen, and the solids slide off the bottom edge. Other screens, including the vibrating screen and the roller drum screen, rely on a motor to move the screen and keep the solids moving. Centrifuge separators use centrifugal force to separate the liquid and solid fractions according to density, allowing the different fractions to exit the separator at different points.

Settling basins may be of earthen construction or constructed of concrete or concrete block. In the basin, the waste stream is slowed to allow gravity to settle the suspended particles. The more dense the particle, the more quickly they settle. Normally the settling basin needs sufficient volume for the water velocity to slow to a maximum of 1.5 feet per second. The settling basin is equipped with a device, often of wood construction, to allow for automatic dewatering. Solids must be removed from the basin on a regular schedule to maintain the basin's effectiveness.

Where This Practice Applies and Its Limitations:

Solid separation applies wherever manure and other agricultural-related residuals are collected and either treated or stored. The separation process can occur either before treatment and/or storage or after treatment and/or storage and land application. The solid separation process must be matched with pumps, pipelines and other components to insure the required flow rates can be achieved.

Some solid separators work well with high solid content waste, and others perform best with low solid

waste. The method of separation must be carefully matched with the consistency and fibrous nature of the material. Separated solids may still retain a lot of moisture, and provisions must be made for retention of drained liquid, as well as the safe storage of the solids. Settling basins normally take up more room than do mechanical separators and are labor intensive in their operation.

Effectiveness:

The effectiveness of mechanical separators is variable, based on the type of separator, type of animal producing the waste stream, the total solids content of the waste stream and other less defined factors. In general, mechanical separators are more effective with ruminant manure than they are with swine waste. Vibrating screens retain 55-70 percent of dairy total solids in the separated solids, 40-50 percent of beef total solids and 35-50 percent of swine total solids. The performance of static inclined screens for dairy waste is similar to that of the vibrating screen, but only 15 percent of the total solids are removed from the liquid fraction of beef waste, which consists primarily of lot runoff. Centrifuge type separators retain 35-40 percent of the total solids in dairy waste in the separated solids, but only 15 percent of the swine total solids.

The effectiveness of solid separation in removing nutrients in the solid fraction is not as well documented. From the limited data available, it appears mechanical separation can remove from 20-30 percent of the nitrogen (N) of the separated solids and as much as 35 percent of the phosphorus (P). Again, the actual amount of N and P removed will vary by separator and type of animal producing the manure stream.

Settling basins are somewhat more effective in removing total solids from the waste stream than are the mechanical separators. A properly sized settling basin will remove up to 60 percent of the total solids from the waste stream, with 40-60 percent being typical. Some settling basins for beef feedlots have been noted to remove up to 90 percent of the total solids from the waste stream. The N and P removal in settling basins will be similar to the mechanical separators.

Cost of Establishing and Putting the Practice in Place:

The cost of mechanical separators can vary widely, with common ranges from approximately $5,000 to greater than $20,000 depending on separator type and size. Size is normally discussed in terms of throughput or volume per unit of time, such as gallons per minute. Ancillary components such as pumps, pipelines, stacking pads and reception pits are often needed.

Settling basins are generally less expensive than mechanical separators due to their simplicity. Typical costs are $3,000 to $5,000 for earth construction and $5,000 to $10,000 with concrete and concrete block. However, as mentioned above, the settling basin will usually require more land and require more labor input.

Mechanical separators in general produce a relatively consistent solids fraction that can be used as bedding in a dairy setting, or possibly used as a feedstock for beef and non-lactating dairy animals. Both the solid and liquid fraction can be land-applied to improve soil conditions and to supply the nutrient needs of a crop. Often the most return from the solid separation process is measured in the reduction of the cost to remove solids from the storage or treatment facility.

Operation and Maintenance:

Maximum flow rates are critical for the proper operation of mechanical separator and the settling basin. If the flow rate in a settling basin exceeds the rate assumed in design, the hydraulic residence time may not be adequate to settle the solid particles. If the flow rate exceeds the screening capacity of a mechanical separator, the efficiency of the separator will be reduced, resulting in a too-wet solids fraction. Generally, the manufacturer's information discusses minimum and maximum flow rates. Both the settling basin and mechanical separator operation are sensitive to the total solids content of the waste stream. Typically, settling basins work best with a total solids content of 1 percent or less. Manufacturer's literature for mechanical separators should detail the appropriate range of total solids in the waste stream.

Settling basins will need to be cleaned out regularly. The frequency of clean out is normally identified during the design phase and should be timed with opportunities for land application. The solid material should be tested for nutrient content and applied either on a N or P basis, depending on current rules and regulations. Many times settling basins are built in parallel so one can dry and be cleaned out while the other is filling. De-watering devices should be checked frequently to insure water can freely escape the facility.

Solids sometimes adhere to screening devices, and if allowed to dry can clog the screen, reducing the efficiency of the separation process. Rinsing the screen after each use will prevent this problem. Stacked solids beneath mechanical separators will often need to be removed to another location before end use.

Life expectancy of solid separation components will vary with

type of material, climate and frequency of use. With proper maintenance, a 10-year life should be expected.

Maintenance of settling basins should be similar to the maintenance of other earthen or structural components of the system. Concrete and concrete block structures should be checked frequently for cracks and premature degradation, and if problems are discovered, they should be corrected. Earthen basins should be checked for signs of leakage or slope failure, and corrective action taken if needed. Vegetation along the edges should be kept mowed, and weeds and woody vegetation removed. Any wood appurtenances should be checked for both natural deterioration and damage caused by humans or livestock, and replaced where necessary.

Screening devices are normally constructed using various kinds of metal. These devices should be checked regularly for deterioration of protective coatings and repaired as necessary. Many mechanical separators also involve the use of electric motors, pumps and gears. These should be routinely maintained as recommended by the manufacturer.

Manure-related facilities are associated with varying levels of safety concerns. Fences and warning signs should be employed as appropriate. Safety guards should be installed and maintained on all exposed moving parts, and all electrical components should be grounded. Accumulation of gases in waste facilities can lead to explosions or asphyxiation. No one should enter a confined space associated with manure without taking proper safety precautions.

References:

More information on solid separation can be found in USDA-NRCS's Agricultural Waste Management Field Handbook (AWMFH), Chapters 10 and 13. The AWMFH can be found on the Web at http://www.ftw.nrcs.usda.gov/awmfh.html. Normally each land grant university will have information on solid separation techniques used in the local area.

For Further Information:

Contact your local conservation district, USDA-NRCS or Cooperative Extension Service office.