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Agriculture and Natural Resources

Liquid Manure Solids Management

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Introduction

Liquid manure contains urine, manure, waste drinking water, flush water, waste feed and animal hair. It can also contain such foreign objects as construction debris, medical supplies and other objects dropped in the barns. However, these foreign objects should be prevented from being added to the manure.

Since manure is biologically active and consists of components with different physical characteristics, several things take place during storage. Biologically, microorganisms begin to break down, or digest, the manure into smaller components. The degree of digestion is greatly affected by the type of manure storage unit and the length of storage. Typically in-house pits, concrete tanks, settling basins and holding ponds are considered storage units in which a minimal amount of digestion takes place. In contrast, lagoons are designed and managed to maximize the digestion. When digestion takes place, the manure is converted into products that volatilize off as gasses, settle out as solids or remain in solution. Physically, the manure segregates into fractions that tend to float, sink or remain in suspension.

As a result of this biological and physical activity, the solids in a liquid manure unit can be found as a floating crust, in suspension or as settled solids. Sometimes, especially with dairy manure, the crust can become thick enough for the top to dry out. If this crust covers enough area, it can help to reduce odor emission from the manure. However, the crust can be a challenge to remix with the rest of the manure and land apply. The manure solids that remain in suspension typically do not cause a problem except in the case of salt formation on recycle lines.

The most problematic fraction of the manure is the settled solids that form a layer of sludge. If the settled solids are not periodically removed, the sludge layer starts occupying the space designed for liquid storage, reducing the available storage volume. This results in a need to pump manure more frequently, which increases the chances of having to land apply manure under environmental conditions that enhance the risk of runoff. The reduced storage volume also increases the chances of freeboard violations and overflows. This type of situation can have significant production, environmental, legal and economic consequences.

This publication focuses on the recommended strategies and the available equipment to manage the solids in liquid manure storage systems. For more comprehensive information on liquid manure systems, refer to the University of Arkansas Extension publication *Liquid Animal Manure Management Systems*, MP395.

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

storages with clay liners as needed to prevent excessive leakage to the ground water. They all store the manure until it can be utilized. The storage period depends on the type of unit and the needs of the farming operation. It may be as short as 45 days for concrete tanks and settling basins. Holding ponds and lagoons usually allow for 180 days.

The design of lagoons is unique in that they are the only storage units that have a treatment volume intended to reduce solids incorporated into the design and management. This treatment volume increases the total volume of a lagoon to about 2.5 times that of holding ponds. Another feature of lagoons is that they have a liquid storage volume, typically 180 days, and a solids storage volume, typically 5 years in Arkansas.

Settling basins are unique in that they function as both solids separators and storage units. They are "flow-through" storage units with sufficient retention time that over half of the manure solids have the opportunity to settle out or form a floating crust. The liquid fraction containing the remaining suspended solids flows into either a holding pond or lagoon. This separation process is effective until the design volume of the settling basin is full. Then the retention time is reduced to the point that most of the solids flow through the settling basin and into the holding pond or lagoon.

Management Options

All liquid manure storage systems have a design storage volume that is matched to the number of animals being housed. This means that they have a design clean-out frequency in which the manure, whether it is a floating crust, a settled solid or in suspension, is removed and utilized. With all the storages, except lagoons, the basic premise of proper management is to agitate the manure so that any floating crusts and settled solids are thoroughly mixed then pumped out for utilization. For in-house pits and concrete tanks this premise should be followed. This means that at the appropriate frequency all of the manure is thoroughly agitated and removed.

The traditional recommendation for holding ponds was 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 phosphorous, to fields that have not traditionally 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.

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 a settling basin 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 effect, 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 5 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 accumulates 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 to is to perform more frequent partial cleanouts of sludge. Some experts recommend leaving some sludge so that the lagoon remains biologically active.

Solids Removal Cautions

Liner Protection

With earthen storages, the clay liner and the manure solids that are incorporated in the surface of the liner seal the storage and keep it from leaking. Damaging the liner can result in leaky manure storages and pollution of ground water. Therefore, when agitating or dredging to remove settled manure solids, it is important not to damage the liner on the banks or bottom of the storage.

Determining Application Rates

The nutrient concentration for manure solids is typically much higher than that of just the top water or even a well-agitated mix. Therefore, the amount of manure applied per acre should be adjusted to reflect the nutrient content of the manure. Consult your waste or nutrient management plan for guidance. If you are planning a one-time renovation or closure, your local conservation district can provide assistance in getting a plan approved by the Arkansas Department of Environmental Quality (ADEQ). Your local Extension office can provide assistance in manure and soil sampling procedures as well as determining appropriate nutrient application rates.

Agitation Equipment

Typically, the most economical way to routinely remove the solids is with agitation. This mixes the settled solids with the liquids prior to pumping. The most commonly used equipment is agitation pumps and prop agitators. Some equipment has both a prop and a pump. These types of equipment are available for use in tanks or earthen storages. For small tanks, the pump on a tank spreader may work to agitate the manure. However this often proves to be unsatisfactory.

Agitation pumps are PTO-powered low-pressure high-volume (3,000 to 5,000 gallons per minute) pumps. Prop agitators are PTO-powered propellers that are either trailer or three-point-hitch mounted. Both work by using the force of moving water to re-suspend the settled solids. Often agitation pumps also have multiple discharges that allow the pump discharge at different heights and directions to aid in mixing and loading tank wagons.

Since both pump and prop agitators use the force of moving water to re-suspend solids and maintain the velocity of the water to keep the solids in suspension, they have a limited range of effectiveness. It is commonly quoted that the maximum range is 50 feet or less from the discharge to re-suspend the solids.

How long, or how far, the solids stay in suspension depends on the size and shape of the manure storage. For smaller nearly square or round storages, the agitator can move enough water that the entire storage can be agitated, as all the water can be moved with enough velocity to keep the manure in suspension. However, it is commonly reported for larger storages that the agitators are able to re-suspend the solids near the bank; however, they then fall back to the bottom, forming an “island” of solids in the center of the storage.

There is a direct relationship between horsepower and how effective agitators are. The larger the horsepower rating of the agitator, the more effective it is in re-suspending manure solids and keeping them in suspension. This means larger agitators are able to agitate larger storage units. It also means that more than one agitator may be more effective than a single agitator. Most pump agitators designed for earthen storages require at least a 90 Hp tractor.

Due to the smaller horsepower requirements, prop agitators are more commonly used in Arkansas. The horsepower requirements of prop agitators start at about 45 Hp although 90 Hp and greater versions are available. There are several national name brands as well as locally manufactured prop agitators that have proven to be effective. However, there have also been some home-built agitators built with limited effectiveness due to design flaws such as unbalanced drive shafts and inefficient propeller designs.

Depending on the size of the storage being agitated, the amount of settled solids and floating crust and the agitator used, agitation may need to be started several hours before pumping. Because manure solids will usually settle out in less than 30 minutes, agitation should continue during the pumping. If the solids have accumulated over several years, it is likely that it will take several pumpings to remove the solids. Either that, or fresh water will need to be added for dilution.

For situations where pump and prop agitators are not effective, such as larger holding ponds and lagoons, or storages where there is a small amount of water covering very dense solids, there are two alternatives. For the case of severe solids buildup and little dilution water, it is possible to use a trackhoe or dragline to dredge the solids from the storage. If this approach is used, the teeth on the bucket should be replaced or covered with a solid lip so that the bottom of the storage is scraped smooth, not dug out. The dredged solids can either be loaded directly into a manure spreader capable of handling very wet slurries or they can be stockpiled and allowed to dewater. If they are stockpiled, the stockpiling area should be bermed so that it drains back into the manure storage, and the surface should be impervious enough to encourage runoff into the manure storage rather than perking into the ground water. Written ADEQ approval should be obtained prior to stockpiling.

For very large lagoons, another option is to use a floating dredge. These dredges are floating barges with variable-depth pumping heads to remove solids from the bottom of the lagoon. Depending on the size, they may have an operator onboard, or they may be operated remotely. Some have automated controls. The solids are pumped from the bottom as a thick slurry without agitation. This slurry can then be land applied by tank wagon or stockpiled and dewatered. If stockpiled, the same general process described above should be followed, except that additional care will probably be required as the slurry is liable to have a much greater tendency to flow.

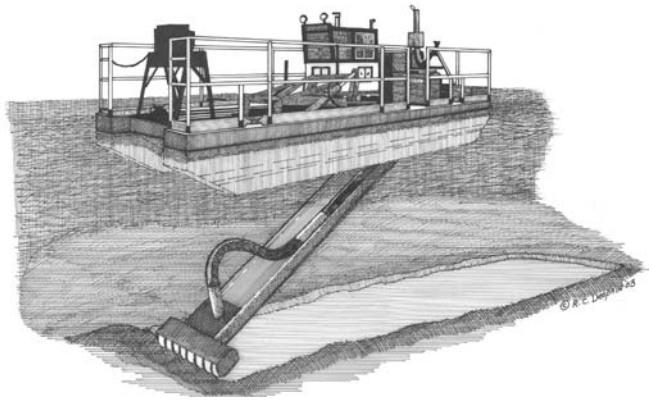

Figure 1. Schematic drawing of a dredge in operation.

Figure 2. Fabric dewatering tube after it has been loaded.

One dewatering option that is starting to see some use is dewatering tubes made of porous fabric. The concept is to locate the tube in the bermed dewatering area so that the leachate drains back into the manure storage. The manure slurry is then pumped into the tube and left to sit. Over time, moisture leaches from the tube until the solids are dry enough to handle with a manure spreader. At that time, the tube is cut open and the solids land applied. After this, the fabric is disposed of.

Additives

A common question concerns the use of additives to reduce manure solids and control odors. There are a large number of products on the market that make these claims. To date, few have been demonstrated effective in replicated research trials. And, most of this work has been conducted under controlled laboratory settings. However, there is anecdotal evidence that some products do work.

If manure solids and odors are a concern, the overall manure management system should be reviewed for possible improvement, especially in the area of solids management. Then, if additives are to be tried, the manufacturer's guidelines should be followed. If possible, free samples or test periods should be obtained. Prior to purchasing and during evaluation, the long-term costs should be compared to the benefits. Other questions should also be addressed. For example, if the use of additives requires a change in management practices, would the change in practices be just as effective without the additives?

Above all, it should be remembered that, at best, additives would be a component of a complete manure management system. They will never completely replace other tools to manage manure solids and odors.

Solids Demonstration

From 2001 to 2003, the Environmental Protection Agency partially funded a manure solids demonstration project at the University of Arkansas Swine Farm and two commercial swine farms in central Arkansas. The objective of the project was to demonstrate that by using available equipment it was possible to prevent the accumulation of manure solids at the new University farm and to reduce the accumulation at existing swine farms. To accomplish this demonstration the University purchased a prop agitator and also hired a custom applicator to manage the manure in its settling basin (Figures 3 and 4). On the two commercial farms, at the beginning of the project the owners had just initiated improved solids management practices by obtaining the prop agitator shared between them. On all three farms, periodic measurements, using survey and global positioning equipment, were used to determine the elevation of the manure solids at multiple locations. Computer software was then used to convert these measurements into surface maps. The same software was used to generate maps to show the

Figure 3. Trailer-mounted prop agitator with mid-size tractor.

Figure 4. Lagoon agitation pump with load pipe and tank spreader in the background.

areas of accumulation and reduction in manure solids as influenced by agitation over the life of the project.

At the University of Arkansas farm, both the prop and pump agitators were effective in mixing the manure prior to pumping. Figures 3 and 4 show the agitators used, while Figure 5 shows the settling basin after pumping near the end of the project.

Figure 5. University of Arkansas Swine Farm settling basin after agitation and pumping. This is the same basin shown in Figures 3 and 4.

Figure 6 shows the surface maps for one of the holding ponds on the commercial farms. It also includes a map showing the areas of solids accumulation and reduction. This figure shows that agitation was effective over time to reduce the manure accumulation. It also shows how the manure surface changes with agitation.

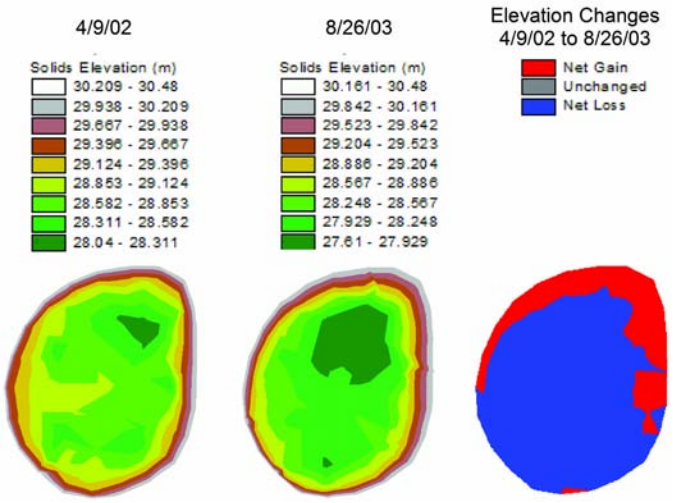

Figure 6. Countour maps showing the effectiveness of agitation in removing solids accumulations from a swine holding pond.

This project demonstrated that by using commercially available equipment and service it is possible to manage manure solids so that existing storage capacity is maintained and capacity lost to accumulated solids can be recovered.

Summary

Liquid manure tends to segregate into floating solids, suspended solids and settled solids. At some point, all liquid manure storage units will have to have the settled solids removed. With the exception of lagoons, the settled solids should be removed at least once a year and more frequently for in-house pits and tanks. At the end of their design life, even lagoons will have to have the settled solids removed as part of the renovation process.

Management options and equipment are available to properly manage manure solids to address production, odor, environmental and legal concerns.

References

Liquid Animal Manure Management Systems. MP395. 1997. Cooperative Extension Service, University of Arkansas, Little Rock, Arkansas.

Sludge Management and Closure Procedures for Anaerobic Lagoons. 2000. North Carolina State University Cooperative Extension Service.

Closure of Lagoons and Earthen Manure Storage Structures. 2002. Texas A&M University Extension Service.

Geo-Textile Tube Dewatering of Lagoon Solids. J. W. Worley, et. al. Paper presented at Ninth International Symposium on Animal, Agricultural and Food Processing Wastes, Research Triangle Park, NC, October 12-15, 2003.

Closure of Earthen Manure Structures (Including Basins, Holding Ponds and Lagoons). 2001. A White Paper Summary from National Center for Manure and Animal Waste Management.

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