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Abstract

Sand can be handled successfully either in a scrape or flush system by developing handling systems that allow for the sand-laden manure to settle prior to the effluent entering a lagoon. The abrasiveness and density of sand create problems in handling the manure. Manure weighs about 60 lb/cu ft, whereas sand has a density of 120 lb/cu ft. Sand-laden manure will have an approximate density of 80 lb/cu ft, if 30% of the manure is sand. Because sand is heavier, it will not remain in suspension as long as manure and settles rapidly. Many problems associated with handling sand-laden manure can be avoided if the solids are stored separately from the effluent.; Dairy Day, 2000, Kansas State University, Manhattan, KS, 2000;

Keywords

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FLUSHING SAND-LADEN MANURE

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Summary

Sand can be handled successfully either in a scrape or flush system by developing handling systems that allow for the sand-laden manure to settle prior to the effluent entering a lagoon. The abrasiveness and density of sand create problems in handling the manure. Manure weighs about 60 lb/cu ft, whereas sand has a density of 120 lb/cu ft. Sand-laden manure will have an approximate density of 80 lb/cu ft, if 30% of the manure is sand. Because sand is heavier, it will not remain in suspension as long as manure and settles rapidly. Many problems associated with handling sand-laden manure can be avoided if the solids are stored separately from the effluent.

(Key Words: Flush, Sand, Manure, Bedding.)

Review of Flushing Sand-Laden Manure

Flushing dairy manure is an alternative to blade scraping of freestalls or holding pens. Advantages include labor reduction with automated systems, limited scraping requirements, lower operating cost, drier floors, potential reduction in odor, and cleaner facilities. An optional method of handling manure may be necessary in colder weather. Flushing does not eliminate the need to apply the manure and effluent to land at environmentally acceptable levels.

Daily water requirements for flushing vary depending on the width, length, and slope of the alley and bedding material. With organic bedding at a slope of 3%, a minimum flush volume is 100 gal/ft of gutter width for flushing lengths of less than 150 ft. Longer lengths require more water with a suggested maximum release of 175 gal/ft of gutter width. A study of six dairies found flush water requirements ranging from 240 to 620 gal/cow/day. Another procedure suggests selecting the larger of two volumes — either 52 gal/cow/flush or 1.35 gal/sq ft of alley/ flush. Observations with sand-laden manure (SLM) suggest that a high-velocity flush system can clean alleys with less with than 1 gal/sq ft, whereas low-velocity system may require more than 4 gal/sq ft.

The cleanliness of an alley depends on the energy of flush water to remove the SLM. Design practices suggest that the flushing wave needs to be 150 ft in length, 3 inches deep, and moving at a velocity of 5 ft/sec. Buildings longer than 450 ft require the flush wave to be at least 1/3 of the total length. If the length is less than 150 ft, then the design procedure is based on a 10 sec contact time. The amount of time flush water moves past a given selection of the alley is known as contact time. However, based on observed procedures, contact times of 10 min or longer often are used in flushing alleys, if the velocity is less than 3 ft/sec. These dairies are using longer flush times in an attempt to avoid scraping alleys.

The two basic flush mechanisms are high- and low-velocity systems. For purposes of this paper, a high-velocity flush system uses wave velocities greater than 5 ft/sec with 7.5 ft/sec being preferred. Low-velocity flush

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systems have wave velocities of less than 5 ft/sec, generally around 3 ft/sec.

Storage structures often are used for high-velocity flush systems, and pumps generally are used for low-velocity flush systems. A tank or tower at the upper end of the area being flushed is used to store the flush water. Flushing tanks with 4 to 12 ft depth have large discharge openings. Towers have depths of 20 ft or more and discharge through 12- to 24-in-diameter pipe. A low horsepower pump is used to transfer water from the lagoon to the storage tank. Flushing-pump systems utilize the lagoon for storing the flush water. A large horsepower pump then pumps the water to the upper end when flushing is desired. Storage towers may be used with low-velocity flush systems, but piping losses reduce the flow velocity.

The release rate varies from a minimum of 10 sec to more than 60 sec for longer buildings with high-velocity flush systems. Release rates can vary from 1,000 gal/min to over 15,000 gal/min, if the system is designed properly. Flush water pumping or low velocity flush systems often are limited by the pump capacity, and the water-release rate is 60 sec or longer. Most of the pumping systems are limited to a release rate of less than 3,000 gal/min.

A simple high-velocity flush system consists of tanks that are 9 to 10 ft in diameter and 25 ft or taller. The flushing system may use a 6- to 7-ft section of 16-inch pipe exiting the tank at a right angle. This pipe has a 45° slope inlet inside the tank. Another 6- to 7-ft section of 12-inch pipe, which includes a 12-inch manual gate valve, then is used to carry the water to the flush alleys. The pipe outlet directs the water along the freestall curb. One field study found that flush velocity decreased from 11.5 ft/sec to 6.7 ft/sec as the head decreased from over 30 ft to less than 10 ft. Based on the number of freestalls and flushing three times per day, the water usage was 48 gal/stall/flush or 140 gal/day/stall. The water usage based on a 8,500 gal/min discharge rate and a 30-sec flush was equal to 0.84 gal/sq ft, giving a flow rate of 700 gal/min and a water usage of 350 gal/ft width of gutter.

Field flush velocities were obtained from four barns using concrete tanks with manual guillotine or scissor-gate flush system. Two of the barns released the flush at a 90° angle to the alleys. The release was parallel to the long axis of the alleys in the other barns. The tanks were commonly 4 ft deep with length and width dimensions of 12 ft by 16 ft. The flush water exited the tank through an orifice measuring 8 inches by 96 inches at full opening. The flush velocities in the guillotine tanks were 6 to 9 ft/sec. The tanks with the flush water exiting at a right angle to the alley had a flush velocity 2 ft/sec slower than the other tanks.

Some scraping or manual cleaning along the freestall curb may be needed, because much of the manure is deposited here. A 0.75- to 1-inch crown in the alley is needed to direct more flush water along the curbs, if freestalls are along both sides. The crown will interfere with scraping. Recently, alleys have been sloped 0.5 to 1 inch from the outside to the freestall curb to increase the depth of the flush wave along the curb with head-to-head freestalls.

Flush water commonly is released using "pop-up" or recessed valves controlled manually or automatically. Automated valves are operated pneumatically. Discharge rate from a valve is influenced by the hydraulic characteristics of the pipeline to the valve. Common design procedures connect multiple tanks to a valve from both sides to maintain a higher head pressure and, thus, increase the discharge rate. Other release methods include a hinged plate, open pipe, and gated pipe.

Flush water is collected at the lower end of a building in a gutter alley or basin. The water flows towards a mechanical separator or gravity-settling basin. The separation allows the solids to accumulate in a basin and the liquid to drain to a lagoon.

Dairies using sand-bedded freestalls need to have a sand trap or sand separator located ahead of the mechanical solids separator. The abrasive action of sand in the pumps and on screens in mechanical solid separators decrease equipment life and increases maintenance cost.

The mechanical separator may be an inclined screen, press roller, or screw press. The inclined screen allows the liquid to pass through the screen, and the solids remaining on the surface are transferred to a storage area. In the press roller, the flushed material passes through a pair of rollers and the water drains away. The screw press uses more pressure to separate liquids and solids. Gravity type systems use a settling basin to settle out the solids and drain off the liquids.

Based on visual inspection of alleys with sand bedded freestalls, the minimum flush velocity should be 5 ft/sec with 7.5 ft/sec being preferred. Current guidelines on release rates with 400-ft alleys seem to be adequate. The water depth at the freestall curb should be a minimum of 3 inches with 4 inches preferred. The energy of the flush water needs to be directed along the freestall curb rather than in the center of the alley.

Gravity and mechanical separations are two basic methods for settling out the sand from the manure stream prior to solids separation. Gravity basins depend on the ability of the system to slow the flush velocity to 1 to 2 ft/sec. At these velocities, the organic matter appears to remain suspended with the liquid and will discharge from the sand trap with minimal settling. Field data show that less than 3% of the solid material in the sand trap is organic material. The sand can be recovered from a solids-separating basin, because much of it settles out near the discharge pipe when a flush system is used. Generally the sand is stacked and dried prior to its reuse.

A mechanical separator has been developed that has the ability to recycle 90% or more of the sand from the waste stream. The sand is much cleaner than that from a gravity separator, because it is washed. The mechanical separator works better with coarse sand than fine sand. Studies have shown that inclined screens are not effective in separating sand from the waste stream. The screen openings are larger than the sand particles. Sand also had a tendency to settle out upstream of the inclined separator as the flush wave velocity is reduced.

Here are some general guidelines to remember when working with sand:

1. Sand-laden manure will not stack or pile like manure mixed with organic material. It tends to spread and move away, particularly in wet weather.

2. The longer sand-laden manure is in storage, the easier it is to handle. A minimum storage of 45 days is recommended.

3. It is easier to handle sand-laden manure contained in a structure other than the lagoon or holding pond.

4. Begin the waste-handling system design by taking advantage of gravity. Use pumps and augers as a last resort in moving the manure stream.

5. Generally, the top surface will be a slurry, and initial emptying of a solids-storage basin takes time. Once the slurry is removed (for small dairies, this represents about 10%), the rest of the material in the structure will be at less than 80% moisture.

6. Flushing systems work better when the energy created by the water depth or head pressure in the flush water tower (and pumps) is used to move manure and sand rather than flush water through the pipes and elbows. A certain amount of energy is lost for every foot of pipe the flush water must move through. When flushing sand, it is better to purchase more storage towers and move them closer to the alleys than to buy pipes and elbows. If the piping system is desired, then use a larger pipe for the manifold system and do not reduce down to the pop-up valve size until after the last elbow or tee joint.

7. Some producers are experimenting with stockpiling gravity-separated sand. Most are partially blending the dirty sand with clean sand. The stockpiling period ranges from 1 to 6 mo prior to reuse. The runoff from the sand pile should be contained and transferred to the lagoon. In a recycled flush water system, the additional drainage area may be beneficial in providing some extra flush water.

Summary

Flushing can be a viable alternative to scraping of dairy manure. Facilities can be constructed for the addition of flushing systems at a later date, even if scraping is planned in the immediate future. This requires placing the buildings at a recommended 2% slope. A 6 to 8 ft difference in elevation between the lower end of the flushed areas and the lagoon freeboard will be necessary for inclusion of separation equipment and transfer collection gutters. Inclusion of flushing systems in existing buildings must be determined on an individual basis. An adequate supply of fresh water for flushing the milk parlor and holding pen also must be available.