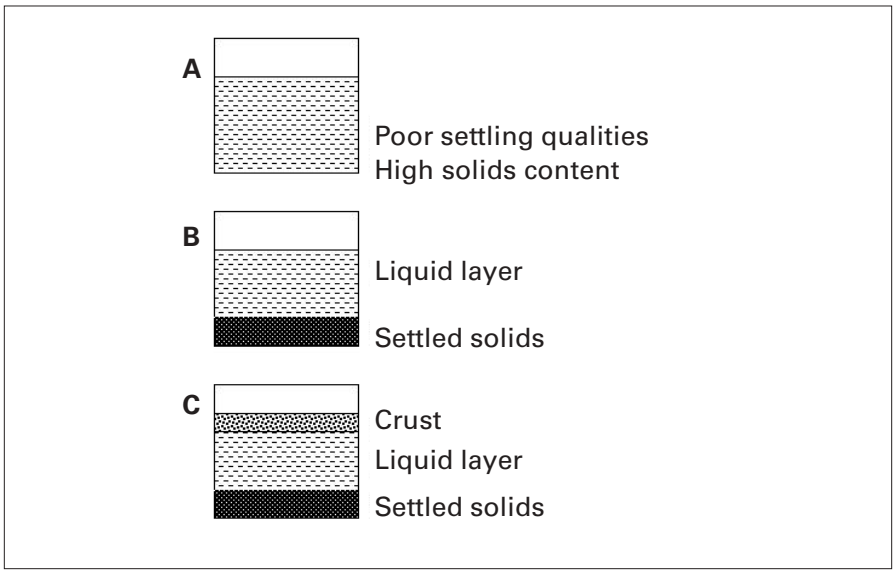

Figure 43-5. Manure settling patterns.

Liquid/Solid Separation

Sedimentation or gravity

Liquid/solid separation is sometimes used to reduce the loading on anaerobic lagoons and thus reduce odors. Sedimentation is the separation from water, by gravitational settling, of suspended particles that are heavier than water. The terms "sedimentation" and "settling" are used interchangeably. The three main types of settling patterns, each exhibiting varying forms of stratification (Robertson 1977), are illustrated in Figure 43-5.

Type A settling usually occurs in manure containing a high percentage of suspended solids (approximately 10% or more), including extraneous bedding material and food residues. Manure from swine houses using wet/dry feeders will exhibit Type A settling. Type B is commonly found in the storage of swine manure with a high proportion of solid particles with a specific gravity greater than one and low total solids (TS) content (< 7%). Type C is found in cattle manure. The crust formation is caused by the presence of food residues and solid particles with a specific gravity less than one.

Most readily settleable solids in livestock manure settle in about 30 minutes... .

Table 43-1. Settling basin performance (results in wet basis).

Manure	Input Solids, %	% Removal from Liquid					Reference
		Solids	COD	TKN	N-org	TP	
Flushed dairy	3.83	55 (VS)	61	-	26	28	Chastain et al. 1999
Dairy	1.1	65	-	40	-	-	Powers et al. 1995
Poultry, beef, dairy, swine, horse	-1	45-76[a]	28-67[a]	-	-	-	Moore et al. 1975
Feedlot runoff	1-3	40-64	-	84	-	80	Lorimor et al. 1995
Flushed swine	0.2	12	-	33	-	22	Westerman 1997
Feedlot runoff	1-3	13	-	0.7	-	0.3	Lorimor et al. 1995

[a] 10-minute settling time

Most readily settleable solids in livestock manure settle in about 30 minutes... .

Most readily settleable solids in livestock manure settle in about 30 minutes or less although some additional settling occurs for hours. Gravity settling in basins or tanks may remove up to 50% of solids. Some organic matter and nutrients are also removed from the liquid fraction (Table 43-1).

Frequency of maintenance and cleanout (solids removal) greatly influences the efficiency of gravity-settling processes. Cleaning the basin after every major runoff event will improve its treatment efficiency, reduce odors, and restore the basin capacity. Basin and tank capacities are determined by knowing the settling velocities of solid particles and peak flow wastewater retention time. The solids storage volume required depends on the solids removal rate from the lot, lot size, and time between cleanouts.

Table 43-2. Approximate percent of nutrients in the solid material as a function of input solids concentration.

Type of Manure	Screen Size, mm	Input Solids, %	TKN	NH_4^+	TP	K
			% of Input Nutrient in the Solids Material			
Dairy	2.4	2	10	1	8	3
		9	36	22	27	22
Swine	0.5	2	5	2	3	2
		5	7	4	5	5

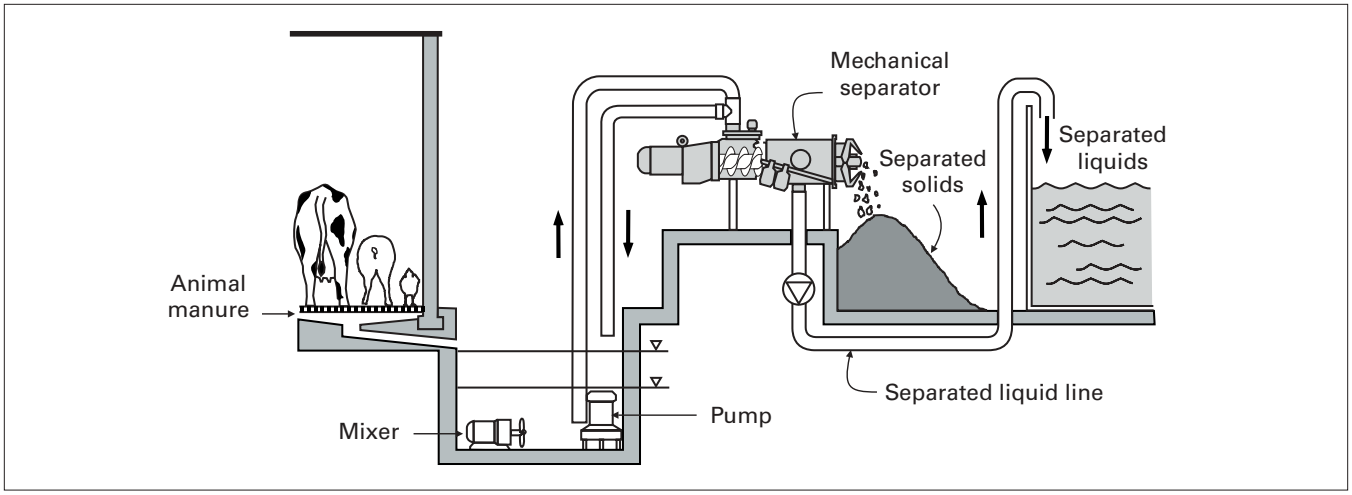

Figure 43-6. Basic arrangement for a mechanical solid-liquid separation system.

Mechanical

Mechanical separators of animal waste include screens (inclined screens, rotating screens, vibrating screens), belt and screw presses, and centrifuges. Such equipment has long been used in both municipal and industrial wastewater operations but has not been commonly used for livestock wastes. However, in regions of concentrated confined animal production, there is more interest in and pressure to remove nutrients from the liquid stream and transport them from the farm.

Performance data of mechanical separators vary widely not only because of the different testing and reporting procedures, but also because the characteristics of the manure used were sometimes different (Zhang and Westerman 1997a). Total solids (TS) in separated material vary from as low as 5% with a stationary screen up to 30% or 35% with centrifuges. Separation efficiencies for TS can vary from less than 10% to about 60%. Mechanical separators also remove some of the volatile solids (VS) and chemical oxygen demand (COD) from the manure and thus can potentially reduce odor. Chastain et al. 1999 indicated VS and COD removals of up to 65% from flushed dairy manure (TS = 3.83%) with a stationary inclined screen (screen size of 1.6 mm). Presses and centrifuges are found to have higher separation efficiencies and produce drier solids than screen separators.

Nutrient removal is also related to input solids concentration. Table 43-2 (Converse 1999) gives an estimate of the nutrient concentration in the solid stream as a function of the input solids concentration for a screw press with different screen sizes. If the input solids to the press were 9%, then approximately 27% of the phosphorus entering the press would end up in the solid material, and 73% would end up in the liquid leaving the press.

Westerman and Bicudo (1998) reported on odor intensity, irritation, and pleasantness from samples taken before and after mechanical separation (screw press) of flushed swine manure. The results presented were means taken from duplicate samples analyzed by eight panelists. They found that there was no significant difference in odor (intensity, irritation, and pleasantness) between flushed wastes and the separated liquid.

Zhang and Westerman (1997a) concluded from a review of previous research results on mechanical separation of animal wastes that fine particles in the manure decompose faster than coarse particles and most of the reduced carbon compounds, protein, and nutrient elements are contained in fine particles. Because these compounds are the precursors for odor generation and the carriers of organic nitrogen and phosphorus, they recommend that solid-liquid separation processes be designed to remove both coarse material and particles smaller than 0.25 mm to significantly reduce both odor generation and nutrient contents.

Separated solids must be further processed if they will be transported off farm for use as feed or fertilizer. Due to the still high moisture content (usually between 70–85%), solids must undergo some type of drying, either mechanical or natural, before they can be used. Storage, handling, and spreading techniques for both liquid and solid manure are required if the solids are separated. Higher investments for equipment must be made for operation and maintenance, and more management skills are needed.

Performance data of mechanical separators vary widely... .

Mechanical separators also remove some of the volatile solids (VS) and chemical oxygen demand (COD) from the manure and thus can potentially reduce odor.

Manure that is stored in earthen basins, pits, or tanks...undergoes biological degradation.