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The removal of solids, P, and other suspended or dissolved constituents can be improved by adding chemicals to the influent of solids removal processes.

Basic Principles of Manure Treatment

Many of the alternative and advanced manure treatment technologies being recommended and tested for livestock and poultry manure are already being used for municipal and industrial waste. Often, these technologies use basic principles to reduce odor and ammonia volatilization and provide alternatives to lagoon systems. In fact, several of these technologies can both reduce odor and ammonia volatilization and provide increased nutrient removal for either existing or new systems. Therefore, it is important to understand the basic principles of manure treatment and to determine the system that best meets a given need.

This section covers the basic principles of alternative and innovative technologies. A description of major alternative and advanced treatment technologies and tables (Tables 25B-1, -2, and -3) that compare their capability to reduce odor, oxygen demand, N, P, and pathogens are contained in Appendix B. Case studies are presented in the last section, which provides more information about the capability of these technologies to meet different manure treatment goals.

Solids removal

One of the first processes in municipal wastewater treatment is removal of large solids by gravity in a grit chamber. Similar basins have been used for solids removal from feedlot runoff or before lagoons. Generally, two parallel basins are built so that while one is in use the other one can be draining, enabling workers to remove solids with a front-end loader by using a sloped access area. Smaller solids can be removed in a sedimentation tank where velocity is greatly reduced, allowing significant removal of solids that settle under the design conditions used. In general, however, sedimentation tanks are not used for animal manure treatment because of the large size required, which results in high construction and operational costs.

Solids removal technologies also include simple incline screens, self-cleaning screens, presses, centrifuge-type processes, and rapid sand filters. These types of separators are being used for animal manure treatment and can reduce C, N, and P loads to subsequent treatment units.

Table 25-1 depicts the performance of mechanical separators.

Sedimentation

Biosolids or generated biomass from biological treatment can be removed in a sedimentation tank or clarifier where the flow velocity is not sufficient to keep a certain size or weight of solid in suspension. Some of these processes, such as a biofilter, must have the accumulated biomass periodically removed or cleaned out. Biosolids or sludge from a sedimentation tank or clarifier must be handled in a manner similar to solids removed by other processes. In an SBR, both aeration and sedimentation occur in the same unit on a sequential time basis.

Flocculation

The removal of solids, P, and other suspended or dissolved constituents can be improved by adding chemicals to the influent of solids removal processes. The chemicals or flocculation agents commonly used for municipal wastewater treatment include alum and lime as well as a range of polymers currently being developed. It is especially important to add the minimum amount of chemicals possible and to obtain good contact with all of the wastewater to maximize efficiency and minimize the amount of sludge. New equipment is being developed that effectively adds the minimum amount of polymer because it is expensive and results in large amounts of sludge that must be managed. If lime is used, then the resulting sludge has enhanced agronomic value.

Table 25-1 Mechanical separator performance.

Type of Mechanical Separator by Animal	Screen Opening, mm	TS in Raw Manure, kg/l	Separation Efficiency, %					TS in Solids, %	Liquid Flow Rate, l/m
			TS	VS	COD	TKN	TP		
Stationary									
Swine	1.5	0.2-0.7	9	-	24	-	-	6	235
	1.0	0.2-0.7	35	-	35	-	69	-	-
	1.0	1.0-4.5	6-31	5-38	0-32	3-6	2-12	5	-
Dairy	1.68	4.6	49	-	-	-	-	12	-
Beef	0.5	0.97-4.1	9-13	-	-	-	-	13-22	-
Vibrating									
Swine	1.7	1.5	3	-	6	-	-	17	37-103
	0.841	1.5-2.9	10	-	1-14	-	-	18-19	15-103
	0.516	1.8	27	-	24	-	-	20	37-57
	0.516	3.6	21-52	25-55	17-49	5-32	17-34	9-17	38-150
	0.39	0.2-1.7	22	28	16	-	-	16	67
	0.44	1-4.5	15-25	18-38	13-26	2-5	1-15	13	-
	0.104	3.6	50-67	54-70	48-49	33-51	34-59	2-8	38-150
Dairy	1.7	0.9-1.9	8-12	-	-	-	-	12-15	35-103
	0.841	1-1.8	12-13	-	-	-	-	18-19	15-76
	0.6	1.0-1.7	10-16	-	-	-	-	12	14-54
	1.7	1.6	12	-	-	-	-	15	40-114
	0.841	1.6	6	-	7	-	-	16	38-108
	0.6	1.6-3.2	1-16		5-7			15-16	19-63
	0.841	6.8	26	-	-	-	-	24	71
Rotating									
Swine	0.75	2.5-4.12	4-8		4			16-17	80-307
	0.8	1-4.5	5-24	9-31	2-19	5-11	3-9	12	-
Belt Press									
Swine	0.1	3-8	47-59	-	39-40	32-35	18-21	14-18	
Centrifuge									
Swine	-	1-7.5	15-61	18-65	7.8-44	3.4-32	58-68	16-27	-
Beef	-	3.6-6.2	51-61	60-65	52-60	23-28	43-48	19-26	-

Source: Zhang and Westerman 1997.

...aeration... remove[s] organic material or oxygen demand...[and] a portion of the N and P by biological uptake... .

Aeration

In a municipal treatment process, aeration commonly follows initial solid separation to remove organic material or oxygen demand, which is often referred to as BOD or COD. Aerobic treatment can also remove a portion of the N and P by biological uptake, but the composition of microorganisms, which is about 50% C, 10% N, and less than 1% P, limits N and P removal. Therefore, in aerobic treatment, about 50% of the C is converted to sludge or biomass that is removed in a sedimentation tank following aerobic treatment. Activated sludge, a commonly used form of aerobic treatment, returns the sludge or biomass to the inflow portion of the aeration basin, providing a high level of acclimated biosolids or biomass in conjunction with a high rate of aeration to rapidly convert nutrients to cell mass. Trickling filters are also used to aerobically treat wastewater by uniformly applying it to a rock filter where biomass grows. When growths become too thick, the biomass is sheared off the rocks and removed in a subsequent settling tank.

Many different types of bubble or surface aerators can provide aeration. The aerators can be used in existing or new lagoons to reduce odor and ammonia volatilization by converting ammonia to nitrate, which subsequently becomes N gas by denitrification in anaerobic zones or subsequent anaerobic units. By selecting appropriate surface aeration equipment or by placing air defusers above the bottom sludge zone, aeration can be designed to mix the total lagoon or only above the sludge zone. When aeration is limited to the lagoon surface liquid, the bottom, or sludge zone, remains anaerobic. Thus, the benefits of anaerobic decomposition of solids can be obtained and the upper portion may be aerated to reduce odor and ammonia volatilization at a reduced energy input. In lagoons without complete or high-rate aeration, it is important to provide sufficient aeration, so that ammonia volatilization or stripping is reduced rather than increased.

...the major benefits of anaerobic digestion are the (1) reduction of COD or BOD and solids and (2) production of methane gas, which has energy value.

Anaerobic digestion

Anaerobic digestion takes place naturally at ambient temperatures under anaerobic liquid or soil conditions such as landfills or animal waste lagoons. Anaerobic digesters have been used at municipal wastewater treatment plants to reduce the sludge generated by aerobic treatment. The most commonly used anaerobic digestion units are mesophyllic, which operate at about 95ºF. The operation of these digesters is relatively routine; they produce a gas with about 60% methane and 40% carbon dioxide. This gas can be used as a fuel for gas combustion engines that drive generators, producing electricity and hot water. Thermophyllic digesters, which operate at about 165ºF, are also used because the rate of gas production is significantly increased, offsetting increased heating requirements. However, the operation of thermophyllic digesters is more demanding because the optimum temperature range is very small and biological upsets are more frequent. In conclusion, the major benefits of anaerobic digestion are the (1) reduction of COD or BOD and solids and (2) production of methane gas, which has energy value. Anaerobic digestion does not reduce manure's N and P content, and thus the liquid and sludge effluent must be managed in a manner that handles or uses these nutrients. To avoid biological upsets and process failure, the maintenance, monitoring, and proper operation of anaerobic digesters are very important.

Natural systems

Many treatment or runoff control systems are being developed that follow the basic principles of natural systems such as wetlands or riparian areas. Constructed wetland systems that can remove high levels of N have been developed for municipal and animal waste. If the wastewater is nitrified before wetland input, denitrification in the wetland system is significantly increased. Vegetative filter strips and riparian areas as well as overland flow plots or wetlands are being used to reduce the pollution potential of runoff or infiltration that may occur from an animal production/manure management system.

Many treatment or runoff control systems are being developed that follow the basic principles of natural systems such as wetlands or riparian areas.