STARTUP AND OPERATION OF A LIME - EnVESSEL PASTEURIZATION PROCESS AT COOKEVILLE, TENNESSEE

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Project History:

The City of Cookeville, Tennessee's wastewater treatment plant is an oxidation ditch process with a design capacity of 7.0 MGD. The plant is currently being expanded to 14.0 MGD. Sludge is wasted from the clarifiers into an aerated holding tank. The sludge is dewatered with a 2.0 meter Komline Sanderson Belt Filter Press with a capacity of 1350 dry pounds per hour. The press dewaters the sludge to approximately 20 percent solids.

In early 1993, Cookeville began to consider various methods of compliance with the new 40 CFR Part 503 Regulations. Methods were considered which would: 1) allow the end product to be successfully marketed; 2) minimize potential and perceived problems associated with the disposal of biosolids; and 3) minimize treatment and disposal costs. After some deliberation, it was determined that the most desirable alternative for Cookeville would be to produce Class A biosolids using lime stabilization and to spread the final product on farm land. Two methods of lime stabilization were considered: Lime Only Pasteurization and Lime-EnVessel Pasteurization. Each of the manufacturers were required to furnish a lime/sludge mixer, a lime feed system, a lime silo, an insulated pasteurization vessel to ensure compliance with the time and temperature requirements contained in 40 CFR Part 503 as well as all conveyors necessary to transport the sludge to the equipment and to load the biosolids directly into a truck. A pilot test was conducted to determine the actual operating cost and land requirements for each of the two systems. The results of the pilot test indicated that lime-EnVessel Pasteurization produced biosolids which were most suitable for Cookeville's needs.

Design Considerations

After pilot testing was complete, a building was designed around the selected manufacturer's equipment. A metal building was selected as the best alternative. The building has open ends to allow free access for trucks. The sides have skirts to within 10 feet of the floor slab to limit the amount of rain that blows into the building. Translucent roof panels were installed to allow light into the building. Roof vents were also provided.

An oversized slab was provided to allow storage of excess biosolids. The slab was extended beyond the limits of the building to provide some open air storage. Pushwalls were provided to allow a loader to scoop up the stored biosolids easily. A pushwall was also provided along the length of the sludge processing equipment to protect it from damage and limit cleanup. Trench drains allow sludge and biosolids from washdown of the equipment to be returned to the head of the treatment plant.

Sludge Characteristics

Pilot testing was conducted in the Fall, when sludge condition and belt press operation were optimum. Startup of the sludge processing equipment occurred in the Spring, when the sludge condition and belt press operation were less than ideal. During the winter months, Cookeville was forced to store sludge in the oxidation ditches because of the inability to dispose of sludge. Washout was prevented by the addition of polymer to the clarifier influent. Filamentous bacteria were present in the sludge in large numbers during startup. Performance of the belt filter press was affected, and the cake solids dropped to as low as 15 percent from the typical 20 percent.

Efforts were made to improve belt press operations during the initial operating period. The belt on the press was changed to one which would allow higher pressure to be applied to the cake.

Chlorine was added to the return sludge to control filamentous bacteria and different polymers are being used in an effort to increase cake solids. Cake solids were over 17 percent prior to conducting the acceptance test.

Process Startup

During the initial operating period, several problems were encountered. The reduced cake solids cause the sludge to stick to the conveyor belts which resulted in cleanup problems. Adjustments to the thumpers has improved the cake release and the addition of drip pans has limited the cleanup problem. Operating experience has shown that cake solids over 18 percent greatly improves the release of the sludge from the belts. Conveyor belts outside the cover of the building accumulated water during rains which was being introduced into the sludge processing equipment. The covers on these belts are being tightened and adjusted to prevent water entry.

A recycle hopper was included in the process design which would allow any material not fully treated to be recycled through the process. The recycle hopper was originally designed to be an in-line unit located at the discharge of the sludge transfer conveyor and just prior to the ThermoFeeder nit. All of the sludge passed through the recycle hopper. The bottom of the recycle hopper contains two 12-inch diameter screws, and during startup, it became apparent that the screws were kneading the sludge into a paste. The end product tended to "flow" and problems with keeping the biosolids in the trucks were experienced. The recycle hopper was removed from the process, and a belt conveyor was extended in its place. This greatly improved the appearance of the biosolids and eliminating the spreading problems. The lime feed point was also adjusted, which improved the biosolids further. The recycle hopper is currently being fitted with wheels so that it can be used to break up the larger clumps of biosolids which form during long-term storage.

Maintenance and cleanup is difficult due to the inaccessibility of the maintenance points and the height of the equipment. Extended grease fittings have been installed at many locations so that lubrication can be done from the floor. A lift will be purchased to allow access to additional maintenance points and to facilitate cleaning.

Performance Testing

Performance testing was conducted to ensure that the equipment was producing Class A sludge and that the full scale equipment operating cost related well to the pilot test data. The sludge processing equipment was run for three days, and testing was conducted on the final day. Four random sets of samples were taken and analyzed. On the fourth day, Lime Only Pasteurization was conducted and samples were taken for comparative purposes.

The sludge feed rate to the system was determined by counting the revolutions on the plunger pump which feeds the belt press, determining the volume per stroke from the manufacturer's literature and sampling for sludge solids concentration. The electrical usage was measured by the electric meter to the sludge processing equipment, which has a separate electrical service. Lime dosage was monitored by a calibrated volumetric feeder and pH was measured in accordance with Standard Methods. Laboratory analysis were conducted on the biosolids for fecal coliform, total solids, TKN, phosphorus, potassium and calcium carbonate equivalent. Table 1 shows the test results for the performance test, and Table 2 shows the test results for the Lime Only Stabilization.

Table 3 shows a comparison between the pilot and full scale test results for the Lime-EnVessel Pasteurization Process. The data indicated a 9.3 percent scale-up factor for lime dosage and a 33 percent scale-up factor for electrical usage for heat should be applied to the pilot test data to compensate for the wetter cake solids which required that more heat be required to heat the increased quantity of water It should be pointed out that the Lime Only Pasteurization pilot test indicated that a 106 percent lime dosage would be sufficient to maintain the required temperature, while full scale testing with lime only required a 127 percent lime dosage, resulting in a 20 percent scale-up factor, again to compensate for the wetter cake.

Table 1
Performance Test Results
RDP EnVessel Pastuerization

Total Sludge Treated:	5,254 dry pounds
Total Test Time:	280 minutes
Total Lime Fed:	2,030 pounds
Lime Dosage:	38.6 percent, dry weight basis
Minimum Temperature Pasteurization Vessel:	158° F
Maximum Temperature Pasteurization Vessel	159° F
Electrical Usage:	560 kwh
Belt Press Cake Solids:	17.3 percent
Biosolids Solids:	29.4 percent
Biosolids pH:	12.1
TKN:	31,400 mg/kg dry wt., 3.14 percent
Phosphorus:	13,700 mg/kg dry wt., 1.37 percent
Potassium:	3,000 mg/kg dry wt., 0.30 percent
Calcium Carbonate Equivalent:	389,100 mg/kg dry wt., 38.91 percent
Fecal Coliform:	<8

Table 2
Performance Test Results
Lime Only Pastuerization

Total Sludge Treated:	2,552 pounds
Total Test Time:	120 minutes
Total Lime Fed:	3,232 pounds
Lime Dosage:	127 percent
Minimum Temperature Pasteurization Vessel:	158° F
Maximum Temperature Pasteurization Vessel	159° F
Electrical Usage:	48 kwh
Belt Press Cake Solids:	17.3 percent
Biosolids Solids:	32.2 percent
Biosolids pH:	12.3
TKN:	26,500 mg/kg dry wt., 2.65 percent
Phosphorus:	10,400 mg/kg dry wt., 1.04 percent
Potassium:	2,600 mg/kg dry wt., 0.26 percent
Calcium Carbonate Equivalent:	606,900 mg/kg dry wt., 60.69 percent
Fecal Coliform:	<8

TABLE 3

COMPARISON OF PILOT TEST VS. FULL SCALE TEST

RDP EnVESSEL PASTEURIZATION

	Pilot Test	Full Scale Test
Lime Dosage	35.3%	38.6%
Min. Temperature	158° F	158° F
Electrical Usage for Heat	0.06 kwh/pound	0.08 kwh/pound
Belt Press Cake Solids	20.1%	17.3%
Biosolids Solids	30.1%	29.4%
Lime Cost - dry wt. basis	$26.49/ton	$28.98/ton
Electrical Cost (total)-dry wt.	$9.41/ton	$11.72/ton
Total Cost-dry wt. basis	$35.90/ton	$40.70/ton1

1Notes: Full Scale Test was conducted on 17% cake solids which contained more water than the 20% cake provided for the Pilot Test. This resulted in more water in the cake which necessitated more BTUs and therefore, a higher cost.

Each ton of biosolids contains 63 pounds of nitrogen and 778 pounds of lime. Assuming that the biosolids are applied to land which is used to grow tall fescue with an annual nitrogen utilization rate of 130 pounds per acre and that the typical annual lime application rate is 2000 pounds per acre, the biosolids application ate is limited by the fertilization requirement to 2 tons per acre. Based on Cookeville's sludge production of 2700 tons of sludge per year, approximately 1350 acres of land are required for land application. Data for Lime Only Pasteurization indicated that land application rate is limited by the lime requirement to 1.6 tons per acre; therefore, 1700 acres of land would be required.

Additional Operating Data

Table 4 shows additional operating data for various lime feed rates. The data, shown graphically in Figure 1, indicates that the sludge processing cost increases as the lime feed rate increases; therefore, the most the most economical operating method would be to reduce the lime as much as possible. Experience has shown that farmers prefer the wetter, more fluid biosolids produced when the belt press cake is less than 18 percent because it spreads better however, the wetter biosolids do not release well from the belt conveyors and cause a cleanup problem. It is possible to produce biosolids which are to wet to stay in the truck when the belt press cake drops below 16 percent. The drier biosolids produced when the belt press cake drops below 16 percent. The drier biosolids produced when the belt press cake is over 18 percent is easier to handle and releases well from the belt, but has a tendency to bridge in the manure spreaders used by the farmers. Cookeville is working to determine the best combination of belt press solids and lime dosage for all involved. Table 4 illustrates a wide range of operating parameters that were investigated. The use of supplement heat allows the lime dosage to be adjusted to suit the needs of different markets for the end product.

Summary and Recommendations

The use of the pasteurization vessel to ensure compliance with the time and temperature requirements of the 503 Regulations simplified the monitoring process and allows the operators to be sure that the requirements were met. Without the pasteurization vessel, questions concerning where the temperature was monitored could arise, causing unnecessary confusion regarding compliance.

TABLE 4

PRELIMINARY SLUDGE STABILIZATION RESULTS

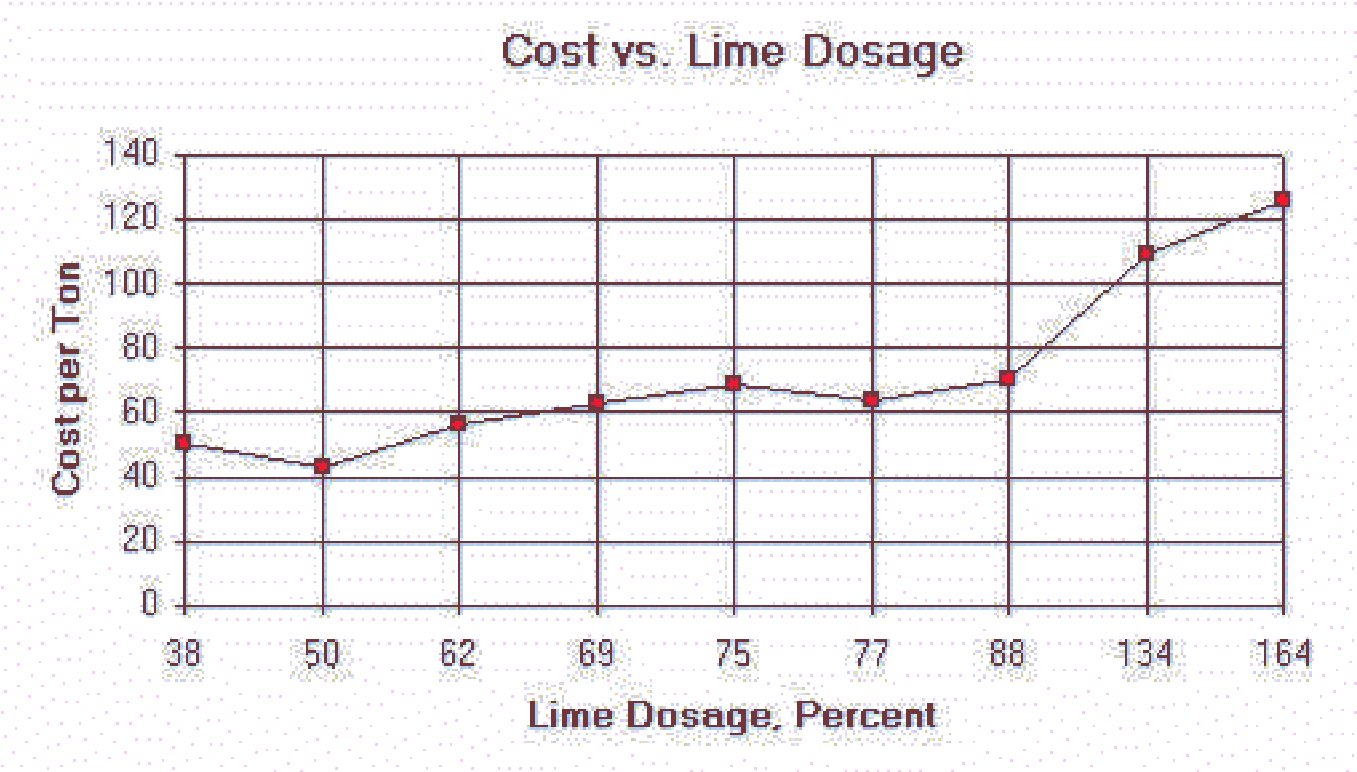
COOKEVILLE, TENNESSEE

								Biosolids		Cost per Dry Ton		
Date	Total Hours Run	Press Solids %	Sludge Feed Dry Tons	Lime Feed %	Elec. Usage kwh/ton	Bio-solids Solids %	Past. Vessel Temp F	pH	24 Hr. pH	Lime Cost $/Ton	Elec Cost $/Ton	Total Cost $/Ton
4-20-95	10.5	17.1	6.8	77	106	32.7	175	12.1	12.1	57.75	5.83	63.58
5-01-95	9.5	17.2	4.3	88	74	33.1	172	12.1	12.0	66	4.07	70.07
5-03-95	11.2	18.3	5.3	50	106	27.0	161	12.1	12.0	37.50	5.83	43.33
5-04-95	11.0	17.5	7.3	38	405	26.3	165	12.1	12.0	28.50	22.28	50.78
5-05-95	8.5	16.6	4.4	164	54	40.0	162	12.1	12.1	123	2.97	125.97
5-06-95	7.8	16.0	4.8	69	200	26.6	165	12.1	12.0	51.75	11.00	62.75
5-08-95	10.0	15.5	5.6	134	157	32.2	170	12.1	12.0	100.50	8.64	109.14
5-10-95	11.0	17.5	6.6	62	170	27.2	166	12.1	12.0	46.50	9.35	55.85
5-11-95	10.3	16.5	5.1	75	220	25.1	164	12.1	12.0	56.25	12.10	68.35

The operation of any sludge stabilization process is dependent upon the condition of the sludge introduced into the process. Long startup periods should be allowed when the treatment plant has large volumes of poor quality sludge. Acceptance testing should be delayed until the sludge condition is representative of normal operation.

The appearance of the biosolids produced by a Lime-EnVessel Pasteurization process is very dependent on the condition of the sludge fed into the system. It appears that there is a particular sludge concentration beyond which the biosolids characteristics improve and the handling of the biosolids is much improved. This "break-point" appears to be about 18 percent in Cookeville, but varies from plant to plant in many cases is much lower. Since the pilot testing was conducted in the Fall, a time when the Cookeville WWTP traditionally has the best quality sludge and produces the highest cake solids, and startup was conducted in the Spring, when the sludge condition is poor and cake solids are low, the appearance of the biosolids during startup did not compare well with the results of the pilot test.

Regardless of the appearance of the biosolids, they meet Class A criteria and are being successfully used on pasture in Cookeville. All of the biosolids produced thus far have been land applied, and the field owners are quite please with the results.



FULL SCALE OPERATING RESULTS
COOKEVILLE, TENNESSEE

503 Testing	Cake	LOP	EVP
% Solids	17.3%	32.2%	29.4%
pH	7.9	12.3	12.1
Fecal Coliform	28,900	<8	<8

Phosphorus (P)	1.04%	1.37%
Potassium (K)	0.26%	0.3%
Nitrogen (N)	2.65%	3.14%
Calcium Carbonate Eq. (CCE)	61%	39%

Lime Dosage (Lbs/wet ton)	437	133
Lime Dosage (% Dry Solids)	126%	38%
Lime Cost ($/ton)	$16.40	$5.01
Electric Cost	$ 0.36	$2.03
Total Cost	$16.76	$7.04