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First-Class TRAINS

Chicago produces Class A biosolids using a low-cost, conventional technology

Lagoons, which are filled slowly over a period of 1 to 3 years, aid dewatering and pathogen inactivation as part of the low-solids sludge processing train.

Better Biosolids

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The Metropolitan Water Reclamation District of Greater Chicago owns and operates seven water reclamation plants, all of which use the activated sludge process. All untreated solids are anaerobically digested at the plants, and most are further processed at the Stickney and Calumet water reclamation plants using two "sludge processing trains" (SPTs) to yield a final product containing about 60% solids. The final product is beneficially used to grow crops, construct and rehabilitate golf courses, and provide daily and final cover for municipal landfills.

The operational protocols used to produce the final dried-solids product from anaerobically digested sludge were conducted under uncodified conditions at the Stickney and Calumet plants' solids processing sites prior to mid-1994. Routine practice was not strictly controlled and did not require workers to keep systematic records on operational protocols, material movement through the SPTs, or solids holding times for lagoons and drying cells. The overriding emphasis was to produce a 60% solids air-dried product, rather than a pathogen-free product. However, based on random quality control and assurance checks, pathogen analysis of numerous samples showed that the resulting biosolids, for the most part, met Class A criteria as specified in the 40 *CFR* 503 regulations. These criteria are less than 1000 fecal coliform organisms per gram, less than three *salmonellae* per 4 g, less than one viable helminth ovum per 4 g of dry weight of biosolids.

Encouraged by this finding, the district initiated full-scale studies to determine whether its SPTs were capable of producing Class A biosolids at all times if they were operated under codified and controlled operating conditions without incorporating any major operational changes or capital modifications.

Uncodified Operations

The two SPTs – one a high-solids SPT (HSSPT) and the other a low-solids SPT (LSSPT) – are used simultaneously to further treat solids that have been anaerobically digested at 35°C with a detention time of about 20 days (see figure below).

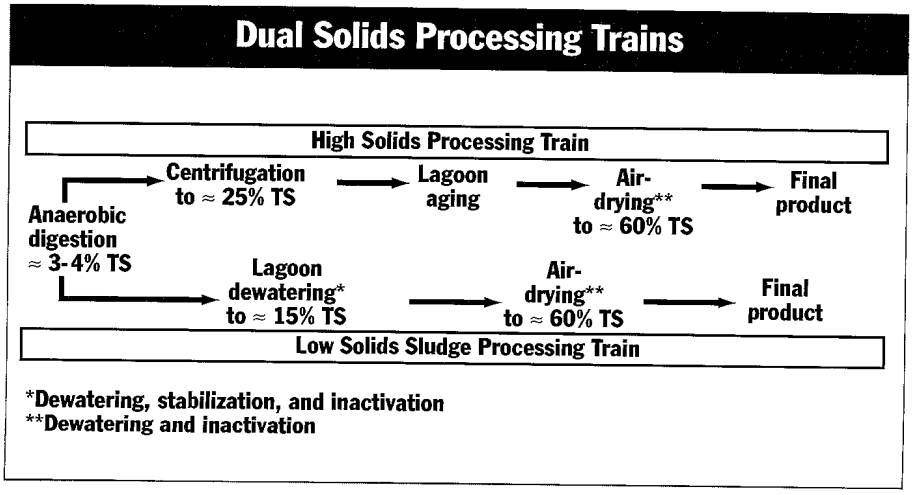
Approximately equal portions of the solids withdrawn daily from anaerobic digesters are processed through both systems. In the HSSPT system, anaerobic digester draw is conditioned by a cationic polymer and dewatered using centrifuges to a cake containing about 25% solids. This cake is transported by railroad cars and discharged into a lagoon at various times throughout the year, except when the ambient temperature is -4°C or less. (At these low temperatures, centrifuge cake freezes in the railroad cars.) The cake is aged in the lagoon to further inactivate pathogenic microorganisms and stabilize the sludge solids. The solids are then removed and air-dried in batches to approximately 60% total solids content on paved drying cells.

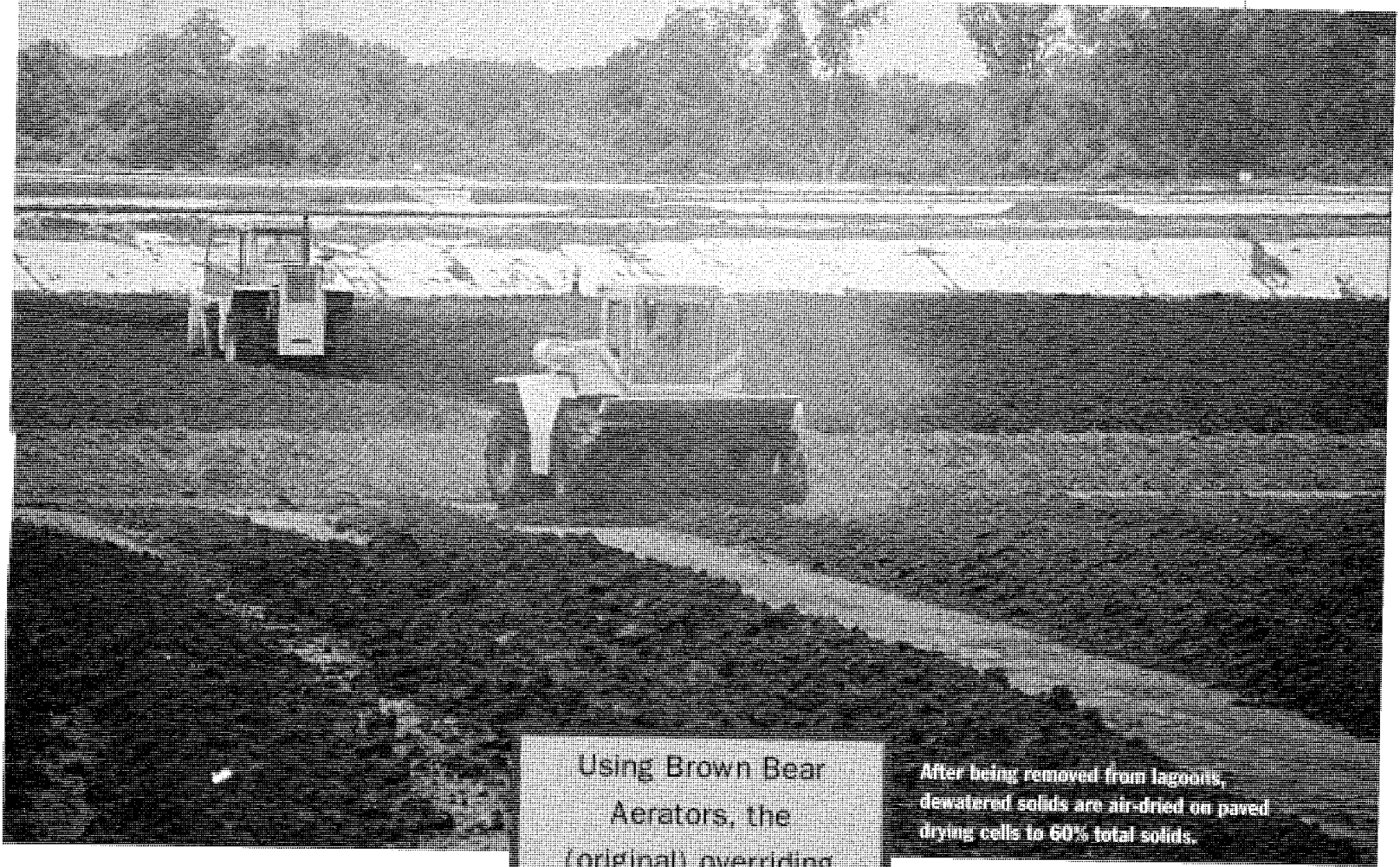
In the LSSPT system, all digested solids not processed in the HSSPT system are pumped in batches into another set of lagoons. These lagoons are filled in cycles over a period of 1 to 3 years. The sludge layer that forms is allowed to thicken further by evaporation and to settle before the next layer is applied. Supernatant that separates from solids is recycled to the plant. This layering process continues until the lagoon is filled. Using what is known as a "slackline process," the solids are dewatered in the lagoon to produce a cake containing about 15% solids, which is stored to achieve additional stabilization and inactivate any pathogens or indicator organisms. Like the HSSPT system, the solids then are air-dried in batches to about 60% total solids content on paved drying cells. In both the HSSPT or LSSPT systems, no codified operational protocols were practiced before the study began at the end of October 1994.

Codified Operational Protocols

The following protocols were codified and strictly implemented in a recently completed 3-year study to control operation of the HSSPT and LSSPT systems:

- The operational requirements for the anaerobic digestion process, an integral part of both the SPTs, remains the same. An average detention time of 20 days at a temperature of 35°±1°C is maintained in the anaerobic digesters.
- For the HSSPT system, centrifugal dewatering operational requirements remain the same.
- For the LSSPT system, digested solids (4% total solids) are not subjected to centrifugal dewatering but are pumped directly into a lagoon for further stabilization, dewatering, and inactivation of pathogens.
- Under codified operation, the minimum solids holding time for both the HSSPT and LSSPT lagoons is at least 1.5 years. The operation of the HSSPT has been modified so that even the last batch of centrifuge cake discharged from railroad cars or trucks is held for at least 1.5 years in the lagoons. Six to 9 months are required to fill a typical





After being removed from lagoons, dewatered solids are air-dried on paved drying cells to 60% total solids.

HSSPT lagoon. During the minimum 1.5-year solids holding time, no additional centrifuge cake is added. Rainfall and water are drained from the surface of the lagoon and recycled to the head of the respective plants. At the end of the holding time, the aged centrifuge cake is removed and trucked to drying cells. Emptying the HSSPT lagoon takes 2 to 6 months; thus, solids can undergo a holding time of up to 33 months when considering filling and emptying times.

- Like the HSSPT lagoons, the final batch added to LSSPT lagoons is held for a minimum of 1.5 years, emptied over a period of 2 to 6 months, and dried on paved drying cells. All solids are held from 18 months to as much as 5 years (3 years for filling, 1.5 years for holding, and 6 months for emptying) in the LSSPT lagoons.
- Complete turning, aeration, and agitation of solids withdrawn from the HSSPT is accomplished at an average of three times a week using equipment such as a tractor with a horizontal auger or a tiller. A minimum of 4 weeks is used for this operation. Periods with fewer than two agitations per week (such as during rainy periods) are recorded but neither counted toward the 4-week agitation limit nor used to determine the average number of agitations.
- Air-drying of solids withdrawn from the LSSPT system is accomplished over a minimum of 6 weeks, during which an average of at least three agitations per week are made. Periods with fewer than two agitations per week are recorded but neither counted toward the 6-week agitation requirement nor used in determining the average number of agitations.
- Air-drying is carried out from May through October and is done at no more than 410 dry ton/ac (150.6 Mg/ha) for the HSSPT system and 230 dry ton/ac (84.5 Mg/ha) for the LSSPT system of the paved drying cells. These rates of application were based on years of practical experience by the maintenance and operations department staff. Solids taken out of the HSSPT and LSSPT lagoons are applied on the drying cells at no more than 18 and 15 in. (457 and 381 mm) of depth, respectively, to be consistent with the loadings of 410 and 230 dry ton/ac.
- The drying solids are formed into windrows when reaching a concentration of 30% to 35%. The windrows help rainwater drain from the air-drying beds during wet weather and increase temperatures for better pathogen destruction.
- To prevent solids from "short-circuiting" through the SPTs, workers ensure that no additional batches are added to the filled lagoons and that a batch of solids undergoing

> Using Brown Bear Aerators, the (original) overriding emphasis was to produce a 60% solids air-dried product, rather than a pathogen-free product.

air-drying on the paved drying beds is not mixed with any other batches.

Pathogen Content Before and After

From 1991 to mid-1994, prior to the strict operational controls, a total of 168 solids samples were analyzed for pathogens. Ninety percent of the 48 air-dried final product samples met Class A fecal coliform criteria, and 100% of 12 air-dried samples (a subset of the 48), met the Class A criteria for *Salmonella sp.*, viruses, and helminths.

From the end of October 1994 to September 1997, samples of digester feed, digester draw, lagoon draws (stabilized, aged anaerobic solids and centrifuge cake), and air-dried final product were collected at various times from both SPT systems, which were operated under controlled conditions. In all, 440 solids samples from the SPTs under codified operations were analyzed for indicator and pathogenic organisms. Samples taken from four points in the HSSPT and LSSPT systems were analyzed – 436 samples for fecal coliforms, 394 samples for *Salmonella sp.*, 345 for enteric viruses, and 429 for helmith ova. From these data, all 155 air-dried final product samples met Class A criteria, indicating that the SPTs did produce a Class A product at all times under the codified and controlled operating conditions.

Air-dried solids samples were considered negative for pathogens if they tested below detection levels. The method detection limits were 0.08 to 2.2/4 g for *Salmonella sp.*, 0.005 to 1.0/4 g for viruses, and 0.0078 to 0.6107/4 g for helminth ova.

It should be noted that because of the low density of viruses and helminth ova indigenous to the samples, a diligent effort was made to increase the sensitivity of the analytical methods and obtain a lower method detection limit for viruses and viable helminth ova, particularly in the lagoon draws and air-dried products, by using a larger sample size than required.

Although Part 503 regulations do not require the demonstration of log reductions to determine whether a specific solids processing technology meets EPA criteria, the district's SPT systems achieve more than 2- and 3-log reductions of helminth ova and viruses, respectively. In addition, measurements of indicator and pathogen organisms have indicated that all batches of the air-dried final product met the Class A standards. In view of these findings, when operated under the codified operational protocols delineated, the district's SPTs should continue to produce a Class A product.

Note: Proprietary equipment and chemicals mentioned in this article do not constitute endorsement by the Metropolitan Water Reclamation District of Greater Chicago.

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