SW17663
composting

ODOR CONTROL FOR BIOSOLIDS COMPOSTING

A comprehensive approach to reduction and control of odors at Schenectady, New York's composting plant included changes in the aeration system, adding wood ash to the mix, and increased retention time in the reactors. Part I

Tim Muirhead, Paul LaFond, and Steve Buckley

CHRONIC ODORS at the 18.5 MGD activated sludge treatment plant in Schenectady, New York, had been a sensitive issue for many years between city management and neighborhood residents living near the plant. Odors became significantly worse when the 15 dry ton per day American Bio Tech (ABT) in-vessel biosolids composting facility commenced operation in the summer of 1987. From June 1987 to June 1991, the city operated the compost facility for less than 100 days. During that time, operators experienced mechanical breakdowns, process failures, compost reactor fires, and continuous discharge of offensive odors, which eventually required the shutdown of the $7 million compost facility.

In late 1990, in an effort to solve the odor problems, the Schenectady City Council began the process of hiring a company to operate, maintain, and manage the facilities. In June, 1991, Professional Services Group, Inc. (PSG) of Houston, Texas was selected as the contract operator for the wastewater treatment and composting facilities. A major objective was to identify the numerous sources of noxious odors and correct the odor problems.

A detailed survey and evaluation identified several odor sources (Figure 1). The compost facility generated approximately one-third of the number of odor complaints by the neighborhood residents living near the facilities, presenting the biggest disruption and most aggravating odor problems for the City of Schenectady.

During the past year, PSG implemented a comprehensive odor management program. Odors are being successfully controlled and reduced at both the treatment plant and composting facility. Several process modifications and equipment changes were made at the compost plant to achieve this control and reduction.

Part I of this article will describe these changes, as well as the distribution of the finished compost products. It focuses on compost odors from fugitive process emissions and finished product area emissions. Part II, to appear in the next issue, will describe the design and installation of the compost facility odorous air handling system, the retrofit of the existing odor scrubber system, and rebuilding the public's confidence about composting.

COMPOST FACILITY DESIGN

The basis of design for the ABT in-vessel biosolids composting facility in Schenectady was to process 15 dry tons of sludge per day, assuming a five day a week operation. The number of modular compost reactor cells was based on a dewatered cake sludge of 24 percent total solids, comprised of 40 percent primary and 60 percent thickened waste activated sludge. The design bulking agent and amendment was pine sawdust at 50 percent total solids of less than ⅛ inch square particle size. The design minimum feed mixture of sludge/amendment/recycle at 35 percent total solids resulted in the construction of two bio cells and two cure reactor cells.

Each compost reactor cell was designed by ABT to be 26 feet by 26 feet by 26 feet, shaped as modular cubes. (In actuality, they are 26' x 25' x 24'.) The Schenectady compost facility has four of these reactors stacked in a row for a design total reactor size of approximately 70,300 cubic feet. Material moves through the in-vessel compost system via two large take-out screws which traverse the length of the bottom of the bio and cure cells, removing approximately two feet of compost at each pass. The design detention time was 13 days in the bio reactors and 13 days in the cure reactors, for a total in-vessel composting time of 26 days.

The ABT composting facility uses the patented AirLance™ system, which has an array of vertical stainless steel cylinders or "lances" suspended from the top of the four compost reactor cells. Each cell contains six

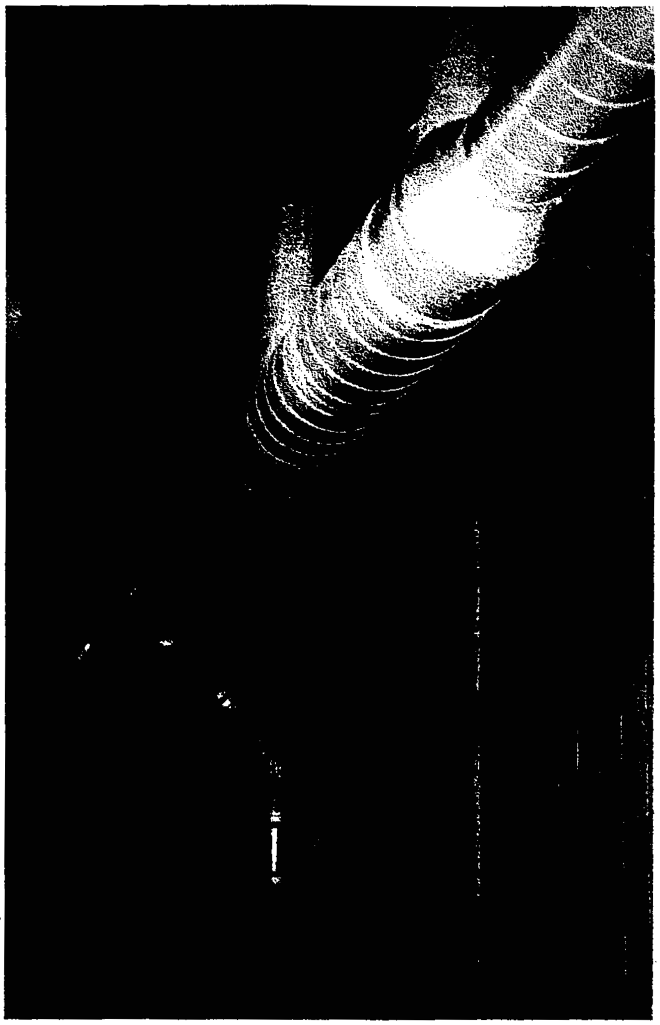


Photo courtesy of PSG

One effective aeration change was allowing the air distribution system to operate continuously in a positive supply mode.

Design and operating solutions, capital improvements, process and equipment changes and routine neighborhood communication were included in the overall plan to correct odor problems.

air headers with eight air lances mounted on each header. The air lances and manifold system provide the vertical supply and exhaust of air throughout the compost biomass over short horizontal distances. A total of 6,400 cfm of air flow is supplied by two low pressure, industrial centrifugal fiberglass fans. An exhaust rate of 8,000 cfm was designed to operate the compost process in a negative pressure mode to remove process steam and odors from within the reactor cells. The two exhaust fans are larger in size than the supply fans to ensure the reactors are maintained at negative pressure.

The negative ventilation pressures and high rates of process air exchange within the vessels were designed to ensure biofiltration treatment of all potential odor sources prior to discharge into the atmosphere. The supply and exhaust air manifold valving was engineered to automatically reverse the air flow and alternate between positive and negative aeration modes every 20 minutes. The objectives of this cyclic air flow operation were to promote aerobic biodegradation, control temperature, remove moisture, capture and treat odors through biofiltration, and ensure maintenance free air lances by controlling solids build-up and preventing their blinding and plugging.

Immediately upon start-up of the compost facility in July, 1987, there were numerous foul compost odor incidents on-site and many complaints by the local residents living near the facility. This resulted in routine shutdowns of the compost operations. The NIMBY (Not In My Backyard) scenario became firmly established as a result of the continuous generation of offensive odors. Problems with anaerobic conditions, poor aeration and porosity in the compost biomass, uncontrolled high temperatures, process fires, plugged air lances, and equipment failures were all significant contributors to compost odors. By 1988, the composting plant was shut down and closed for repairs. An incinerator located at the wastewater treatment plant was used to dispose of the sludge.

COMPREHENSIVE APPROACH

Major sources of odors from the in-vessel facility include fugitive, point source, and area emissions. The success of the composting plant and elimination of sludge incineration in Schenectady would be contingent upon these three sources of compost odors being fully corrected.

In June, 1991, PSG initiated a comprehensive odor management plan geared towards specific solutions to each source of odor. Design and operating solutions, capital improvements, process and equipment changes, routine neighborhood communication, a public relations program, community support and involvement, compost plant tours, public and educational presentations, technical writing, and compost marketing and distribution have been included in the comprehensive approach to correct the compost odor problems and eliminate the legitimate NIMBY concerns of our neighbors.

The compost odor management program did not focus exclusively on the in-vessel facility. Rather, the entire treatment plant was evaluated in order to solve all the odor problems at the compost facility in the minds and perceptions of the neighborhood and city administration. Compost operations would be evaluated and deemed a success on the basis that all wastewater treatment plant and compost facility odors be identified and corrected.

The first step was to increase the level of monitoring and regulation of all industries discharging odorous wastes into the City's sewer system through an improved and more effective industrial pretreatment program. PSG also implemented a biosolids conditioning program by adding iron salts (ferrous chloride) before the plant headworks, which also controlled strong septic odors.

The high level of odorous volatile organic compounds (VOCs) found in the raw wastewater solids (81 percent) were identified as a primary cause of the offensive and very pervasive odors when composted. To break them down into less volatile, more stabilized materials, two of the wastewater treatment plant's anaerobic digesters, which had been abandoned for many years, were refurbished and reactivated. These now operate as a "Process to Significantly Reduce Pathogens" (PSRP) and reduce approximately 40 percent of the biosolids which must be dewatered and composted. Digestion also has reduced the volatile content of the biosolids by 48 percent and accordingly, has reduced the odor potential at the compost facility.

Several mechanical and process improvements were made to the two, 1.5-meter belt filter presses to increase the dewatered solids content from 18.5 percent to an average of 26.5 percent. The higher cake solids significantly reduced the amount of bulking agent (wood amendments) which must be used in the compost facility to achieve the desired in-feed materials matrix and solids content (Figure 2). The drier cake solids also reduced the amount of moisture which must be removed in the composting process, as well as the mass emissions of odorous steam which must be captured, exhausted, and treated to nondetectable levels before discharge to the atmosphere.

COMPOST EQUIPMENT CHANGES

During the summer months of 1991, several mechanical improvements were made in the compost facility to address equipment reliability, process control, and operator safety problems. The two compost screws which mix the biosolids with the amendment were refurbished by spraying them with a hard ceramic coating to ensure long life in the abrasive and corrosive composting environment. The leveler device, which operates as a trolley on guide rails to distribute the in-feed mixture of biosolids and amendment, was modified to achieve a complete and uniform fill of each compost reactor cell. (Uniform materials distribution prevents short circuiting of fresh, unstable compost and controls the compost bulk density in the reactor cells.) New cross bars and openings were provided to distribute a higher level of in-feed compost more evenly across each reactor with the drag flights.

An ultrasonic level sensor was installed on the bottom of the discharge plate of the compost leveler to accurately monitor the filling of compost material in each area of the reactor cells. The existing programmable logic controller (PLC) was modified to allow the leveler to be remotely operated and automatically controlled by the level sensor, a retrofit that also created safer working conditions.

Historical problems of overfilling the reactors, jamming the leveler, and damaging or breaking the drag flights and drive chain have been greatly reduced. In addition, the controlled distribution of compost material and complete fill of the reactors also have eliminated the sliding of compost in the reactors. In the past, downward sliding of compost at an angle created high side thrust forces on the air lances and bowed many of them into "banana shaped" units, which adversely impacted their uniform vertical air distribution performance.

MODIFIED AIR LANCES

The 216 air lances in the four reactors were removed, inspected, unplugged, cleaned, repaired, and modified. The cyclic operation of positive and negative aeration had blinded and eventually plugged the lances. In the process of cleaning the air lances, most of them were found to have damaged internal components.

Given the damage and historical operational problems, the baffles which were intended to provide for horizontal air distribution in the vertical lances were aban-

Figure 1. Treatment plant odor sources and odorous compounds from composting facility.

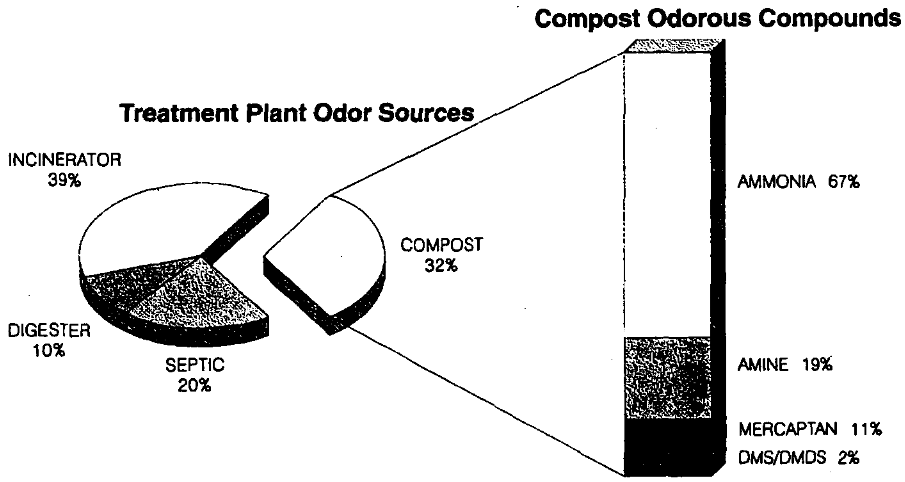


Figure 2. Volumetric ratio of amendment to biosolids (A/B) for infeed materials matrix.

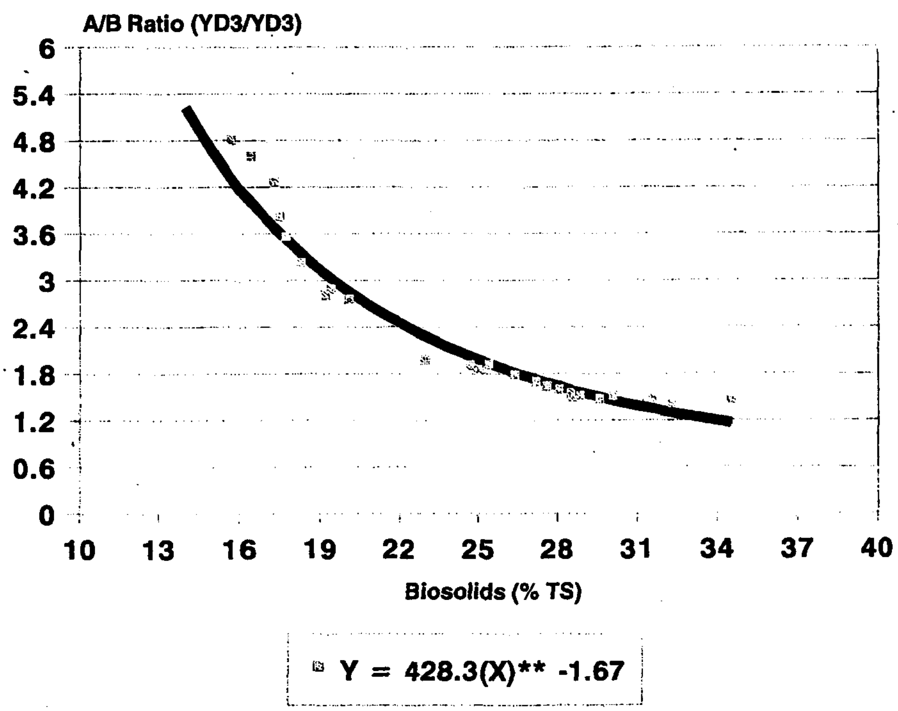
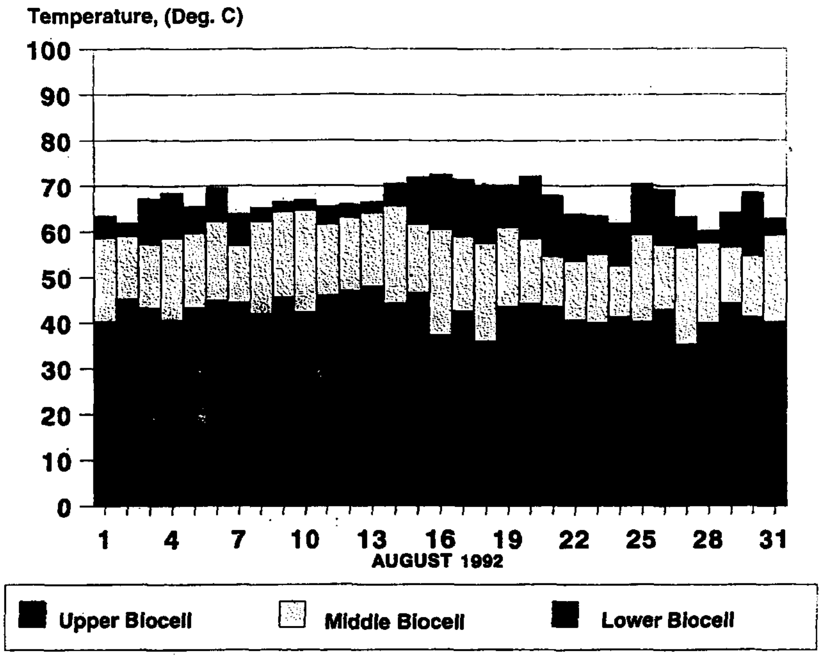


Figure 3. Temperature profiles within compost piles.



Positive aeration increased the air flow capacity of the supply fans at lower power requirements.

doned. PSG retrofitted each air lance with a single PVC insert instead of the original three section pieces. An improved air distribution mechanism was installed by increasing the number of orifices for each insert. A tapered pattern was designed, where a larger number of holes were provided at the bottom of each lance. This pattern achieved uniform air distribution and significantly improved oxygen transfer in the lower sections of the reactors which contain compost material with the highest bulk density. Specifically sized holes were designed and fabricated in a perpendicular arrangement to achieve complete radial (360 degrees) air distribution, independent of the installed position of the air lance in the reactor cells.

Rubber boot seals were installed at the top of each air lance before resuspending them from the air headers in the four compost reactors. Daily material transfers and natural settling and compaction of compost in the reactors causes the top of the air lances to become exposed directly to the facility headspace above the reactor cells. The portion of the air lances exposed to the atmosphere did not contain the normal back pressure applied on the well screen by the compost biomass. As a result, supply air at the top of the exposed lances would take the path of least resistance and discharge directly into the headspace and not into the compost mass. This resulted in oxygen deficient conditions in the compost biomass, causing foul odors, uncontrolled high temperatures, and wet, unstable compost. The boot seals prevent any short circuiting of air at the top of the compost reactors when they are not completely full, allowing for proper horizontal aeration throughout the 26-foot vertical compost piles.

POSITIVE AERATION WITH OUTSIDE AIR

Anaerobic compost conditions, poor aeration and porosity, wet compost, and uncontrolled high reactor temperatures (above 75°C) were identified as the largest and most significant contributors of noxious odors. The problems occurred even at maximum supply fan output. During city operation, the reactors became so hot that smoldering fires inside the piles would occur at times, further contributing to the odor problems.

Fundamentally, these problems were corrected by doubling the oxygen transfer rate by using the modified air lances and changing the air distribution system to operate continuously in a positive supply mode. The positive aeration technique has maintained continuous aerobic conditions and allowed for the control of temperature in the bottom of the deep reactors, where temperatures above 75°C commonly occurred in the past. The varying bulk density of the compost and porosity within compost piles 26-feet deep result in a well-defined temperature profile (Figure 3). Air flow to the compost process is controlled by maintaining a temperature range set point of 60° to 70°C in the lower portion of each reactor cell. If the temperature rises above 70°C, the supply air flow to the bio and cure reactors is increased to prevent pasteurization of the biomass, which would creates enzymatic production of highly odorous fatty volatile acids.

Positive aeration of the AirLance™ system has increased the air flow capacity of the supply fans at lower power requirements. Twice the number of air lances are operated in a supply mode, which significantly reduces the back pressure applied by the compost mass on the discharge side of the supply fans. During positive/negative aeration, the supply fans at maximum output could only provide 2,000 cfm, 62.5 percent of the 3,200 cfm design capacity. When the aeration mode was adjusted to all positive, the supply air flow immediately increased approximately 75 percent to 3,500 cfm at the same power requirement.

Approximately 1,000 cfm per reactor cell (0.064 cfm per cu.ft. of compost biomass) is required to achieve a dry, stable finished compost within 28 days at an in-feed compost mixture of 39 percent solids. Reduction in air flow rates and the lower back pressures have allowed the supply fans to operate more efficiently and economically. In addition, positive aeration does not require the use of the exhaust fans, which results in substantial electrical power savings.

Fresh outside air is now supplied to the compost reactors. This eliminates the historical problems of wet, odorous, unstable compost because the supply fans no longer receive foul, saturated processed air from the exhaust fans. An air-to-air heat exchanger is used in the winter to preheat the cold fresh process air before it is supplied to the compost reactors to maintain temperature control.

AMENDMENT RECIPE USING WOOD ASH

To eliminate poor and problematic process conditions and reduce production of odors and fugitive emissions inside the compost facility, different wood amendments were tested and an amendment recipe was developed. The wet and fine particle sawdust amendment (55 percent solids; 1/16 inch) was supplemented with dry, medium particle size (90 percent solids; 5/8 inch) pulverized wood pallets to decrease amendment usage and increase reactor porosity. The sawdust supplier was required to install a rotary drum dryer to decrease the moisture by a minimum of 15 percent or be penalized by a 15 percent lower purchase price.

Based upon numerous full scale trials, the optimum amendment recipe is 64 percent by volume of soft pine sawdust and 32 percent hard wood pulverized pallets. The sawdust provides moisture absorption, readily available carbon for the compost biomass, and the "free-flowing factor" required in the vertical ABT reactor system. The pulverized wood provides porosity and macrostructure for the compost matrix.

The remaining four percent of the amendment recipe is comprised of wood ash, which is blended with the other two wood amendments at a 1:25 volumetric ratio. The high carbon wood ash is a virgin timber by-product from wood fired power plants. It treats the very pervasive and offensive odorous sulfur compounds (dimethyl sulfide, dimethyl disulfide, and mercaptans) within the vessel by the process of adsorption. This is similar to the removal mechanisms used in activated carbon columns. The low solubility properties of DMS/DMDS and mercaptans result in their greater affinity to be adsorbed by the wood ash than less soluble odorous nitrogen compounds, such as ammonia and amines.

The high alkaline wood ash (pH 11.5) is an inert material that does not provide any additional organic load to the compost process. The amount used in the amendment recipe is controlled by maintaining an in-feed compost mixture pH of 8.0.

The unit cost of the three component amendment recipe is $63.50 per dry ton of biosolids composted. Wood ash, due to its fine particle and powder type characteristics, does not reduce the amount of sawdust and pulverized pallets required for optimum composting and product quality. One bucket is added in the middle of the 25 bucket cycle of amendment addition, coating the entire volume of sawdust and pallets loaded into the storage silo. Essentially, the wood ash becomes the odor control component in the compost matrix. Despite its adsorption of the organic sulfur compounds during composting, the finished compost product is nonodorous. These low odor threshold compounds are bound in the compost and do not become liberated when the finished product is subject to materials handling.

Several other process control and operational changes have been made to the compost plant to minimize and control the production of compost odors. All four reactors are now utilized to process an average biosolids loading of 9.5 dry tons per day, based upon a seven day operation. The facility operates at 89 percent capacity, based upon the design 15 dry ton per day loading and five day a week operation. Forty cubic yards of dewatered biosolids are mixed daily with wood amendments and loaded as an in-feed mixture to the bio cell reactors at an average of 39 percent solids. Loading and material transfers are conducted once per day to maintain reactor levels at full capacity. This ensures proper distribution and prevents short circuiting.

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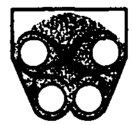

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The "once through" approach has significantly reduced the movement of unstable and partially composted material within the facility.

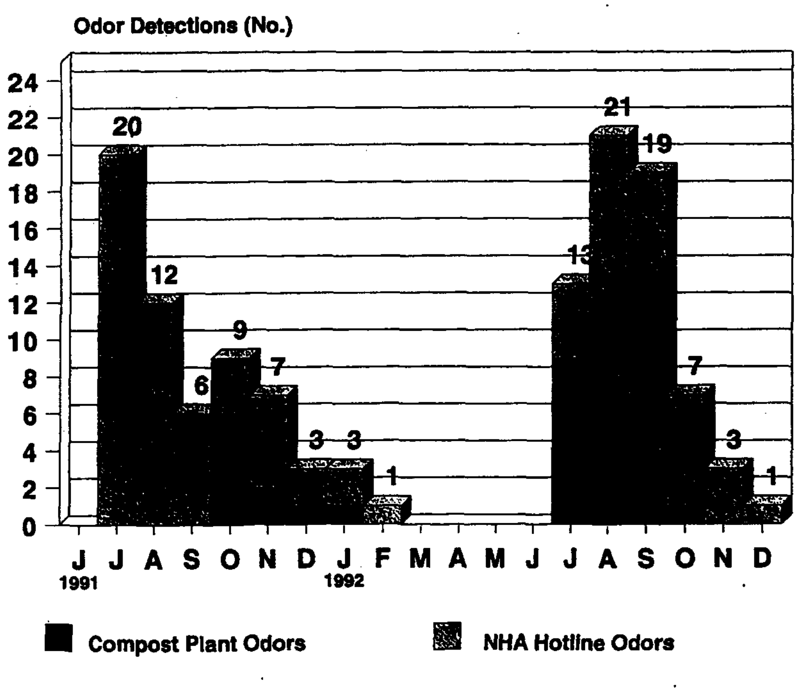
A "once through" approach is now used, where the four cells operate in a plug flow manner. A daily compost transfer is made from the bottom of the bio cells to the top of the cure cells, creating space for the fresh in-feed compost mixture to be added to the top of the bio cells each morning. Finished compost is discharged as required, based upon settling and compaction in the reactors.

City operation relied upon several daily transfers of material from the bottom to the top of the same set of reactors to aerate and dry the compost. This continuous movement of compost and short circuiting of the piles has been eliminated. The "once through" operation has significantly reduced the movement of unstable and partially composted material within the facility. As a result, the production of odorous steam and fugitive emissions inside the compost plant have been controlled and minimized.

The compost material now remains in the vessels for at least 28 days — roughly two weeks in the bio reactors and two weeks in the cure reactors — to become dry and fully stabilized. Retention time under the previous operation was 10 to 17 days. The increased solids retention time (SRT) has significantly reduced the level of odorous emissions from outside storage.

Compost recycle, which was used heavily during city operation, has been eliminated from the process to maximize the detention time of fresh compost in the reactors and ensure proper biodegradation and stability. Elimination of recycle also reduces the level of daily materials' movement and minimizes the production of odorous steam emissions within the facility that must be captured, exhausted, and treated to nondetectable levels.

Figure 4. Number of odor detections over 18 months



The carbon to nitrogen (C/N) ratio of the Schenectady in-feed compost mixture with the three component amendment recipe is 26:1; the finished compost C/N ratio is 15:1. An average volumetric amendment to biosolids ratio of 1.9:1 (yd^3/yd^3) is maintained when the dewatered cake solids average 26 percent total solids. This yields an in-vessel SRT of 29 days, based upon a volume reduction of 66 percent through materials mixing and compression and an actual processing volume of 62,400 cubic feet in the compost reactor cells.

FINISHED COMPOST DISTRIBUTION

The finished compost is screened and stockpiled using conveyors in a new 15,000 sq. ft. three-sided storage facility, which contains individual bays and leachate collection. The storage building was erected in a specific location to shield from the prevailing wind and prevent the movement of any odorous compost emissions from leaving the plant site and blowing directly into the neighborhood. Compost is stored for at least 21 days while product testing and laboratory analyses are conducted. This storage period complies with the minimum combined on-site time (for composting and curing) of 50 days as required by New York State DEC Part 360 regulations to market and distribute a Class I compost. Large volumes of the finished compost have been stored on-site to meet the required retention time without creating an odor problem from area emissions.

Two compost products — mulch and fines — are marketed under the trademark of OR-GRO® - High Organic Compost and distributed on a bulk loaded basis. Demand for the 25,000 cubic yards produced annually exceeds the supply. The Class I products are marketed at wholesale prices ranging between $2.50 to $5.00 per cubic yard, depending upon volume and season of the year.

ODOR CONTROL SUCCESS

One measurement of success with the comprehensive odor control program has been that detection of compost odors as reported on the Northend Homeowners Association (NHA) hot-line have been reduced in the past 18 months of operation (Figure 4). City officials, and more importantly the NHA neighborhood residents living near the facilities, report significant improvements in odor control. Noted one NHA member at a city council meeting: "...The odor control improvements that have been achieved have provided a positive environment in our neighborhood...We don't talk about the odors from the wastewater treatment plant or compost facility anymore. We're looking forward to a very peaceful year." ■

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