COMPOST FACILITY ODOR CONTROL USING BIOFILTRATION: COMPARISON OF APPROACH AND PERFORMANCE AT AN OPEN FACILITY AND A TOTALLY ENCLOSED FACILITY

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INTRODUCTION

Odor control is one of the major issues affecting design and operation of compost facilities. Several facilities have been shut down because of odors. Often, these shut downs are a result of poorly designed or operated compost facilities with little or no odor control. Biofiltration systems are effective at treating and reducing odorous emissions. The effectiveness of the biofilter system is often times a function of the odorous air collection system. There are two general alternatives for collection of odorous air from aerated composting systems. The first alternative is collection of all of the air inside a totally enclosed compost facility. Makeup air is normally brought into the building from outside to provide fresh air for worker comfort or for heat and moisture removal. This approach results in collection and treatment of large volumes of air with diluted odorous compound concentrations. The second alternative is collection of the compost process exhaust. A blower is operated in the negative mode whereby air is drawn through the compost pile and then conveyed to a common odor collection header. This approach results in collection and treatment of smaller volumes of air that is typically hot and has high odor compound concentrations. This paper presents information at two facilities that utilize these different odor collection alternatives.

Davenport Compost Facility

Basis of Design

The City of Davenport, Iowa (the City) owns and operates a 28 dry ton per day (DTPD) aerated static pile biosolids and yard waste compost facility. The biosolids are anaerobically digested and then dewatered to between 13% and 20% total solids (TS) using belt filter presses. The dewatered biosolids are hauled via dump truck from the wastewater treatment plant to one of two biosolids receiving bins located in the mixing area of the compost facility. In addition, clean yard waste is delivered by private and public vehicles to a paved outside storage area where it is ground through a horizontal grinder. The ground yard waste is supplemented by wood chips and rubber tire chips for use as a bulking agent. The bulking agents are mixed with the biosolids through either of two continuous feed pugmill mixers. The flow of bulking agents and biosolids is controlled to achieve a target mix solids content of 40% TS. Composting occurs in a 66,000 square foot (SF) building which is totally enclosed and insulated. Pre-cast polymerized concrete trenches are placed in the concrete compost floor and provide aeration to the compost pile. Twenty-four blowers are automatically controlled (on/off) by a temperature feedback system to control the aeration rate to the 24 individual aeration zones. Following three weeks of composting, the material is screened through a trommel screen. The overs are recycled as bulking agent, and the compost is cured for an additional 30 days prior to marketing.

During the planning stages of the project, one of the primary objectives of the City was to effectively manage odors so there would be no off site odor impacts. To accomplish this primary objective, the mixing and composting areas were totally enclosed in an insulated pre-engineered building. The exhaust air from the mixing area is utilized as make-up air to the compost building to reduce the total volume of air to be treated. Exhaust gas from the entire compost building is treated through a biofiltration system. The exhaust system ventilates a total of 210,000 cubic feet per minute (CFM) and provides ~12 air changes per hour. The biofilter consists of eight independently controlled blowers and biofilter cells. The odor collection system consists of 12 intakes spaced equally along the wall on the east and west sides of the composting building. The ductwork is aluminum and conveys the exhaust air to the blowers and to the biofilter cells. A series of manually operated dampers allows an individual cell or blower to be isolated for maintenance. The biofilter is 42,000 SF and was designed at a loading rate of five CFM/SF. The exhaust air is conveyed through a series of polyethylene laterals with a

custom hole pattern to evenly distribute the air into an 18 inch deep aeration plenum. The aeration plenum consists of washed round stone and serves to evenly distribute the air through the biofilter media. The media is four feet deep which provides a nominal open bed residence time of 48 seconds. The media consists of yard waste compost and wood chips. An automated irrigation system provides surface moisture addition to the media.

Operating Experience

The biofilter system began operating in July 1995. Performance testing was conducted in October 1995 using odor panel analysis according to ASTM E679-91, and an average odor removal efficiency of 86% was achieved. Two of the eight cells had media removed and replaced in October 1996 to correct drainage problems resulting from improper pipe installation between cells. The originally installed geotextile fabric was also removed to enhance air distribution in these cells. The geotextile fabric in the remaining six cells was removed in May 1997. The biofilter system was initially designed to operate with spray nozzles in the duct ahead of the biofilter for dust removal. The spray nozzles were utilized sporadically during the initial two months of operation and have not been used since. As a result, dust accumulated in the air distribution laterals beneath the biofilter media. The laterals have been retrofitted to include an extension and end cap which allows for periodic cleaning. The biofilter system has operated efficiently, and no odor complaints have been received from neighbors since the facility began operation.

Cape May County Municipal Utilities Authority (CMCMUA)

Basis of Design

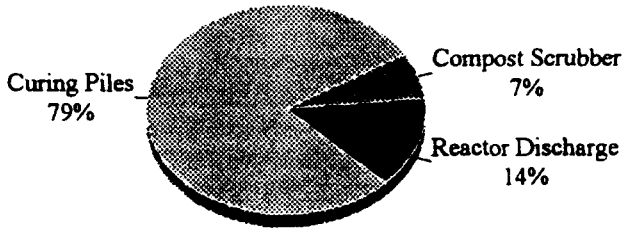
The CMCMUA owns and operates a 20 DTPD in-vessel biosolids composting system to manage dewatered raw solids from four secondary wastewater treatment plants. The biosolids compost facility began operation in 1985. The facility consists of two Purac reactor (vertical) vessels, which are totally enclosed in buildings. Originally, the facility was designed to function with the two reactors in series. However, increased loading to the plant prompted the CMCMUA to modify the facility so that both reactors operate in parallel. During peak summertime loading conditions, the reactors process 20 DTPD. The sludge cake is approximately 28% solids and is mixed with bulking agents such as shredded pallets and recycled material. Prior to placement in the reactors, the shredded pallets are typically mixed on a two to one ratio with the recycled material from the reactors and then blended with the biosolids in an automated pugmill mixer to achieve a target mix solids content between 38% and 40%. Material is then loaded into one of the two reactors where it is maintained for a two week period. After the two week period, the material is discharged from the reactors into a dump truck and then transported to the adjacent curing pad where front end loaders place the material over aeration pipes. The pipes are connected to blowers in an extended aerated static pile fashion. Prior to the biofilter project, the blowers operated either on or off as controlled by the operator with a cycling timer.

Odor control at the compost facility has improved over the years to the point now where all fugitive emissions from the solids and bulking agent storage areas, buildings, the solids receiving building, mixing building, and the composting reactors are being contained and collected for treatment in a three stage chemical scrubbing system which then discharges exhaust gases through a 100 foot high stack. While such an approach provided significant improvement in odor control at the facility, odor complaints persisted during peak loading conditions in the summertime months. It was determined by observations of operations personnel that off site odor impacts remain primarily from the untreated curing process odors rather than the scrubber exhaust. It was this area where fugitive odor emissions were identified as potential problems off site and where an odor study was focussed.

At the beginning of the odor study, some CMCMUA staff thought that enclosing the curing area and treating all of the building air was the only method to reduce odors from the curing process. The odor study verified that the majority of the odors were emanating from the curing piles and that the majority of the odors were generated in the first 14 days of curing. Figure 1 summarizes the percentage of odorous emissions from the major sources. Furthermore, the odor study determined that 90% of the curing odors appeared to be released when blowers were in the "on" mode. In a subsequent composting bin study, the amount of odors generated were reduced by providing air continuously rather than intermittently (on/off cycle). Based on this information, it was determined that odorous emissions from the facility could be substantially reduced by installing an aeration system that could operate in the negative mode, thereby pulling air through the compost piles, and collecting this odorous process air for treatment through a biofilter system.

FIGURE 1
CMCMUA COMPOSTING ODOR EMISSIONS

% Contribution of Sources During Reactor Discharge



The odor control portion of the curing process involved the first 14 days, and the new biofilter odor control system was designed to consist of the following:

- Ten variable speed curing blowers with a capacity of between 200 and 800 CFM.
- Central odor collection ductwork to convey exhaust gases from the curing piles to the biofilter system.
- Two biofilter booster blowers, each rated at a capacity of 1,200 CFM.
- Two cooling chambers designed to reduce curing pile exhaust temperature to less than 40°C.
- Two biofilter cells with an effective treatment area of 300 SF each.

The modified process description is as follows:

Compost discharged from the reactors is placed in an extended aerated curing pile for the first 14 days out of the reactor. The curing pile aeration blowers are connected to four inch diameter high density polyethylene (HDPE) perforated aeration pipes. This aeration pipe has a customized hole pattern for even air distribution and is reused after each curing cycle. The variable speed blowers are operated at the higher aeration rate initially as the material is discharged from the reactor. The system is sized such that two of the aeration blowers can operate at the maximum aeration capacity of 600 CFM, and six of the aeration blowers can operate at a lower aeration rate of 200 CFM with two fans in stand-by. The curing aeration blowers are operated utilizing a temperature feedback control system which is controlled by temperature sensors in the cure pile blower exhaust airstream.

Exhaust gas is discharged from these blowers into one of two chlorinated polyvinyl chloride (CPVC) collection ducts which are used to convey the odorous gases to the biofiltration system. The biofilter blowers are operated at a constant speed to provide 1,200 CFM of capacity through the system. During periods when inadequate flows are being provided by the curing blowers, outside air is automatically introduced into the ductwork to maintain a constant flow rate to the biofilter system. Two cooling chambers were constructed out of surplus aluminum storage tanks with coarse spray nozzles at a water flow rate of between 15 and 20 gallons per minute. These cooling chambers provide a nominal gas residence time of 3.75 seconds to allow for cooling of the curing pile exhaust gas. The gas then passes through the biofilter blowers and is distributed to two independently operated biofilter cells. Each cell is an open bed design consisting of a main distribution header and six air distribution laterals (six inch diameter) beneath the biofilters. The cells include a PVC liner to collect any excess irrigation water which is drained back to the wastewater plant for treatment. The distribution laterals are placed in an 18 inch deep bed of washed, round stone above which is a four feet deep layer of media consisting of a uniform mixture of wood chips and stabilized yard waste compost. The gas loading rate to the biofilters is four CFM/SF, providing a nominal gas residence time of 60 seconds. Moisture control in the biofilter cells is provided through surface irrigation during summertime months. During the wintertime, the filter is operating in a condensing mode, and surface irrigation is not necessary.

Operating Experience

The biofiltration system has been on-line since July 1996. Odors from the curing portion of the compost facility decreased markedly since the facility was placed on-line. Pressures and temperatures to the system are measured on a regular basis by operations personnel. The addition of the automatic temperature feedback control system has reduced the level of effort required to monitor the curing operation. Once a curing pile has been constructed, the blowers are placed in automatic mode. The PLC based control system adjusts the variable speed blowers to maintain pre-determined set points. The status of all equipment is graphically displayed in the control room. The performance trends of each blower is also recorded by the computer.

Two operational problems surfaced during the initial operation of the facility. The first problem was with regards to scaling of the cooling chamber. The original design called for the use of non-potable water (effluent) from the neighboring wastewater treatment facility to cool the curing gases and remove some of the ammonia. The high seasonal temperature (approximately 27°C) of this water did not provide a great enough temperature difference for adequate cooling, so a well was drilled to obtain lower temperature water. The well water was extremely hard and had a near neutral pH. The high level of ammonia within the curing process offgas resulted in a slight increase in the spray water pH due to the high solubility of ammonia. As a result, precipitation of salts occurred, creating a heavy scale formation on the packing and the inside walls of the cooling chamber. A small acid feed system was installed to add sulfuric acid to the system to lower the pH level, thereby minimizing scale formation and maximizing ammonia removal. The second problem which occurred during initial stages of the operation was that of increased backpressure and decreased flows. Initially, the cells were constructed with a geotextile fabric between the stone layer and the media. This fabric fouled within eight months of start-up resulting in a decreased airflow to the biofilters. Subsequent removal of the geotextile fabric and replacement with a six inch layer of wood chips in the spring of 1997 resulted in normal operations at the facility. Flows and pressures within the system are at or above the design levels.

Performance testing of the biofilter system was conducted in July 1997 during peak loading conditions. The biofilter achieved 98% odor removal as measured by ASTM E679-91. Ammonia concentrations to the system were between 225 and 275 ppm. The spray chamber reduced the ammonia concentration by approximately 58%, and the overall biofilter system achieved a 99.9% ammonia removal efficiency. In the spring of 1998, new cooling chambers and a mist eliminator were installed to further enhance cooling and ammonia removal prior to the biofilter. In an effort to optimize biofilter performance during peak odor conditions, the CMCMUA has replaced the media each year of operation.

COSTS

Capital costs for the Davenport Compost Facility biofilter were approximately $490,000 or $2.33 per CFM of air treated. Capital costs for the CMCMUA Compost Facility biofilter (not including curing costs) were approximately $135,000 or $56.25 per CFM of air treated. The higher cost per CFM at the CMCMUA facility can be attributed to the following factors:

- Economies of scale
- Use of spray chambers for cooling and ammonia removal
- Use of PVC liner
- Use of concrete retaining wall for media

The largest portion of the operating cost for a biofilter system is typically electricity to operate the blowers. The second largest operating cost is generally media replacement. Other costs include labor for periodic inspections and testing associated with monitoring the biofilter system and equipment maintenance. The operating costs for the Davenport biofilter are approximately $235,000 per year, or $1.10 per CFM per year. This is based on media replacement every two years. The operating costs for the CMCMUA biofilter (not including compost curing costs) are approximately $15,100, or $6.30 per CFM per year. This is based on replacing media each year.

BIOFILTER DESIGN CONSIDERATIONS

The Davenport Compost Facility and the CMCMUA Compost Facility illustrate unique methods of control and treatment of odorous emissions utilizing biofiltration. Table 1 summarizes each of the exhaust gas streams treated.

TABLE 1

Exhaust Gas Source	City of Davenport Compost Building	CMCMUA Compost Curing Blowers
Airflow, CFM	210,000	2,400
Temperature, °F	40 - 80	130
Dust	High	Low
Inlet NH_3 Concentration, ppm	0 - 35	225 - 275
Inlet Odor Concentration, D/T	350 - 640	4,825 - 5,790
Loading Rate, CFM/SF	5	4

The exhaust gas flow rate is much higher when an entire building is ventilated as compared to only the exhaust gas from the process blowers. The smaller flow rate from the process blowers yields a hotter exhaust gas with higher ammonia and higher odor concentrations. High exhaust gas temperatures require cooling prior to treatment through a biofilter. Biofilters operate more efficiently with gas temperatures below 105°F. The higher ammonia levels necessitate the use of an ammonia removal pre-treatment system to optimize biofilter performance. The higher odor levels dictate a lower biofilter loading rate in order to achieve high odor removal efficiencies. The high levels of dust associated with ventilating the entire building require dust removal pre-treatment or the ability to clean the dust out of the aeration system.

CONCLUSIONS

Two distinct alternatives for the capture of odors at aerated compost facilities exist. These two alternatives are complete enclosure and capture of all exhaust air and collection of only compost exhaust air. The decision must be based on objectives of the owner/operator as well as financial limitations.

The City of Davenport Compost Facility illustrates the odor control effectiveness of completely enclosing the composting operation and treating all of the exhaust through a biofilter system. The CMCMUA Compost Facility illustrates that substantial odor reduction can be achieved through a biofilter system treating only compost process exhaust. Different design factors including the level of dust, ammonia concentration, and temperature of the odorous air must be considered when designing and operating a biofilter system. In addition, an odor study can help identify odor sources and prioritize the use of odor capture and treatment equipment.