SMART SERIES-ODOR MANAGEMENT

BioCycle April 2007, Vol. 48, No. 4, p. 25

Tackling odors at composting facilities is a manageable task made simpler by inventorying and treating all sources and tapping into technology advances.

Nora Goldstein

PERHAPS one of the most difficult realities that had to be faced 15 to 20 years ago by the composting universe is that the phrase, “odor-free” - at least when it comes to composting - is probably an oxymoron. Feedstocks that biodegrade within the timeframe of a managed composting process contain odor-generating compounds. There will always be some level of odor associated with composting. The key, which many operators have learned the hard way, is to contain and treat them within the facility footprint. These same odor-rich process air streams also have corrosive qualities, especially as they relate to release of ammonia in enclosed composting halls. Therefore the science and engineering of odor management can have a direct correlation to corrosion prevention.

Learning how to manage odors successfully has been a series of unfolding insights over many years. A biosolids composting plant in Maryland, using aerated static piles with negative aeration, initially started with a small biofilter made from the finished compost. A change of process at the wastewater treatment plant (which changed characteristics of the biosolids) led to off-site odor generation and complaints. Plant operators doubled the size of the biofilter, which did little to mitigate the problem. The biofilter was pretty much deemed a failure at that time (mid-1980s) and plant management invested in a chemical scrubbing system. Articles in BioCycle throughout this time period and into the 1990s tracked this facility's experience with scrubbing technologies (see “Improving Compost Odor Scrubbing Performance,” January 1995 for a summary). It started with a misting tower technology, and eventually led to a 3-stage system (ammonia removal; oxidation; final wash). Scrubbers were installed at other composting sites as they were viewed as the most effective treatment technology. While some successfully treated composting process odors, they were capital and management intensive.

During the 1990s, a number of horizontal agitated bay composting systems were installed, primarily to process biosolids and ground yard trimmings and/or wood chips. While some of these sites installed chemical scrubbers, the vast majority opted for biofiltration of process and building air. Enough had been learned from early installations to recognize that biofilters actually are quite effective at treating odorous air streams from composting operations but they have to be engineered, sized and maintained correctly. It also was recognized that biofilters can perform more effectively if the odorous air stream is pretreated through a scrubbing system to knock out ammonia, and/or to humidify the air. A technological marriage of sorts was made between biofiltration and scrubbing technologies.

Several other critical facets of odor management emerged over the 1990s and into the new century - identification and analyses of odor compounds; systematic inventorying of all odor sources; odor dispersion modeling to track how and where odors move off-site; and operator "accessible" odor monitoring and measuring tools.

Operators also recognized the importance of controlling fugitive odors, installing high-speed doors on tipping and composting buildings and using odor neutralization products released in a vapor phase around building doors or at sites that are open to the atmosphere.

This fourth Smart Series article highlights some of the advances in odor control knowledge, practice, tools and technologies. The sidebar contains some key definitions and phrases.

SMARTER ODOR MANAGER

To learn more about how the confluence of science, technology and experience has made composters smarter odor managers, we turned to Derek S. Webb, P.E. Director of Technology and Emerging Markets for BIOREM, a manufacturer of high efficiency biofiltration systems based in Guelph, Ontario. BIOREM has been working with several composting facilities in Ontario and eastern Canada that process source separated residential and commercial/institutional organics streams, all using enclosed composting systems. The company has about 550 biofilter installations worldwide, the majority in North America treating odorous air streams at wastewater treatment plants and biosolids facilities. "How have we become smarter odor managers?" asks Webb. "The whole science and art of odor control and management have really taken off in the last 10 years. For example, odor control used to be a subjective science, but with increasing use of odor panels - dynamic olfactometry - a lot more science has been put behind it.

"For odor control in general, knowing what is in the air becomes critical, and has a major impact on the type of technology to use. The first step is an analysis of odor inlet levels to determine what compounds are present and in what magnitude. Second is knowing how to deal with the types of odor compounds present. Hydrogen sulfide (H_2S) is a good example. When bacteria degrade H_2S, one of the by-products is sulfuric acid, which can acidify the filter bed that the microbes are living in. That may not be good for microbes needed to degrade other compounds. Nitrogen-bearing compounds like ammonia also can be toxic to bacteria if the levels are too high. Another group of compounds to be aware of is VOCs. When organic materials break down, there is a release of organic acids such as aldehydes that typically are more difficult to remove regardless of the technology. Knowing what odor compounds are in the air stream is essential to designing the pretreatment and biofiltration systems."

Other critical pieces of information needed about the air stream when designing an odor treatment system are the level of moisture, temperature, and amount and type of particulates. "That information helps to design the pretreatment stage," Webb adds. "Is the air too hot, too cool, too dry? Does it contain dust? Any appreciable dust in the air stream when it gets into the biofilter will quickly blind the media." He notes that the more complex the air stream going into a biofilter, the more phases of conditioning are necessary. “If the air stream has high ammonia and high H2S, for example, that may require a scrubber to remove the ammonia, a biotrickling filter to remove the H2S, and a biofilter to remove all remaining compounds.”

Many in-vessel composting operations are managed with fairly high air flow rates for compost process control and air exchanges in the building. Backpressure on the aeration system due to compaction of the filter media and clogging in the aeration trenches in the composting building not only makes overall air handling inefficient, it increases utility costs to run the entire plant. “Operational costs based on backpressure to air flow becomes critical, especially at composting plants with very large air flow rates,” says Webb. “For example, our biofilter design is optimized at 1- to 2-inches of water column. In Ontario, utility costs are roughly $50,000/year/ inch of water column based on a 250,000 cfm system. So when the backpressure builds to 6- to 8-inches of water column, you can see how the utility costs can skyrocket.” He adds that BIOREM installs sensors at every foot of media depth to take pressure readings. This gets reported via the software management system so that the operator can monitor backpressure and respond if there is an increase.

The learning curve about the biofilter media itself has come light years as well. In the early years, compost facilities would use a combination of their own material and wood chips (or just wood chips) and blow the process and building air through it. The higher temperature of the inlet air, along with the moisture, would lead to a composting-like environment in the biofilter, with bacteria degrading the wood as a carbon source. The biofilter would perform well initially, but over a period of six to 12 months, the media would degrade, leading to compaction and clogging. The net effect is that air flows along the paths of least resistance, and can escape the biofilter untreated. In a short period of time, this can lead to high levels of maintenance, neighbor complaints and bed replacement. Over the years, compost facility designers began to pay more attention (and capital) to pretreatment of the process and building air and the media components and blend. It was recognized that the surface area of the media was a factor in the overall performance of the biofilter. “The higher the surface area, the higher the potential attachment site is to support bacteria that will degrade odors,” explains Webb. “Also, the higher the surface area, the higher the contact area is for the odor compounds. The wood chip media might be as large as 1-inch by 1-inch by 4-inches, and it tended to have smooth surfaces, so the effective surface area was very low. In turn, this required longer retention time of the odorous air stream in the biofilter for effective treatment.”

Another insight Webb offers into the media is that some odor compounds are hydrophobic and others are hydrophilic (water loving). This means that some are soluble and others are not. This reality was a factor in BIOREM's engineering of a synthetic media that degrades both hydro and hydrophilic compounds. “The formulation has a coating that attracts the water soluble compounds first, and then a bacteria that releases an enzyme to oxidize the hydrophobic compounds,” he explains. Buffers are added to the media to reduce acidification.

The synthetic media has 11,000 sq. ft. of surface area/gram available for potential attachment sites for bacteria or biofilm to solubilize compounds out of the air into the moisture film. This contrasts with approximately 10 sq. ft./gram for wood chip-based media, adds Webb. “We learned an important concept that what is good for biology is not good for physics when it comes to effective biofiltration. “In effect, using a small particle size organic media to gain surface area can ultimately increase the backpressure on the biofilter because of clogging. So we went about finding a way to get what we needed out of one parameter and fool the others. Our media has surface area but because it is a mineral structure, it doesn't compact and allows air to flow freely."

For composting facilities using organic media, Webb stresses the importance of how the media should be placed in the biofilter cell. "One facility we worked with placed the media in the corner and then worked outwards to fill it in," he explains. "When they ran out of material, they would get another load. The result was that there were two different materials at the same depth, with two different aerodynamic characteristics. Air can be difficult to work with. It has a mind of its own. Air will choose the path of least resistance, so if one section has more coarse wood chips and the next section has more fines, air will go with the wood chip side and not be effectively scrubbed of odor compounds. If you are unsure of the feedstock source, build the biofilter in layers so at least you have the same aerodynamic characteristics in that layer as the air travels upwards."

Recently, the Region of Peel, Ontario opened a source-separated organics composting facility (see "Source Separated Collection And Composting Expansion," January 2007), designed to process 72,000 metric tons/year. The Ontario Ministry of the Environment odor emissions guidelines have a limit of one odor unit (OU) at the property line. The composting facility, which uses the Christiaens aerated tunnels, generates 30,000 cfm of odorous waste gas. The Region of Peel installed a BIOREM biofilter with permanent media (Biosorbens®). Two cells, each designed to treat 15,000 cfm of odorous air, are housed in a 20 meter by 20 meter building. "It must achieve less than 500 OU at the biofilter exhaust to meet the one OU at the property boundary," says Webb.

As part of the compliance (and required for project completion), the system was tested to ensure it met the 500 OU at the biofilter outlet, in this case a stack. The inlet odor was measured at 6,600 OU; the outlet odor was 130 OU, or 98 percent odor destruction capability, notes Webb. Chillers were built into the collection system treatment train to maintain the temperatures. The system also has a cross-flow humidification chamber to further cool and humidify the air. The system airflow is controlled by the duct static pressure; other process parameters - individual cell air flow, air temperatures, differential cell pressures, biofilter media temperatures, fan speed, etc. - are displayed and controlled on a computer touch screen. Irrigation cycles are controlled by the computer, and are set to provide sufficient supplemental moisture for the biofilter media.

HIGH CARBON WOOD ASH

The Town of Kennebunkport, Maine operates an aerated static pile facility, composting 800 cubic yards/year of dewatered biosolids (belt filter press at 13 to 16 percent solids) in a roofed but open-sided building. When the composting site opened, wood chips were used as a bulking agent. "We had odor complaints and the Maine Department of Environmental Protection asked us to shut down," recalls Ron Taylor, Chief Operator with the Town of Kennebunkport. A school is less than 100 yards away, so getting odors under control was critical. "We stopped using wood chips and switched to wood ash from a paper mill boiler plant," he says. "Another small biosolids composting plant in Scarborough, Maine had tried wood ash and it successfully treated the odors. We became the second biosolids composting plant in Maine to switch to wood ash."

Biosolids are mixed with wood ash in a 1:1 ratio. Some recycled compost is added as well. Since Kennebunkport began using wood ash over 10 years ago, it has not received an odor complaint. The wood ash is stored under roof. There isn't a need to screen the finished compost, which is marketed to topsoil blenders for loam products. The particle size of the finished compost would pass a 3/8-inch screen, notes Taylor.

New England Organics, based in Portland, Maine, supplies wood ash to a number of composting operations in New England, including Kenne-bunkport. The company manages wood ash for more than seven wood-fired power plants. "The type of boiler often dictates whether the wood ash is suitable for composting," explains John

Kelly, Product Marketing Manager for New England Organics. “The ideal wood ash for composting is coarse in texture, almost like a char, and is high in carbon. We have found wood ash with a carbon content of 30 to 60 percent works extremely well in controlling odors and produces a quality finished product. Conversely, higher efficiency biomass boilers, especially ones using fluidized beds, produce powder-fine wood ash that may have less than 10 percent carbon. This low carbon wood ash is suitable as a lime substitute, but it lacks porosity, which is a benefit to the use of high carbon wood ash for composting, especially when used as a substitute for wood chips.”

Kelly adds that some of the high carbon ash, due to its loose texture and pore space, has a bulk density of 500 to 800 lbs/cubic yard. Moisture content is about 20 to 30 percent, which also is an advantage, especially when the ash is used to bulk wet material such as biosolids. At a pH of 12, the wood ash has abrasive qualities, but doesn't seem to pose any significant corrosion problems to the composting equipment. The high pH also does not create any noticeable increase in ammonia, and it only causes a slight increase in the pH of the final product, says Kelly. New England Organics charges composting facilities for the wood ash. “The price is about the same, or even less than sawdust, and the wood ash can replace sawdust as a bulking agent,” he explains. “When the odor control benefits are factored in as well, facilities see an economic advantage to using the wood ash.”

ENZYME TREATMENTS

Little Hannaford Farms in Centralia, Washington processes yard trimmings, daft from chicken processing plants, cattle manure from a fairgrounds and sheet rock waste from new construction. The site composts in windrows that are “in one big block,” explains Dennis Felt, owner of Little Hannaford Farms. “We place the windrows, which are about 10- to 12-feet high, right next to each other to retain heat and moisture. Piles are agitated using a loader with a 10-cy bucket that can move about 1,000 cy/hour. We work the windrows from the south to the north. Finished material on the north end goes directly to a CEC Screen-It deck screen. We do this turning process once a week.”

About nine years ago, Felt met David Hill from GOC Technologies at a BioCycle conference. “We were having some odor problems, and David was just introducing the 506 bioaugmentation odor treatment product for waste management facilities,” he recalls. “We started using the 506, which gets incorporated with incoming material, and the 505 product that is applied topically to the windrows after turning. Recently we started using the GOC 2300 and have found that the bioaugmentation product actually accelerates the composting process in addition to controlling odors.”

The GOC products utilize enzymes that react with bacteria in the composting materials to break down the odor compounds. The formulas have been engineered by identifying what bacteria must be present to break down specific compounds, and what enzymes are needed along the way to react with those compounds. Some treatments biochemically enhance growth of various microorganisms, which, in turn, facilitate desirable chemical reactions. Other products are strong surfactants that facilitate rapid penetration of water and deodorizers into an odorous mass. The company has developed enzyme-based products for specific compost feedstocks, including manure, green waste, food waste and biosolids.

P. 27 Terms & Definitions

Odorant -- Substance (compound such as ammonia, hydrogen sulfide, butyric acid) capable of eliciting an olfactory response.

Odor -- Sensation resulting from stimulation of the olfactory organs.

Odor Concentration -- Number derived from the dilution of a sample of odorous air. The sample is dynamically diluted using an instrument called an olfactometer. The odor threshold (concentration) is reported as a dimensionless dilution ratio, or dilution to threshold (D/T).

Odor Intensity -- Relative strength of the odor above the threshold that is referenced by a comparison of the odor intensity of the sample (odorous air) to the odor intensity of a series of known concentrations of the reference odorant, n-butanol. The odor intensity of the sample is expressed in parts per million of butanol equivalence.

Odor Threshold -- Minimum concentration detectable or the minimum detectable difference between two concentrations.

Odor Unit -- One odor unit is the amount of odorant(s) present in one cubic meter of odorous gas (under standard conditions) at the panel threshold.

Olfactometer -- Dilution apparatus that mixes odorous air in specific ratios with odor free air for the presentation to an odor panel.

Field Olfactometer -- Hand-held olfactometer that takes real-time measurements of the level and strength of ambient odors (vs. measurements taken directly from the odor source).

Dilutions to Threshold (D/T) -- Dilution-to-threshold techniques dilute an odor sample with odorous air at a number of levels and the dilution series is presented in ascending order of concentration. From one level to the next, the dilution decreases and the amount of odorous air increases. Odor guidelines/regulations for composting facilities may be stated in D/T.

Detection Threshold -- Concentration at which 50 percent of a human odor panel can identify the presence of an odor or odorant without characterizing the stimulus.

Recognition Threshold -- Concentration at which 50 percent of the panel can identify the odorant or odor.

Sources: St. Croix Sensory, Inc. website (www.fivesenses.com) and "The Science of Smell Part 3: Odor Detection And Measurement," Iowa State University Extension, October 2004.