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Biosolids and Residuals Management Fact Sheet

Odor Control in Biosolids Management

DESCRIPTION

This Fact Sheet provides information on the control of odors from biosolids production facilities, and the prevention of odors from the storage, distribution, and application of the biosolids product. The level of detail is intended to provide an overview for decision-makers including wastewater treatment plant managers and authority managers. The information provided is not intended to be design guidance.

Nuisance odors are a common occurrence at wastewater treatment plants, biosolids processing facilities, and biosolids recycling locations where proper management and control are not implemented. Failure to acknowledge the potential for odors and to work to prevent odor emissions can result in complaints, shutdowns, expensive retrofits, and non-acceptance of the finished product. Every operation should keep a systematic record of odor complaints.(Chlupsa) Proper facility design, operation, management, control and careful oversight are necessary to minimize odors. Water quality professionals have a responsibility to mitigate nuisance odors.

The most successful odor control programs are those that take a holistic approach and examine the complete system from sewer users to land application practices. Just as a good physician can identify the cause of the illness and not just treat the symptoms, effective odor management will identify and manage the source of odors and not just attempt to mask or hide the offensive odors. In addition, a holistic approach will encompass effective communications with those groups that may be negatively impacted by odors.

Nuisance odors can have detrimental effects on aesthetics, property values, and the quality of life in communities subjected to them. There are odorous compounds that are classified as toxic pollutants, but emissions of these compounds are restricted by air quality regulations and their control is not part of this discussion. An odorous biosolids product, or a biosolids treatment process that results in odor emissions, may be perceived as unhealthy due to the origin of the solids. The cause of health complaints in the absence if irritation or toxicity is poorly understood. (Schiffman et, al.) Tangential information is available from other industries but there is no necessarily direct relevance to biosolids odors. More research is needed to identify potential health effects of biosolids odors.

Odor complaints at operating facilities can lead to long term problems. Local public opposition can delay or prevent expansions or upgrades to facilities required to improve water quality. The anticipation of nuisance odors from proposed land application programs can limit the implementation of a worthwhile beneficial reuse program.

Why Do Biosolids Generate Odors?

The beauty of biosolids is that is an abundant source of food for microorganisms including protiens amino acids and carbohydrates. These beasts in biosolids degrade these energy sources and odorous compounds are formed. (Walker, 1991) Organic and inorganic forms of sulfur, mercaptans, ammonia, amines, and organic fatty acids are identified as the most offensive odor causing compounds associated with biosolids production. These compounds typically are released from the biosolids by heat, aeration and digestion. The odors vary by the type of residual solids processed and the method of processing.

Anaerobic digestion of primary wastewater residuals produces hydrogen sulfide and other sulfur-containing gases, while alkaline stabilization of the solids volatilizes ammonia along with other volatile compounds. Composting odors can be caused by (Walker) ammonia, amine, sulfur-based compounds, fatty acids, aromatics and hydrocarbons such as terpenes from the wood products used as bulking agents. Aerobically digested and air-dried biosolids may contain little hydrogen sulfide, but have mercaptan and dimethyl sulfide odors.(Bertucci, Dodd, Hatfield, Williams)

The five independent factors that are required for the complete odor assessment are:

1. Intensity or pervasiveness- a measure of the perceived strength of the odor compared to concentrations of a standard compound.

2. Character - which relates to the mental association made by the subject in sensing the odor.

3. Hedonics - the relative pleasantness or unpleasantness of an odor sensed by the subject.

4. Detectability or quantity - the number of dilutions required to reduce an odor to its minimum detectable threshold odor concentration (Switzenbaum et al., 1997, Walker).

5. Mass - total mass per unit time or the volume of odorous air produced.

APPLICABILITY

Odor Control at Biosolids Processing Facilities

Biosolids processors are faced with odors during thickening, digestion, dewatering, conveying, storage, truck loading, air drying, composting, heat drying, alkaline stabilization, and/or incineration. The odors may be point sources or ambient air (in a belt press room for example.) The odors may emanate from point sources or be present in ambient air from area sources. A comprehensive odor audit and air dispersion modeling is the best assurance that capital and operating dollars are spent wisely. Facility owners should look for a consultant who specializes in biosolids odor control when initiating an odor audit. An odor audit will accomplish the following:

- Quantify odors from each odor emissions source.

- Analyze for odor causing compounds.

- Determine the processes by which odor causing compounds are formed.

- Identify the most significant odor sources.

- Obtain data for odor emissions air dispersion modeling.

- Determine the most cost effective odor management plan.

Good management practices or modification to the operation may reduce odor emissions; however, odor containment and treatment at the biosolids processing facility may be necessary to control downwind effects.

The value of air dispersion modeling prior to final design should not be underestimated. Information obtained from modeling may result in design changes such as; increasing stack height, increasing stack velocity, providing reheat to increase thermal buoyancy, or dilution with ambient air. (Haug, 1990) These low cost features can save significantly on capital and operating costs and improve effectiveness.

Likewise, effective communication with the affected community is important to enhance odor management and reduce the number of complaints.

Odor Control at Land Application Sites

The biosolids producer should accept responsibility for odor control at land application sites. Even if the producer hires a contractor to provide transportation, storage, or land application services, the terms of the agreement should include management practices to minimize odors. In addition, the generator and contractor should have an odor response plan in place to provide guidance and policy on documenting and responding to odor complaints. The land applier should have the ability and responsibility to divert biosolids from a site that is experiencing odor problems.

Biosolids producers should make every effort to minimize odors at the application site because the long term efficacy of land application depends on it. A dramatic increase in local ordinances that ban or restrict the use of biosolids has been observed in recent years as a result of odor complaints. A nationwide survey (Biocycle 1999 revealed that odors at land application sites were usually the initial operating problem that resulted in complaints, which were followed by questions and often, organized public opposition.

Federal Biosolids Regulations do not regulate odors because it was believed that odors from land application did not present human health effects. It has been said, however; "Biosolids odors may not pose a health threat, but odors are killing public support for biosolids recycling programs." (Toffey, 1999)

The most cost-effective approach to odor control may be to examine the operation and maintenance practices at the processing facility. Septic conditions may result in a biosolids product that is more offensive than necessary. Some polymers break down into odor forming compounds under high heat and elevated pH. Incomplete anaerobic digestion can result in worse odors than no digestion at all. Blending of raw and WAS prior to liquid storage can result in higher concentrations of Dimethyl Sulfide. (Hentz and Cassel, 2000)

Methods to reduce odors at land application sites include:

- Properly stabilize, condition and manage biosolids at the treatment works to minimize odors from the final product.
- Select remote sites and fields away from neighbors (USEPA & USDA,2000).
- Apply well stabilized material.
- Clean tanks, trucks, and equipment daily.
- Whenever possible, subsurface inject or incorporate biosolids into the soil (WEF 1997).
- Minimize the length of time biosolids are stored (USEPA & USDA,2000).
- Reduce visibility and maximize the distance of the storage area from occupied dwellings (USEPA & USDA,2000).
- Avoid land application when wind conditions favor transport of odors to residential areas (USEPA & USDA,2000).
- Plan field storage of biosolids based on the stability, quantity, and length of time biosolids are stored in addition to the location of the site with respect to nearness to neighbors and the meteorological conditions (USEPA & USDA,2000).
- Avoid land application when nearby residential areas are planning outdoor activities or around holidays such as Memorial Day, Independence Day, and Labor Day WEF 1997).
- Develop an odor control plan and train all staff to identify and mitigate odors.
- Have alternate management including land-filling for particularly malodorous batches of biosolids.

Process Management

The degree of odor control necessary for biosolids processing facilities is determined by site-specific criteria such as:

- The current and future proximity of a site to residential or commercial developments.
- Local wind patterns, air mixing and dispersion (air stability) factors.
- Temperature and humidity.

- The variability of the above factors on a daily and seasonal basis.

- The amount of biosolids being processed.

A computerized air dispersion model that addresses magnitude, frequency, and duration of events, and is calibrated and verified with on-site monitoring, can be an effective tool to predict the impact of odor emissions. This type of model may determine how much and what type of control will be necessary to prevent or minimize the impact. To accomplish this task with some certainty of success, a formal odor study should be commissioned.

During the planning or preliminary design of a proposed biosolids processing facility, an odor study should be conducted in light of the knowledge and experience gained from successful operations at similar facilities. For existing facilities that have nuisance odor problems, the study should determine the degree to which specific unit processes or area sources contribute to the offsite impact. A detailed sampling and monitoring program should be conducted to determine a not-to-exceed nuisance odor level. Liquid and gas samples can be chemically analyzed for specific odor compounds. Both direct sensory measurements of odor intensity and odor strength are also useful to identify the sources of the complex mixture of odor compounds typically responsible for nuisance complaints. Direct sensory measurements are conducted by a panel of trained observers (expert noses) which analyzes and rates air samples in terms of odor intensity (n-butanol scale) and odor strength (dilution to threshold or D/T scale.) A comprehensive odor study should result in a full understanding of the source and nature of the odor emissions, identify available methods of odor control, and establish criteria to measure the effectiveness of the control technology.

Local ordinances may establish the degree of odor control required. Generally, the ordinances are written to prevent nuisance conditions at and beyond the facility property lines. Numerical limits of allowable concentrations of odorous compounds are specified in some localities, while others specify the frequency and/or duration of the detection of off-site odors as the criteria for violation of nuisance standards.

Sources of Odor

Wastewater collection systems with long detention times can result in septic conditions throughout the wastewater treatment plant and subsequent odor problems in biosolids handling and end use. Aerated static pile, windrow and in-vessel composting processes can produce objectionable odors if anaerobic conditions occur and even with aerobic conditions. Ventilation of air through the compost material helps to control composting temperature, maintain aerobic conditions, and provide a means to direct the exhaust air stream into an odor control device. The alkaline pasteurization process produces ammonia as well as other odor-causing compounds. Large scale facilities are often enclosed and ventilated to a wet chemical scrubber. Heat drying facilities usually use wet scrubbers and/or afterburners such as regenerative thermal oxidizers.

Biosolids processing facilities can be operated and managed to reduce odor generation and emissions. The quantity and intensity of odorous compounds can be reduced by:

- Operation and maintenance procedures to prevent anaerobic conditions.

- Addition of oxidizing agents to prevent formation of hydrogen sulfide.

- Selection of polymers which are resistant to breakdown at high temperatures and pH.

- Optimizing all stabilization processes such as anaerobic digestion, aerobic digestion, or alkaline stabilization.

- Evaluate the impacts of blending different types of solids and storage. (Hentz and Cassel)

- Scrubbing with a properly operated chemical scrubber or biofilter.

Addressing O&M optimization may result in dual benefits. First, it will reduce the amount and intensity of odors generated at the site, minimizing costs of odor control equipment. Second, it will generate a less odorous product, which will be easier to store, transport, utilize, or market.

OVERVIEW OF ALTERNATIVES

Current Status

Current methods to control odors from biosolids production facilities include biofilters, activated sludge basins, wet chemical scrubbers, regenerative thermal oxidizers, and odor counteractant or neutralizing agents. The method chosen should be based on the results of an odor audit and the type of odor causing compounds present.

Biofilters- Description

Biofilters remove odors from a foul air stream by the adsorption and absorption of odor causing compounds onto a natural media bed where microorganisms oxidize the compounds. The indigenous bacteria and other microorganisms of the media acclimate to the compounds present and are sufficient to provide the "scrubbing" action; no bacterial innoculation or chemical addition is required. Biofilters commonly are used to treat the air from all types of composting operations.

Biofilters-Advantages and Disadvantages

Advantages

Biofilters provide significant reduction of overall odor emissions including Volatile Organic Carbon emissions. It is a simple technology with minimum moving parts and low energy requirements. Cold winter temperatures do not affect biofilter performance. Biofilters have a low profile and are not as visible to neighbors as a system requiring a stack. All the above advantages are true if biofilters are properly sized, kept moist, and renewed periodically.

Disadvantages

A major limitation of biofilters is the large land area required for installations. The size of the biofilter surface area is directly related to the airflow to be treated and the need to provide about a 45 to 60 second detention time. Poor biofilter performance is usually attributed to lack of moisture in the filter media. Other performance inhibitors are short-circuiting, pH depression, and high temperatures. A concentration of ammonia greater than 35 ppm in the foul air stream may cause a toxic accumulation of ammonium in the media, leading to reduced ammonia removal efficiency. The need to keep the biofilters moist results in a significant amount of water usage and the need to treat or dispose of leachate and condensate. Design criteria are not well established and biofilters may not be appropriate for very strong odors.

Biofilters -Design Criteria

The medium is a mixture of materials that may include bark, wood chips, yard waste or agricultural waste compost, peat moss, sand, pulverized volcanic rock, or oyster shells.

Oyster shells, or similar materials, can provide pH control within the media. (Haines et al). Rock, sand and bark are necessary to provide and maintain porosity of the bed. The medium may be kept moist by spray nozzles in the foul air collection system and at the top of the biofilter surface.(Haines et al).

Sometimes, water is also added inside the filter through drip piping. The media bed is placed over an air distribution system consisting of perforated piping installed within a bed of gravel. An impermeable membrane, such as a HDPE or PVC liner, is placed under the gravel to facilitate leachate collection and disposal. The biofilter can be constructed within a compacted soil trench or between soil berms. If the biofilter is installed within a concrete, masonry, plastic or similar container, the container must be designed to prevent short-circuiting at the side walls and to resist corrosion from the acidic leachate.

The size of the biofilter is determined by the airflow to be treated. The accepted loading rate of a biofilter is 3 to 4 cfm per square foot of media bed, with a media bed depth of 3 to 4 feet. Design should provide for ease of removal because biannual replacement or replenishment of the media may be required. Periodic mixing or turning of the media may be required to maintain the design air flow and head loss through the odor control ventilation system.

Biofilters are widely regarded as an effective, low cost method of treating low to moderate odorous air. A well operated and maintained biofilter can reduce odors by 95% or greater (Schiffman et al) (Boyette and Bergstedt). In some cases, biofilters have resulted in the elimination of odor complaints. (Alix). In other cases, improved composting operations and biofilter renovation combined resulted in a reduction of odor complaints. (Haines et al).

Biofilters -Operation and Maintenance

It is important that biofilters be kept moist so that the microbial community remains healthy and effective. The goal is to operate the biofilters as close to 100 percent humidity as possible. It is also important to keep sufficient void space and avoid air channeling, which results in short circuiting the media. Large amounts of dust and particulate matter in the foul air will build up in the biofilter media and shorten the replacement time. In addition, back pressure on the blowers will increase maintenance requirements. An appropriate temperature range must be maintained to keep the microbial organisms healthy and functioning. High temperature air (130-140 deg F) from composting processes contains high concentrations of ammonia that may be toxic to microorganisms. A typical biofilter life expectancy is one to seven years with biofilter replacement every two years. Operators should develop a biofilter performance monitoring protocol for routine assessment of odor control efficiency.

Activated Sludge Basins -Description

Similar to biofilters, the activated sludge basins used for secondary treatment at municipal wastewater treatment plants can provide odor removal by adsorption, absorption, condensation and microbial oxidation.

Activated Sludge Basins -Advantages and Disadvantages

Advantages

This can be a very cost effective alternative for facilities which operate aeration basins. (Bowker) Costs are usually lower for both capital and operating expenses. Systems have been in operation for over 40 years, and more than 25 facilities have used this technology. This system is effective in treating moderate to high strength odors. Activated-sludge basins are simple, with low operation and maintenance considerations (WEF MOP 24).

Disadvantages

Concerns about blower corrosion have been the major impediment to use of activated sludge basins. However, steel inlet filters and piping are more common points of corrosion. There are reports of accumulation of a tar-like substance or greasy film on the internal components of blowers, and the volume of foul air to be treated may exceed the demand of the aeration tanks. The method may not be appropriate for very strong odors.(WEF MOP 24)

Design Criteria - Activated Sludge Basins

The foul air is ventilated through a dedicated blower and diffuser system or through the process air distribution system. The foul air diffuser should be submerged at least eight feet to achieve high odor removal efficiency. The blower and diffuser equipment must be designed to withstand the corrosive nature of the air stream. Use of stainless steel, PVC, and moisture traps will minimize corrosion. The foul air volume can be minimized by using flat gasketed covers on tanks or individual enclosures for dewatering or blending equipment. Inlet covers will prevent particulate accumulation in fine bubble diffusers. Deep bed nitrification biotowers are also used for odor control.(Lutz et al)

Operation and Maintenance - Activated Sludge Basins

If a diffused aeration system already exists, little or no increase in O&M costs should be expected. The blowers and air filters must be cleaned periodically and the system monitored for odor causing compounds.

Wet Chemical Scrubbers

Wet Scrubbers are best suited to treating high intensity odor emission and large air volumes. They are usually used at alkaline stabilization facilities, biosolids drying facilities and incinerators. There are several types of wet scrubbers, the most commonly used in biosolids facilities include packed bed, mist, and venturi scrubbers. All are designed to maximize the contact between the odorous compounds of the foul air stream and a "scrubbing" chemical solution. The compounds are absorbed and then oxidized by the chemicals. The performance of a wet scrubbing system depends on the solubility of the odors in the scrubbing solution. This should be determined by testing or from previous installations.(Heller and Heller) Multiple stage systems, using water or acid in the first stage to remove the ammonia, followed by a chlorine or caustic and chlorine in the second stage to remove sulfur based compounds, are used to treat composting odors and more commonly the ventilated air from alkaline pasteurization facilities.

Advantages and Disadvantages - Wet Chemical Scrubbers

Advantages

A two or three stage scrubber system can remove a wide variety of odor-causing compounds. The units have proven to have variable chemical consumption and to be effective and reliable.

Disadvantages

There is a potential for emission of chlorinated compounds and particulate from the scrubber exhaust stack, as well as a potential for emission of a bleach odor if chemical feed is not properly controlled. Chemicals, power, and maintenance can be expensive, and large amounts of water are needed. The spent chemical must be properly disposed, and softening is required for the water.

Design Criteria - Wet Scrubbers

The three most common types of wet scrubbers are packed bed scrubbers, mist scrubbers and venturi scrubbers.

Packed beds use a shower of scrubbing liquid over a bed of high-surface-area plastic media to promote droplet and film contact within a reaction chamber. The foul air is ventilated through the plastic media in a direction that is co-current or counter-current to the liquid flow. The advantage of a packed scrubber is that the concentration of the scrubbing solution can be varied in response to fluctuating odor levels. These units are usually the least costly method of treating high intensity odors at dewatering and storage facilities. *Mist scrubbers* use compressed air to atomize a stream of scrubbing liquid and a controlled ventilation pattern within the reaction chamber to promote contact without the use of media. Advantages of mist scrubbers include a lower water usage and the ability to handle a wide range of flow rates. The disadvantages of mist scrubbers are O&M costs of the air compressor, larger space requirements, and the small clearances on the spray nozzles require water softening and occasional acid washes (Heller and Heller). *Venturi scrubbers* are similar in operation to mist scrubbers, but atomize a high-pressure stream of scrubbing liquid without compressed air. The type of scrubbing liquid used depends on the odor compounds to be treated. A combination of sodium hydroxide and sodium hypochlorite is effective for sulfide odors, while dilute sulfuric acid is effective for ammonia odors.

Effective cooling of the scrubber gasses is also needed for ammonia removal (Horst et al, 1991).

Operation and Maintenance - Wet Chemical Scrubbers

Wet scrubbers require pumps, compressors, valves, and instrumentation. As a result, operation and maintenance costs are significant. Occasional maintenance and calibration is required for the chemical supply system, liquid distribution nozzles and ORP (oxidation reduction potential) and pH probes. System maintenance can normally be performed without interrupting the treatment. However, mist scrubbers may require slightly more nozzle maintenance because of the use of finer spray nozzles.

Variable odor concentrations and constituents in the process air will make scrubber operations difficult and reduce effectiveness. Composting operations have found that improving compost operations, specifically mixing and uniform aeration, results in less variability in dimethyl disulfide concentrations in the scrubber feed air. Fewer and smaller operating adjustments are required to maintain optimum scrubbing conditions. (Murray et al, 1991)

Regenerative Thermal Oxidizers (RTO's)

RTOs use a high temperature to incinerate airborne compounds in a short residence time combustion chamber. This technology is usually used for biosolids heat dryers, incinerators, or evacuation air from biosolids storage tanks.

Advantages and Disadvantages - RTO's

Advantages

RTOs typically are used for VOC emission control, with odor removal being incidental. This equipment is compact compared to the area needed for wet scrubbers or biofilters. They are well suited to treating low volume, high strength air streams. RTO's are more energy efficient than conventional afterburners requiring only 10 to 20 percent of the energy. Thermal efficeincies are often 90 to 95% and the use of digester gas can reduce fuel costs.

Disadvantages

There are relatively few applications of RTOs specifically for the control of biosolids processing odors. Operators report these units are a significant fuel cost. The system is only economical for high-strength, difficult-to-treat air streams.

Design Criteria - RTO's

The required temperature in the combustion chamber is 1,350 to 1,600 degrees F with a detention time in the range of 0.3 to 3 seconds. It is also important to configure the system to provide sufficient turbulence and oxygen for efficient combustion. (Heller and Heller, 1999) The RTO may be fueled with fuel oil or natural gas, and heat exchangers recover much of the exhaust gas heat to preheat the incoming air.

Operation and Maintenance - RTO's

RTO's are an expensive odor control technology to operate and maintain. High temperatures result in significant fuel costs and frequent maintenance and/or replacement of instrumentation.

Counteractants, Neutralizing Agents and Oxidizang Agents

These products are used to reduce the impact of odors from area sources, such as biosolids curing or storage piles and point sources such as ventilation exhaust stacks. Essential oils and proprietary compounds are used as odor masking agents and as odor neutralizing or counteracting agents. These materials generally are non-toxic and non-hazardous to humans and the environment. They may be dispersed as a fine mist into the air at processing facilities or added to the liquid waste streams.

Oxidizing agents released into the wastewater react with odor causing compounds to form a more stable, odor free compound.

Advantages and Disadvantages - Counteractants, Neutralizing Agents and Oxidizing Agents

Advantages

The use of counteractants and neutralizing agents can be initiated quickly at a low capital cost. The use of oxidizing agents, or counteractants, in the waste stream can greatly reduce odors in the workplaces especially around thickening and dewatering equipment. At some facilities the addition of potassium permanganate, an oxidizing agent, temporarily reduces odors in the biosolids product,(Pisarczyk and Rossi) thereby making land application less objectionable to a farmer's neighbors. Some plants also observe improved dewatering when using potassium permanganate.

Disadvantages

It is possible that the perfume-like odor from some neutralizing agents may be perceived as an objectionable or nuisance odor. The effectiveness of neutralizing agents are limited to the area in which they can be dispersed. Oxidizing agents can act as a bactericides and inhibit biological processes. The presence of non-odorous substances that react with the oxidizer, will greatly increase the cost of treatment.(WEF) Oxidizing agents are not always effective and are sometimes expensive. The system has a poor database and limited information on odor removal efficiency.

Design Criteria - Counteractant, Neutralizing Agents and Oxidants

Essential oils and proprietary compounds are dispersed into the foul air stream as a vapor or fine mist. Either a reaction chamber is provided to maintain a contact and residence time or the ventilation ductwork or exhaust tower is used to apply the agent. Some products are claimed to polymerize and precipitate odor molecules from the air stream. The neutralizing agents are sometimes sprayed continuously in the vicinity of odorous tanks, truck loading or storage areas.

Another design uses oxidizing agents such as chlorine, hypochlorite, chlorine dioxide, hydrogen peroxide or potassium permanganate to prevent septic conditions and the resultant hydrogen sulfide odors. A small amount of oxidant is blended with wastewater or liquid wastewater solids. A potassium permanganate dose of 0.3% can reduce the Threshold Odor Number from 1500 to 200. The required dosage is dependent on pH. Less potassium permanganate is needed at pH 5 or 7 than at pH 9 (Pisarczyk. and Rossi, 1992).

Operation and Maintenance - Counteractants, Neutralizing Agents and Oxidizing Agents

Once the proper dosage is determined, operation and maintenance is relatively simple. Routine maintenance of pumps, spray nozzles and automated systems is required.

PERFORMANCE

The following table shows removal efficiency for a variety of odor control technologies. Within the past 5 years, the design and operation of biofilters has been optimized and is now better understood than ever. Most work on biofilter is for use at composting facilities but due to their low cost, they are also being examined for heat drying facilities.

TABLE 1 REPORTED REMOVAL EFFICIENCIES

System	H_2S	NH_3	Odor Units (D/T)
Biofilter	> 98%	> 80%	> 95%
Activated Sludge (coarse bubble)	< 85% - 92%	> 90%	90 - 95%
Activated Sludge (Fine Bubble)	> 99.5%	N/A	> 99.5%
Wet Scrubbers	> 95%	> 95%	< 80%-99%
RTO	N/A	N/A	> 95%
Chemical oxidants	>99%[1]	N/A	up to 99%
Counteractants and neutralizing agents	30%	30%	N/A

[1]Hydrogen sulfide concentration measured above the conveyor leaving the centrifuge.

Source: Schiffman et,al, Williams, Ostojic & O'Brien, Giggey et al, Solomon, LeBeau & Milligan, Pisotti, Singleton et al; Vaith et al; Ficek.

As with any odor control equipment, removal efficiency is only one aspect of effectiveness. Odor modeling will identify odor receptors and determine the likelihood of odors being detected off site.

TABLE 2 RELATIVE COSTS OF ODOR CONTROL TECHNOLOGIES

System	Overall	Capital	Operation/ Maintenance	Electrical or fuel	Supplies/ Chemicals	Effectiveness
Biofilter	Moderate	Moderate- but land area needed	Moderate	Low	Water needed	High>95% in compost
Activated Sludge Basins	Low, if existing system	Low, if existing system	Low, if existing system, may corrode blowers	Low , if existing system and biosolids processing facility is close	Low	High 90-95% for H2S and Ammonia
Wet Chemical Scrubbers	High	High-up to 50% of total plant costs	High - much high speed equipment + instrumentat'n	High - must move water at high pressure	High - chemical costs and water demand	High <80%-99% handles alkaline stab and all plant odors
Regenerative Thermal Oxydizers	High	Moderate	High- due to high temp equipment	High - tremendous heat demand	High - oil or gas	Good for organic odorants from incinerators, and heat dryers
Oxidizing Agents	Varies- moderate to high	Low	Low- just mat'l handling issues	Low - small pumps required	High - potassium permanaganate can be expensive	Varies from one plant to another
Counteractant & Neutralizing Agents	Moderate	Low- moderate	Varies from one plant to another	Low	High - usually patented compounds	Varies, but may help at end use site.

Source: Hentz et al, Haines et al, Giggey, Ostojic and O'Brien, Pisarczyk and Rossi, Ponte, Bowker, Vaith et al, Williams, Wu.

COSTS

Costs for odor control will vary significantly from one location to another and from one technology to another. At the Hoosac Water Quality District (HWQD) composting facility the biofilter was less than 3% of the capital cost and media replacement was about 7% of O&M costs (Alix,1998) . Multistage wet scrubbers and RTO's can result in 30 to 50% of capital and operating costs of a biosolids processing facility. Potassium permanganate costs $1M per year at a facility that dewaters and incinerates 60 dry tons per day (DTPD) which equates to $45 per dry ton.

The following table compares the cost factors for each technology. In addition, biosolids processing facilities should budget funds to conduct a facility wide odor audit, use odor modeling whenever possible, avoid septic conditions in wastewater and solids, evaluate polymers and liquid blending and storage practices, maintain records of odor complaints and conditions, and incorporate language in land application contracts to assure best management practices.

REFERENCES

Other Related Fact Sheets

Alkaline Stabilization of Biosolids
EPA 832-F-00-052
September 2000

In-Vessel Composting
EPA 832-F-00-061
September 2000

Land Application of Biosolids
EPA 832-F-00-064
September 2000

Centrifugal Dewatering and Thickening
EPA 832-F-00-053
September 2000

Filter Belt Press Dewatering
EPA 832-F-00-057
September 2000

Recessed Plate Filter Press Dewatering
EPA 832-F-00-058
September 2000

Other EPA Fact Sheets can be found at the following web address:
http://www.epa.gov/owmitnet/mtbfact.htm

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