IDENTIFYING & ADDRESSING OUTDOOR ODOR EMISSIONS

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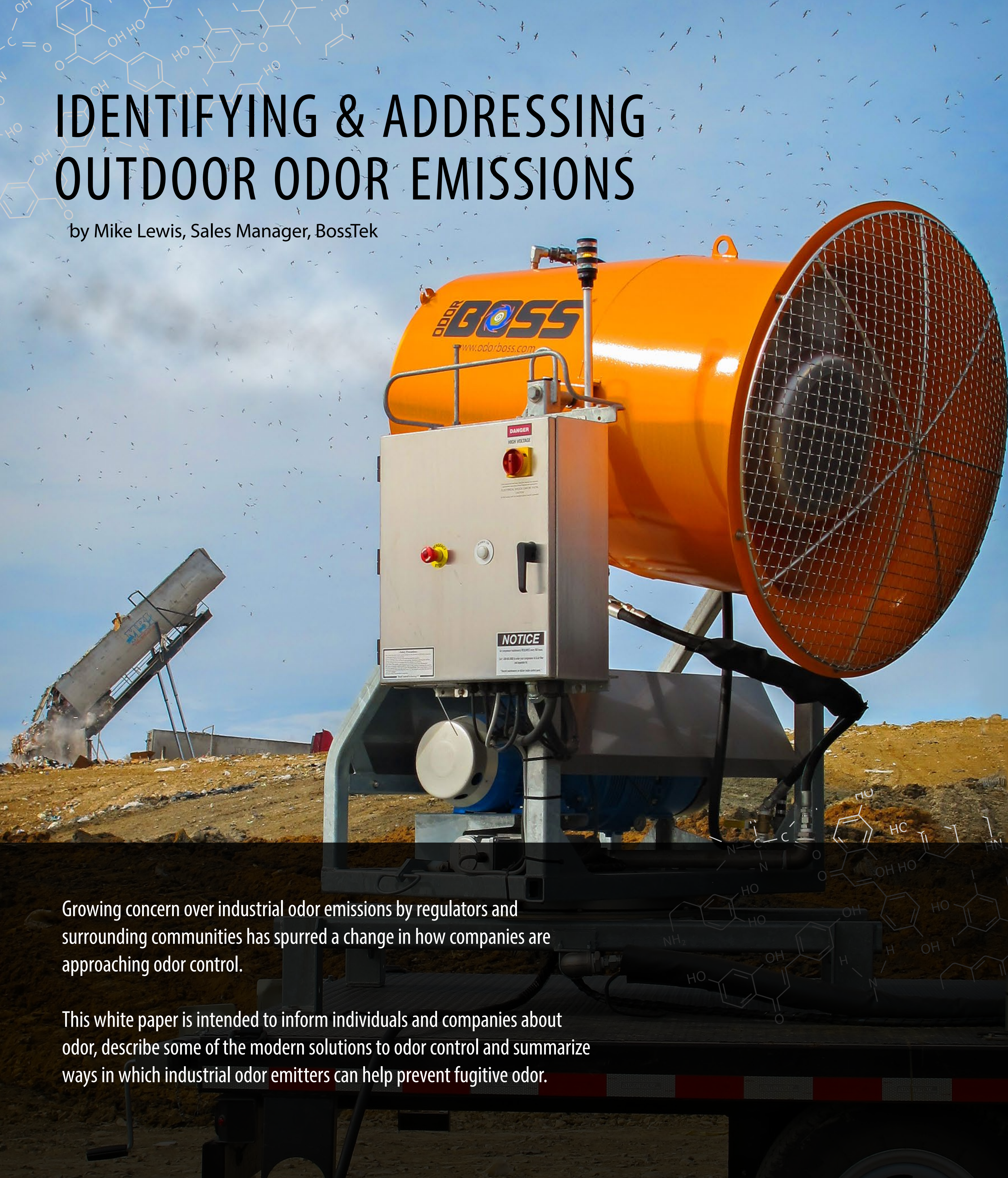

Growing concern over industrial odor emissions by regulators and surrounding communities has spurred a change in how companies are approaching odor control.

This white paper is intended to inform individuals and companies about odor, describe some of the modern solutions to odor control and summarize ways in which industrial odor emitters can help prevent fugitive odor.

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INTRODUCTION

In the past, civil planning for industrial odor control for landfills, sewage treatment, mills, refineries and chemical manufacturers was done by concentrating them in an area specified for industrial activity or setting them far away from urban centers.

For much of the industrial revolution, beginning in the late 18th century, communities that depended on these industries for survival tolerated the impact of odor. However, a combination of population growth and rising real estate prices have caused communities to expand around these areas, leading to a sharp increase in complaints.

Industries and municipalities have attempted to apply odor control strategies, but many of the older technologies are marginally effective and the strategies often accomplish only the minimum an organization is obligated to perform to remain compliant. However, the shifting social attitudes toward industrial odor emissions have become an economic issue to companies as fines, legal fees and political pressures mount.

Community relations and the environmental impact of odor have surged to the forefront, necessitating a need for industry to find modern odor control technology that is highly effective and environmentally safe, such as newly-developed chemical treatments dispensed by powerful fan-driven cannons as airborne vapor or topical atomized mist.

ABBREVIATIONS

ACGIH = American Conference of Governmental Industrial Hygienists
ADA = Americas with Disabilities Act
ATSDR = Agency for Toxic Substances and Disease Registry
DMDS = dimethyl disulfide
DMTS = dimethyl trisulphide
EPA = US Environmental Protection Agency
IRCCS = Italian Department of Environmental Health Sciences
m^3 = cubic meters
NIOSH = National Institute of Occupational Safety and Health
OSHA = U.S. Occupational Safety and Health Administration
ppm = parts per million
ST = Short Term Exposure Limit
TWA – Time weighted average
µg = microns (micrometers in diameter)
VFA(s) = volatile fatty acid(s)
VOC(s) = volatile organic compound(s)

TYPES OF ODOR

The vast majority of smells are a combination of five elements: Carbon, Nitrogen, Oxygen, Sulfur, Hydrogen.

Bacteria grow and multiply by digesting the five elements, and odor emissions are commonly caused when organic solids volatize faster than the bacteria can process it. However, bacteria (such as E. Coli) breaking down proteins can also emit smells.

Odors found in different organic, industrial or chemical processes are classified in large categories, but can be further isolated by subcategory based upon the origin (see figure A).

COMMON ODOR TYPES BY INDUSTRY

This is a short and general overview of common emissions from odor-causing industries susceptible to complaints or violations:

Sulfite paper mills emit sulfur dioxide from smoke stacks or primary effluent, causing odors.

Wastewater treatment emits VOCs such as hydrogen sulfide, propanol (colorless liquid with a slightly irritating, fruity odor) and toluene (colorless, water-insoluble liquid with a smell associated with paint thinners).

Sewage Treatment, Swine, Poultry and Fertilizer commonly emit sulfur compounds: methane thiol, ethane thiol, 2-propane thiol, 2-butane thiol, DMDS, DMTS, thiophene, diphenyl sulfide and hydrogen sulfide.

Landfills emit organic compounds such as ammonia, hydrogen sulfide, and certain volatile amines, including putrescine and cadaverine.

Chemical or power production emits ammonia, ozone (electricity smell) and nitric oxide.

	Formula	Origin	Odor Threshold	Perception Threshold	Molecular Weight	OSHA Limit
Acetaldehyde	CH_3CHO	Pungent Fruity	0.004 ppm	0.21	44.05	200 ppm
Ammonia	NH_3	Pungent sharp	0.037 ppm	46.8	17.03	50 ppm
Cadaverine	$NH_2(CH_2)_5NH$	Putrid decaying flesh	0.204 ppm	0.50	102.18	____
Dimethyl Sulfide	$(CH_3)_2S$	Putrid decaying plant	0.001 ppm	0.011	62.13	10 ppm
Hydrogen Sulfide	H_2S	Rotten Eggs	0.00047 ppm	0.0047	34.1	20 ppm
Methyl Mercaptan	CH_4S	Skunk Rancid	0.0011 ppm	0.0021	48.1	10 ppm
Sulfur Dioxide	SO_2	Pungent Irritating	0.021 ppm	0.021	64.07	5 ppm

Figure A.

IMPACTS OF INDUSTRIAL ODOR EMISSIONS

Legal

In 2013, the South Carolina Supreme Court issued an award of more than $2 million for damages to six property owners in Perrin Babb V. Lee County Landfill.[1] The lawsuit cited "nuisance, trespass and negligence" due to industrial odor emissions from the landfill. According to the court, odor is a tangible infringement on the owners' property.

Prior to this decision, plaintiffs were required to prove physical damages to their property, such as soil or ground water contamination, of which odor emissions are only one element. Upon precedent, odor emissions can now be considered "trespassing" onto private land, resulting in monetary damages from hindering or preventing the property owner's ability to rent or sell.

According to the decision, there are three elements by which odor emitters can be exposed to a lawsuit: "trespassing" resulting in "a physical, tangible invasion" of the property, causing a "nuisance" and subsequent "damages to the person incurred through the loss of enjoyment of the property." This leads to proof of "negligence" where "physical injury or property damage" were established through diminished property and rental value.

Using this as precedent, several lawsuits have been filed across the United States, exposing odor emitting industries that previously had enjoyed relative autonomy to expensive consequences.

Environmental

A detailed study regarding the environmental effects of odor from landfill VOC emissions was issued from the IRCCS in 2013.[2] Researchers concluded that the direct impact from odor on the affected area is negligible, but the indirect impact is profound. Odor can be absorbed by surrounding soil and can cause certain animal and insect species to avoid the area, initiating an unknown impact on the ecosystem. For this, they urge more study.

Community

The IRCCS study goes on to conclude that the health effects of odor on humans (nausea, breathing problems, stress, etc.) is more of a nuisance than a direct impact on the health and mortality of nearby communities. "The health risk assessment carried out in this study indicates that the potential incremental cancer risk, for residents living in the vicinity of the facility, is negligible, and other health effects are not likely to occur."

According to the ATSDR[3], a federal public health agency within the United States Department of Health and Human Services, odor toxicity is contingent upon the quantity and concentration of a substance in the air and the frequency and duration of exposure.

All of these factors combined can cause odor to become toxic and cause adverse health effects. Without those conditions, odors are generally not toxic. However, the ATSDR further elaborates that people who are sensitive to environmental odors may react adversely to low concentrations and that sensitivity can form after long-term exposure.

Not addressed in the study is the serious community-relations/public-relations issue that odor causes. Local print, television and online media often cover the story of the effects of odor on residents because it concerns their audience. Constituents in affected districts can put pressure on municipal, county and state representatives, forcing increased inspections, fines and new regulatory guidelines

Substance	OSHA	NIOSH	ACGIH
Benzene	1 ppm (ST) 5 ppm	Ca 0.1 ppm (ST) 1 ppm	0.5 ppm (ST) 2.5 ppm
Ammonia	25 ppm (ST) 35 ppm	25 ppm (ST) 35 ppm	25 ppm (ST) 35 ppm

Figure B.

Economic

The economic consequences can be separated into tangible and intangible:

Tangible economic impacts of odor are legal payouts or settlements, regulatory fines, production/revenue loss from forced downtime, odor control equipment improvement or replacement costs and increased labor costs for monitoring and maintenance of emissions.

Intangible economic impacts of odor are lower staff morale/productivity, bad press negatively affecting stock price, and tense community relations leading to complaints and wider regulatory scrutiny.

Moreover, lack of adequate action to eliminate odor emissions can sour relations with local lawmakers, environmentalists and community organizers, possibly limiting future growth in the area.

ODOR EMISSION REGULATIONS

Workplace

Workers with a sensitivity to chemicals, smells or who suffer from a medically related odor issue may have the right to a job accommodation. Odor issues that obstruct “major life activities” must be addressed immediately by the employer or the company may be liable under the ADA, in particular the supplemental ADA Amendments Act of 2008.[4] In § 4(4)(a) of the amended law, major life activities include caring for oneself, performing manual tasks, seeing, hearing, eating, sleeping, walking, standing, lifting, bending, speaking, breathing, learning, reading, concentrating, thinking, communicating and working. Directly related to breathing, excessive odor may put the company in violation of the ADA.

Regulations

OSHA, NIOSH and ACGIH have clear, but varying, OEF and exposure guidelines for different odor-causing compounds either defined as a carcinogen (such as benzene) or harmful/toxic to humans (ammonia, for example). There is an extensive list on the OSHA website.[5] For a general reference, OSHA guideline 1910.1000(b)(3)[6] states:

During an 8-hour work shift, an employee may be exposed to a concentration of Substance A (with a 10 ppm TWA, 25 ppm ceiling and 50 ppm peak) above 25 ppm (but never above 50 ppm) only for a maximum period of 10 minutes. Such exposure must be compensated by exposures to concentrations less than 10 ppm so that the cumulative exposure for the entire 8-hour work shift does not exceed a weighted average of 10 ppm.

Companies are recommended to use OSHA guidelines as a benchmark and then use other organizations’ guidelines as a goal (see figure B).

ODOR EMISSION DETECTION

Regulators depend on complaints to be alerted to odor emissions. Budgets and staff at state and federal offices are generally too limited to enforce regulations without a reason to do so. Since odor is not considered a pollutant (only the substance from which it derives), regular monitoring of odor emitting industries in rural or limited population areas is low priority. Complaints are directed to the odor emitter. Once enough people have detected and complained about the smell, mediation procedures begin, where local regulators work with the emitter to seek a solution.

If the solution does not work or is deemed inadequate, then monitoring and testing for violations begin. These are followed by fines or, in extreme cases, temporary shutdown of operations if the OEF exceeds the rules and the emission type and concentration is considered potentially harmful or toxic.

TESTING AND MONITORING

Testing and monitoring methods vary based upon the rules and budget of the agency. For the purposes of this paper, only outdoor testing equipment is examined, though some may be able to be adapted for indoor testing. Some of the general testing methods include:

Subjective Odor Survey is perhaps the most common testing method. The inspector simply walks the compliance perimeter and sniffs. If a smell is detected, the next course of action is taken, which is either more intensive testing or another appropriate action, i.e. internal inspections, equipment inspections, fines, etc.

Flux chamber collection is the most common EPA approved collection system. Air is collected in a vacuum sealed chamber. Samples from the chamber are drawn out by sealed syringe and injected into an air-tight testing tube for further analysts.

Air testing bags draw air directly into a sealed bag for immediate testing. They are simple and more economical, but less reliable than a flux chamber, due to the fact that they can be prone to leakage or contamination in the collection and testing process.

The *Field Olfactometer* is a piece of equipment that uses the regulator's sense of smell to determine whether the smell has exceeded the permissible distance.

The regulator first gets to the edge of compliance, downwind from the odor emission. With the specialized attachment held to the face, fouled air is pulled through a charcoal filter to the nose. Using long nasal breaths, a dial in the front ranging from 2 to 500 is turned with each breath.

Once the smell is detected, the inspector checks the dial. According to the manufacturer, a reading excess of 15 indicates non-compliance.

A *Lab Olfactometer* is used after the sample is taken. A panel of subjects is used to determine if the smell is compliant. Through a tube at different smelling stations, the odor sample (highly diluted by air) is released until 50 percent of the panel can smell it, thus determining the "perception threshold." Once that is determined, the concentrations are calculated based upon the amount of air, yielding the dilution-to-threshold (D/T).

Scentroid is an air-borne odor collection and sensing drone that delivers real time sample results based upon a host of detectable substances. Relatively new on the market, it can sample a wide testing area within a short amount of time.

CHEMICALS USED FOR ODOR SUPPRESSION

Generally, there are five categories of chemicals used for odor control: masking agents, neutralizers, oxidizers, topical foam and deodorizers. Masking agents introduce another smell intended to overpower, improve or dilute foul odor emissions.

The most ancient known method of odor control, perfumes and natural oil extracts have been used for thousands of years to remedy everything from body odor to landfills. Modern chemical masking agents are formulated to be delivered as a fine spray or as a concentrated additive, but are largely considered to be inadequate on an industrial scale.

Neutralizers are chemicals that block olfactory sensory neurons in order to dampen the neuron's ability to detect and discern smells. Delivered as a fine mist intended to travel on ambient air currents with odor emissions, neutralizers for the most part are considered environmentally safe, however they carry the potential of preventing humans and other animals with similar olfactory mechanisms from smelling hazardous toxins or gases.

Oxidizers introduce oxidization agents (oxygen, peroxide, hydrogen peroxide, chlorine or chloride) into a substance in order to kill the bacteria that cause odor. Completed in specialized chambers at the processing level or in preparation for disposal of waste products, oxidization is applicable to specific industrial activities such as wastewater treatment or preventing the formation of odorous biofilm in liquid impounds.

Topical Foam is a biodegradable chemical treatment for organic compounds that is distributed from a chemical tank by hose with a foam-aerating nozzle. It traps gas emissions by forming a protective coating. The benefit of foam is that the operator can visually confirm full coverage. The method is most economical for open truck or train transport or storage piles that experience little disruption because odor emissions can escape once the foam barrier is broken.

Deodorizers have been found to be the most effective control for the majority of industrial odor emissions, treating the smell on a molecular level by removing the odor-causing element. These chemical additives are available as biodegradable formulations that are completely safe to plants, animals and humans.

They can be dispensed at a ~500:1 water-to-chemical ratio using a variety of technologies, such as the industrial fan-driven OdorBoss® Topical (OB-60 T) atomized mist cannon (droplet size ≈100µg) for topical treatments or the OdorBoss® Gaseous (OB-60 G) vapor cannon (droplet ≈10µg) for airborne applications.

Topical deodorizers affect areas as large as a football field, treating material on the ground at the point of emission, which allows for larger droplet sizes. The airborne delivery system relies on engineered droplets small enough to travel long distances on ambient air currents with odor molecules and interact with them.

ODOR SUPPRESSION METHODS

Odor is suppressed through several means. The common methods of odor control occur either during production or at the point of emission. Some processes allow odor to be washed, filtered or suppressed prior to producing the finished product using biofilters or bioscrubbers. Other applications emit odor constantly and require covering, masking or suppression using topical coverage or airborne treatments.

Impounds are an elegant way of describing digging a hole or finding a gully in which solid and liquid waste is dumped, then covering it with soil. An ancient method for a whole host of organic and chemical materials from various industries, including landfills, over time soil erosion can expose methane emissions from VOCs and cause foul smelling runoff. Without proper impound lining, decomposed organic or toxic material can seep into ground water and potentially foul the soil and water over a large area.

Coverage is perhaps the most common large-scale odor suppression technique at demolition and excavation sites, using soil, foam or plastic sheeting for above ground storage piles. However, exposure to wind and erosion makes this an ill-advised permanent solution.

Topical chemicals have various applications, and are generally used by large landfills emitting VOCs. Frequently distributed using powerful industrial atomized mist cannons (OB-60 T), sprayer tanker trucks with hose attachment or via misting bar, the chemical saturates the material and disrupts the biological process that causes odor.

Chemical air treatment is distributed by industrial vapor cannons (OB-60 G), overhead sprinkler lines or perimeter misting systems, and deliver a fine engineered vapor over a wide area that follows odor molecules in the atmosphere, attaches to them and alters their molecular composition to eliminate the odor-causing element.

Activated sludge diffusion is a biological floc composed of bacteria, protozoa and oxygenated air that is injected into odor-causing liquids to treat VOCs in surface impounds, storage ponds and waste water treatment. The process removes phosphates, eliminates gases such as carbon dioxide, ammonia, and nitrogen and oxidizes carbonaceous biological matter.

Bioscrubbers are generally used for treatment of VOCs, solvent problems (alcohols, ketones, and acetates), ammonia removal, cadaverine and putrescine odor removal, NH3 and H2S removal in water purification, sulfur component removal from flue gases in the rubber industry and the production of methionine and polymers. Consisting of two reactors, in the first reactor, the odorous substances are absorbed in a tower in a "liquid phase," then go to a second reactor, which is an activated sludge unit. In the last phase, microorganisms grow in suspended flocks in the water, degrading the pollutants.

Biotrickling filters are generally used for the treatment of biological material, VOCs, etc. A slowed process is needed in the removal of high concentrations of gaseous odor (H2S, NH3, and CS2). Waste gas is forced through biotrickling filters made of chemically inert material such as plastic or ceramic structured packing (rings, saddles, etc.), open pore foam, unstructured celite, activated carbon or mixtures of different materials. The filter serves as carrier for biofilm-creating microorganisms. While passing through the column, the pollutants from the gas diffuse into the biofilm and are degraded by microbial activity. In general, most of the odorous material is degraded in the biofilm, but part may also be removed by suspended microorganisms in the recycled liquid.

CASE STUDY #1 - FOOD PRODUCTION

A sugar production facility in the Midwestern U.S. processes 1.5 million tons per year of sugar beets to yield more than half a billion pounds of sugar annually.

The odor-generating process involves washing the incoming stock, catching the debris and depositing it into a settling pond. A slurry is created with water jets to allow the remaining settled solids to be pumped into tanker trucks, then recycled by transporting it back to the fields, where it's injected into the soil as a nutrient-rich organic fertilizer.

The disturbance from the high-pressure water jets tends to release large amounts of odor vapor as the liquid reaches the proper consistency. Although a perimeter odor control misting system forms a barrier surrounding the ponds, it doesn't reach far enough to interact with the odor at its worst -- as it's being generated.

After visiting colleagues at a nearby scrap yard using an OB-60 G industrial vapor odor cannon, operators decided to rent one to run during the emptying of the settling ponds. Using plain water with an injection system, the unit precisely meters in a specially formulated and environmentally safe deodorizer with approximately a 1000:1 water-to-additive ratio.

The water and treatment agent mixture is pumped from the tank by an integrated 10 HP air compressor through the single nucleating nozzle, which atomizes the pressurized liquid.

The cone of fog is propelled by a 25-horsepower electric fan generating 30,000 cubic feet per minute (152.4 CMS), and the unit features a standard 359° built-in electric oscillator. In addition to its side-to-side oscillation, the cannon also has a vertical angle adjustment between 0-50º for expanded reach and precise aiming.

After running the unit 24/7 for a month, odor complaints ended and visitors to the site remarked on the unit's effectiveness. According to operators, representatives traveled across the country looking at different methods in action and said that they haven't experienced anything so mobile, yet effective.

CASE STUDY #2 - CHEMICAL EMISSION

An environmental consulting company found coal tar waste had leached into the ground of an 11-acre demolition site of an old manufactured gas plant located in the Eastern U.S. Coal tar can contain up to 50% naphthalene, a volatile organic compound (VOC) containing benzene, described as an acrid, bitter chemical, similar to the odor emitted by roofing tar. The estimated 85,000 tons (77,110 metric tons) of extracted soil was piled into storage mounds approximately 30-40 feet (9-12 meters) high.

As excavators and front loaders disrupted material in the ground or stored in piles, the odor was released and immediately carried on air currents. Higher temperatures increased the intensity of the smell. Complaints about odor emissions inspired workplace regulators and local legislators to pressure managers into halting operations and covering all exposed material with chemical foam and/or plastic sheeting until the operators were able to find a viable solution. They decided on an industrial vapor cannon with airborne deodorizer.

Using the same delivery method of vapor cannon described in Case Study #1, the biodegradable chemical from the OB-60 G travels on air currents with the odor-causing molecules. Safe for humans, animals and plants, it attaches to molecules and alters their composition, eliminating the component that causes the smell – in this case, benzene. Once the droplets evaporate, the chemical remains airborne for a period of time, further treating lingering odor molecules.

After implementation, the site did not experience any further downtime due to odor and the complaints stopped. Positioning the unit upwind using oscillation and the vertical adjustment, the chemical can be distributed in the path of the fugitive odor, even toward emissions from the top of the storage piles before they reach the site line.

CONCLUSION

As odor emissions become more of an economic and regulatory concern for companies, modern odor control technology offers a number of tools. From drone powered testing to environmentally safe deodorizers dispensed by powerful vapor cannons, fast and effective odor detection and suppression is widely available on an industrial scale.

When odor emissions are assertively addressed using modern technology, good environmental stewardship, economic benefits and reduced liability follows. But the most important benefit is community relations. By curbing complaints from neighbors, operators enjoy less scrutiny from regulators over odor issues and retain a positive relationship with local leaders.

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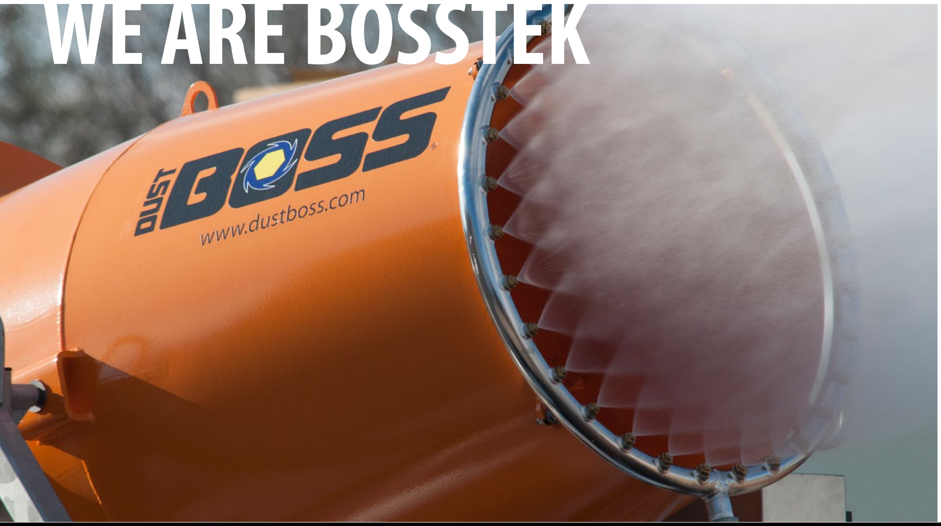

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