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EP Features:

Odors -- Let Nature Finish the Job

Innovations in biofilters now allow them to handle higher airflows and a wider range of odorous compounds

Do you remember when the presence of paint shops, farm animals, sewage treatment plants and mill towns was as plain as the nose on your face? Advances in technology have reduced our exposures to solvents and odors, but most of us still rely on our noses to determine the safety or acceptability of the air we breathe.

Biofiltration for odor control is often simply finishing what nature started. Many objectionable odors are airborne intermediates from the partial degradation of organic materials. In a biofilter, the microbes use the offensive organics as a food source, safely converting them to carbon dioxide and water vapor. Biofilters are effective controls for odor sources, such as sewage lift stations and treatment plants, food and agriculture processing, rendering, confined animal operations and many industrial solvent emissions.

Impacts of Odors

As a child, our family would pass by two different paper mills on the Willamette River in Oregon on our way to visit relatives. My only memory of those mill towns was how bad they smelled. I didn't understand how anyone could live there. I also remember cousins visiting us on our small farm and complaining about the manure smells, which were just part of life to me. In contrast to these negative odor impacts, our manufacturing facility today is located near a cookie bakery. We are frustrated that they don't provide samples to go with their industrial odors. Smells, and the way they affect us, are very subjective yet powerful.

Our noses are actually incredibly accurate and sensitive analytical instruments. Most of us can detect certain odors at the parts-per-trillion level. Nature has provided us this natural detector partly as a defense mechanism against toxic gases and spoiled foods. We will leave an offensive location, if possible, and we aren't likely to ingest something we can't get past our noses. Fortunately, the majority of harmful gases and contaminated materials have odors that we find objectionable; although chemicals that have no odor, cause olfactory fatigue or have inadequate odor warning properties can be extremely dangerous.

The down side to our natural reaction to smells is that living or working around foul odors degrades our quality of life. Today's industrial society has numerous odor sources that are more and more in conflict with working and living environments. Frequently, odorous operations that were purposely located out in the country years ago are now surrounded by urban growth. Some technological advancements have reduced industrial odors. The paper mills from my childhood memories are still in operation, but they no longer stink. Many similar reductions in odor and solvent emissions have been made by other industries. However, odors that cannot be eliminated are becoming less tolerated, resulting in complaints, appeals for tighter regulatory controls and even lawsuits.

Odor Control Technologies

A variety of approaches have been employed to control odors, including dispersing a masking odor that is (supposed to be) less objectionable and simply increasing the ventilation (remember the old adage: "Dilution is the solution to pollution"). The most effective technologies are those that actually eliminate the odorous compounds. Many objectionable odors are airborne intermediates from the partial degradation of organic materials, especially under anaerobic conditions. Other odors result from industrial emissions of organic solvents and vapors. If these odorous compounds, primarily composed of carbon, hydrogen, sulfur and nitrogen, can be fully oxidized, the odors can be largely eliminated.

Oxidation of odors and volatile organic compounds (VOCs) is the process of converting hydrocarbons and partially degraded organic molecules to carbon dioxide and water vapor. This is accomplished by several different processes in air pollution control equipment. In thermal oxidation an elevated temperature of around 1500 degrees Fahrenheit is maintained to combust the solvents and odorous compounds. In catalytic oxidation, a catalyst metal is combined with heat to facilitate the chemical conversion. In activated carbon systems, the organics are simply captured in the charcoal matrix, then burned during the regeneration process. In bio-oxidation, commonly termed "biofiltration," microbes consume the odorous organic pollutants as a food source. All four of these oxidation processes result in the organics being converted to carbon dioxide and water vapor.

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Basics of Biofilters

So, what is a biofilter? Filter suggests a physical mesh that removes particles from the air, but that is misleading. Biofiltration is actually an air treatment process based on processes that are literally as old as dirt. Nature has provided bacteria and fungi that are capable of using almost any organic material as a food source. These microbes are plentiful in organic soils and decaying vegetable matter. Biofilters are a controlled environment where the organic odors and solvents are brought in contact with the natural microorganisms that can use them as a food source. The concept, then, is to pass the contaminated airstream through a biological matrix material, such as compost, where the microbes will capture and eat the solvents and odors.

Traditional biofilters have successfully used these principles for decades, with more widespread use in Europe than the United States. They have typically been very large, single-layer units that rely on a loose bed of organic media to control conditions for treatment. There have been significant limitations in handling high or variable organic loadings, and the large footprints, some the size of football fields, have made them impractical for many developed industrial locations.

Engineered biofilters use a variety of advances to increase their efficiency of treatment and reduce their size from something like a parking lot to a parking space. First, the contaminated airstream is conditioned to maintain temperature and humidity levels ideal for the metabolism of the microbes. Second, the compost or organic media that supports the microbes is structured to increase the effective surface area and allow treatment throughout the depth of the beds.

For example, an EPA fact sheet gives a guideline for sizing conventional biofilters of three to four cubic feet per meter (cfm) per square foot of bed area, with a three to four foot thick bed. For the 10,000 cfm paint manufacturing facility discussed later in this article, this would suggest a biofilter with a bed area of more than 2500 square feet and containing 8000 to 12,000 cubic feet of bed material. The engineered biofilter in operation at the facility has airstream conditioning and three stacked beds within a column eight by 10 feet, for a bed area of 80 square feet and containing a total of 720 cubic feet of structured biomatrix.

An induced-draft blower is used to draw the odorous emissions to the biofilter system. The contaminated airstream is conditioned by bubbling up through the sump water and then treated through the structured compost media.

The energy demands in biofiltration are to move the airstream through the biofilter and for adjusting the temperature and humidity. Generally, the energy usage of biofilters is one-fourth to one-tenth the demand of incineration technologies. The result is that biofiltration is an energy-efficient and sustainable technology for odor and VOC control.

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How Do You Quantify Odor?

The traditional method for measuring the effectiveness of pollution control equipment is to compare the contaminant load going into the system with the contaminant load coming out. If the odor is due to a specific chemical, this method can be employed. However, non-chemical odors are another matter. For example, manure gasses may contain as many as 80 to 200 different gasses with different odor characteristics. Mechanical and chemical analytical methods simply are not effective.

The human nose is the most sophisticated tool for detecting odors, and the evaluation methods all lead toward odor panels with different ways of calibrating our noses and comparing odors. One method uses an odor wheel similar to those used to describe aromas of beer and wine, but with descriptors such as earthy, rotten, soapy, fishy, gassy, rancid and medicinal. Some efforts are being made to standardize the results of odor panels through established Intensity and Threshold Dilution Ratio parameters that could lead to a more scientific basis for odor evaluation and regulatory action. Still, the majority of situations end up quantifying treatment by interviewing different people who have smelled the source air before and after treatment.

Sewage Treatment Case Study

Bio• Reaction Industries operated a biofilter through the summer of 2001 at a sewage treatment plant in Wilsonville, Oregon. The odor source was a metal dumpster used to hold materials removed from the grit chamber and screens at the headworks of the plant. Odors have historically been significant and the source of complaints from nearby residents. The biofilter essentially eliminated the odor problem. The odor from the dumpster was described as strongly rancid, putrid and offensive while the air leaving the biofilter was described as having a very mild odor smelling slightly musty or like compost. The result was positive for the neighbors and plant operators, as evidenced by the significant reduction in odor complaints.

A similar biofilter has been in operation for five months at a sewage lift station in North Carolina. Odor complaints have stopped, and those smelling the inlet and outlet have used similar descriptors for the change in odor. An additional 170 cfm unit has just been purchased.

Paint Solvents Case Study

A paint formulator in Eugene, Ore., has been a development partner with Bio• Reaction Industries to pilot this technology for VOC control. Odor reduction has been a bonus. The facility collects the vapors from their mixing and canning operations and historically released them untreated into the neighborhood, resulting in frequent odor complaints. Now, with the biofilter treating the entire building discharge of 10,000 cfm, the odors are greatly reduced. The concentrations vary with operations, but this performance represents roughly 50 to 200 pounds per day of solvents that are no longer being dispersed into the neighborhood.

The paint facility anticipates the voluntary treatment will allow them to receive Synthetic Minor permit status, avoiding significant costs for Title V and MACT permit (under the Clean Air Act) compliance while providing a tangible environmental improvement in their neighborhood. The Pollution Control Tax Credit and Energy Tax Credit also allow the facility to recoup more than 65 percent of their capital cost over several tax years.

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Conclusion

Biofiltration is an effective treatment technology for odors and VOCs. Engineered biofiltration has made a number of advances that have resulted in much smaller biofilters capable of handling higher airflows and a wider range of solvents and odor compounds than are typically handled with traditional biofilter technologies. The end result is air-handling equipment that performs much like mechanical treatment systems, but is biologically based with significant savings in energy costs.

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