Microbes and fungi help clean the air

A small but growing number of businesses and industries are looking to microbes and fungi to remove pollutants from their air emissions. The technology is already well established in Germany and the Netherlands, and regulators expect that upcoming testing scheduled through the U.S. EPA's Environmental Technology Verification (ETV) program will help it gain a foothold in the United States.

The engineering firms that are promoting what they call bioreactor systems for air pollution control are positioning them as a more sustainable approach to cleaning emissions of hazardous air pollutants. The basic approach involves establishing a colony of microbes and fungi that can biologically absorb and digest airborne pollutants—mainly odors and volatile organic compounds—and convert them into carbon dioxide and water vapor.

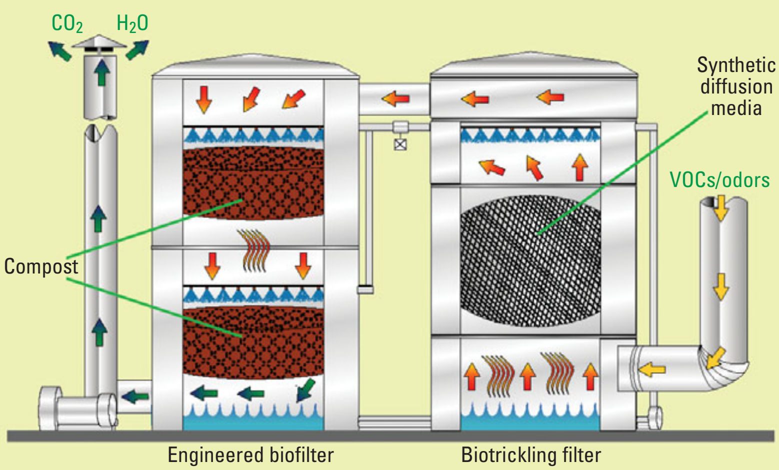
Bioreactor systems, which are also called biofilters in Europe, have advantages over the conventional thermal oxidation, catalytic oxidation, and carbon filtration technologies for controlling this kind of air pollution because all three produce secondary air pollution in the form of nitrogen oxides (NO_x) and the bioreactors do not, says Mohamed Serageldin, an environmental engineer with the U.S. EPA's Emissions Standards Division in Research Triangle Park, N.C. They also can be less expensive than all of the conventional options and use less energy than the high-temperature oxidation methods, says Loren Garner, an environmental engineer at Bio Reaction Industries, LLC, a Tualatin, Ore., firm.

Bio Reaction's biofiltration technology was highlighted at the Environmental Innovations Summit conference held in Crystal City, Va., in September, and it is expected to be the first bioreactor system for cleaning air emissions to undergo testing through the ETV program's Air Pollution Control Technology Verification Center sometime next month, according to Bob Zerbonia, the task leader for the ETV project at RTI International, the nonprofit research organization that is helping to coordinate the project.

FIGURE 1

Bio Reaction's bioreactor system

Engineered biofilters rely on microbes and fungi to remove odors and volatile organic compounds from industrial air. An Environmental Technology Verification test of these technologies is scheduled to be conducted through the U.S. EPA beginning next month. Bio Reaction's system is scheduled to be the first tested.



Bio Reaction's system is noteworthy because it is one of the most developed at this point in the United States. However, it is based on one of four approaches to creating bioreactor systems, Serageldin stresses. It is what he calls a water-trickling bioreactor system; the other options are packed-bed bioreactors, activated carbon bioreactors, and membrane bioreactors. However, the terminology being used is far from standardized at this point.

All four kinds of bioreactor systems tend to have an air pollutant removal efficiency of 85%, whereas the conventional alternatives can remove 95% of the regulated chemicals in the airstreams they are used to treat, Serageldin says. But he stresses that this lower removal efficiency doesn't represent a regulatory hurdle, because many of EPA's Maximum Achievable Control Technology (MACT) standards give industries more flexibility for choosing control technologies.

The MACT standards (especially those related to solvents and coatings) are in many cases formatted such that a variety of measures can be implemented either separately or in combination to reduce overall hazardous air pollutant emissions, Serageldin explains. Unlike the Best Achievable Control Technology standards that the Clean Air Act's Title V requires some companies to comply with, MACT standards don't necessitate the application of add-on control devices that result in the highest reductions in pollutants.

For example, the MACT standards allow companies to couple pollution prevention and emissions control technologies to lower their emissions, such as choosing solvent coatings with less hazardous air pollutants and using a biofilter, Serageldin says. The states that have permitted the use of biofilters for air pollution control include California, Oregon, and Georgia, he says, stressing that he has been as yet unable to compile a definitive list.

A number of the new bioreactor systems being promoted for reducing air emissions, including Bio Reaction's technology, are what has become known as engineered biofilters. They require much less space than conventional bioreactor systems, Garner says. Although conventional systems can be the size of a parking lot, engineered biofilters like Bio Reaction's take up little more than a typical parking space. He says that his company's technology is smaller than most of the other small engineered biofilters currently being developed, including products in the works at Project Performance Corp., Biorem, Bioway, USFilter, Biocube, Inc., and Envirogen, Inc.

Bio Reaction's systems are able to process up to 25,000 cubic feet of emissions per minute, although they can handle higher loads with multiple units. The residence time typically ranges from 10 to 20 seconds, Garner says, noting that he believes his technology is a bit faster than most other engineered bioreactor systems. In some cases, engineered bioreactor systems may be faster than carbon filtration, he adds.

Bio Reaction's use of spherical ball structures as the substrate for growing microbes and fungi significantly increases the amount of surface area available for treatment, Garner says. Other than that, he won't say much about the balls used in his technology, beyond that they're approximately one inch in diameter and contain the compost mixture used to feed the microbes in the biofilter.

Garner readily admits that his organization hit on the idea of using these balls after spending seven years unsuccessfully optimizing the structure and composition of their compost. "In desperation, we started experimenting with things that looked really goofy," he admits with a laugh, calling it "thinking outside the box". The end result is a proprietary component of the technology that gives the company a competitive edge, he says, adding that the beds composed of the balls can range in depth from 18 inches to 6 feet.

Additionally, Bio Reaction's use of a biotrickling filter to pretreat airborne waste streams eases the challenge of controlling the temperature and humidity in their biofiltration chambers, which can be a problem in larger biofilters, Garner says. The combination of the biotrickling filter and the balls, as shown in Figure 1, allows Bio Reaction to "maintain a more steady, productive ecosystem inside."

The biotrickling filter helps ensure that Bio Reaction's system responds well to shocks, including spikes in the levels of contaminants, shutdowns, and temperature changes, Garner says. Arguably the biggest challenge that manufacturers of bioreactor systems face is in assuring industry that the technology can withstand such shocks without allowing the emissions they control to go out of compliance, Serageldin says.

Although some bioreactor systems use compost derived from sewage sludge, Bio Reaction's compost is simply vegetable waste or yard debris combined with soil and "some inert components", Garner says. The population of microbes and fungi, which forms as a bioslime on the surface of the balls, consists of whatever organisms thrive when feeding off the particular polluted airstream to which they are exposed, he says.

Thus far, Bio Reaction's engineered biofiltration technologies are permitted for use in controlling odors from municipal sewage treatment plants, as well as paint formulation and application, Garner says. Bio Reaction is also pilot-testing the technology for controlling odors from food processing and animal processing; for industries where alcohols are emitted, including wood products, and semiconductor manufacturing; and for pulp and paper processing, auto parts manufacturing, and die-casting, he says.

Bio Reaction's ETV test will evaluate the biofilter's ability to treat the VOCs generated during paint formulation at a California facility, Garner says. The standard test protocol requires 1 week to 10 days' worth of testing, Zerbonia says. —KELLYN S. BETTS