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Innovative Uses of Compost

Bioremediation and Pollution Prevention

Each year agricultural effluents, industrial residues, and industrial accidents contaminate surface waters, soils, air, streams, and reservoirs. A new compost technology, known as compost bioremediation, is currently being used to restore contaminated soils, manage stormwater, control odors, and degrade volatile organic compounds (VOCs).

Compost bioremediation refers to the use of a biological system of micro-organisms in a mature, cured compost to sequester or break down contaminants in water or soil. Micro-organisms consume contaminants in soils, ground and surface waters, and air. The contaminants are digested, metabolized, and transformed into humus and inert byproducts, such as carbon dioxide, water, and salts. Compost bioremediation has proven effective in degrading or altering many types of contaminants, such as chlorinated and nonchlorinated hydrocarbons, wood-preserving chemicals, solvents, heavy metals, pesticides, petroleum products, and explosives. Compost used in bioremediation is referred to as "tailored" or "designed" compost in that it is specially made to treat specific contaminants at specific sites.

The ultimate goal in any remediation project is to return the site to its precontamination condition, which often includes revegetation to stabilize the treated soil. In addition to reducing contaminant levels, compost advances this goal by facilitating plant growth. In this role, compost provides soil conditioning and also provides nutrients to a wide variety of vegetation.

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Soil Bioremediation

Heavy Metal Contamination

Dr. Rufus Chaney, a senior research agronomist at the U.S. Department of Agriculture, is an expert in the use of compost methods to remediate metal-contaminated sites. In 1979, at a denuded site near the Burle Palmerton zinc smelter facility in Palmerton, Pennsylvania, Dr. Chaney began a remediation project to revitalize 4 square miles of barren soil that had been contaminated with heavy metals.

Researchers planted Merlin Red Fescue, a metal-tolerant grass, in lime fertilizer and compost made from a mixture of municipal wastewater treatment sludge and coal fly ash. The remediation effort was successful, and the area now supports a growth of Merlin Red Fescue and Kentucky Bluegrass.

Chaney has also investigated the use of compost to bioremediate soils contaminated by lead and other heavy metals at both urban and rural sites. In Bowie, Maryland, for example, he found a high percentage of lead in soils adjacent to houses painted with lead-based paint. To determine the effectiveness of compost in reducing the bioavailablility of the lead in these soils, Chaney fed both the contaminated soils and contaminated soils mixed with compost to laboratory rats. While both compost and soil bound the lead, thereby reducing its bioavailability, the compost-treated soil was more effective than untreated soil. In fact, the rats exhibited no toxic effects from the lead-contaminated soil mixed with compost, while rats fed the untreated soil exhibited some toxic effects.

Photo courtesy of U.S. Department of Agriculture. ARS, Beltsville, MD.

Soil near the Burle Palmerton zinc smelter facility was so contaminated with heavy metals that residents of nearby towns were unable to grow grass lawns and instead used stones and pebbles as shown above.

In another study, Dr. Lee Daniels and P.D. Schroeder of Virginia Polytechnic Institute, Blacksburg, Virginia, remediated a barren site contaminated with sand tailings and slimes from a heavy mineral mining plant. The application of yard waste compost revitalized the soil for agricultural use. The compost was applied at the rates of 20 tons per acre for corn production and 120 tons per acre for a peanut crop.

Photos courtesy of Virginia Polytechnic Institute, Blacksburg, VA.

A heavy mineral mining plant site with sand tailings and slime was remediated for corn and peanut production with the application of yard waste compost.

Organic Contaminants

Dr. Michael Cole, an expert in the degradation of organic contaminants in soil, remediated soil containing 3,000 parts-per-million (ppm) of Dicamba herbicide to nondetectable levels in 50 days. Cole mixed wood chips and mature compost into soil to make the combined substrate 10 percent (by volume) compost and wood chips and 90 percent contaminated soil. According to Dr. Cole, Dicamba does eventually degrade in nonamended soil; however, that process takes years instead of days. In addition to speeding up the bioremediation process, use of compost can also save money. Traditional remediation by landfilling and incineration can cost up to five times more than bioremediation by composting technology.

According to Dr. Cole, compost bioremediation, more than any other soil cleanup technique, results in an enriched soil end product and leaves the earth in better condition than before it was contaminated.

Petroleum Hydrocarbon Contamination

Soil at the Seymour Johnson Air Force Base near Goldsboro, North Carolina, is contaminated as a result of frequent jet fuel spills and the excavation of underground oil storage tanks (USTs). Remediation of several sites on the base is an ongoing project since materials are continually loaded or removed from USTs, and jets are continually refueled. The base deals with a variety of petroleum contaminants, including gasoline, kerosene, fuel oil, jet fuel, hydraulic fluid, and motor oil.

In 1994, the base implemented a bioremediation process using compost made from yard trimmings and turkey manure. Prior remediation efforts at Seymour involved hauling the contaminated soil to a brick manufacturer where it was incinerated at high temperatures. Compared to the costs of hauling, incinerating, and purchasing clean soil, bioremediation with compost saved the base $133,000 in the first year of operation. Compost bioremediation also has resulted in faster cleanups, since projects are completed in weeks instead of months.

The remediation process at Seymour includes spreading compost on a 50- by 200-foot unused asphalt runway, applying the contaminated soil, then another layer of compost. Workers top off the pile with turkey manure. Fungi in the compost produce a substance that breaks down petroleum hydrocarbons, enabling bacteria in the compost to metabolize them. Clean-up managers determine the ratio of soil to compost to manure, based on soil type, contaminant level, and the characteristics of the contaminants present. A typical ratio consists of 75 percent contaminated soil, 20 percent compost, and 5 percent turkey manure. A mechanical compost turner mixes the layers to keep the piles aerated. After mixing, a vinyl-coated nylon tarp covers the piles to protect them from wind and rain, and to maintain the proper moisture and temperature for optimal microbial growth.

Stormwater Management

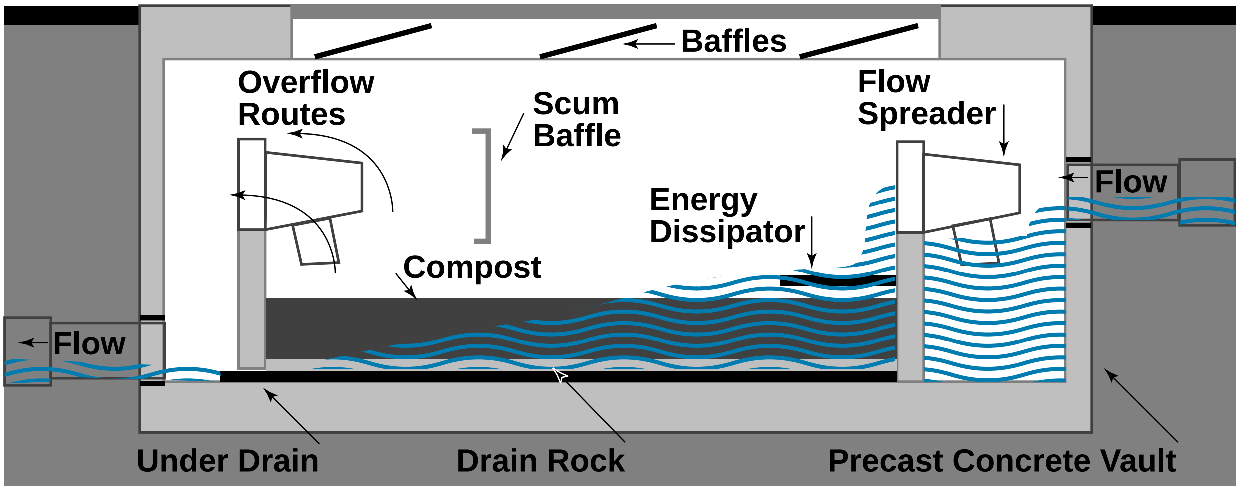
Stormwater runoff is excess water not absorbed by soil after heavy rains. It flows over surfaces such as roads, parking lots, building roofs, driveways, lawns, and gardens. On its journey to larger bodies of water (streams, lakes, and rivers), municipal and industrial stormwater can carry a wide range of potentially harmful environmental contaminants, such as metals, oil and grease, pesticides, and fertilizers. These types of contaminants pollute rural water, damage recreational and commercial fisheries, and degrade the beauty of affected waterways, among other things.

Stormwater runoff must be treated before it is discharged into water to meet the U.S. Environmental Protection Agency's National Pollutant Discharge Elimination System regulations. To comply, some municipalities and industries are turning to solutions that involve compost technology instead of more expensive traditional treatment methods, such as vegetated filter strips or grassy swales (phytoremediation) and holding ponds. These traditional methods require much larger tracts of land than methods utilizing compost and are limited in their removal of contaminants. In one industrial area, for example, a traditional holding pond required 3.5 acres and cost $45,000, while a compost stormwater system, designed to handle the same amount of runoff, required only 0.5 acre, required less maintenance, and cost $17,300.

Compost Stormwater Filters

The compost stormwater filter (CSF), one type of bioremediator, is a large cement box with three baffles to allow water to flow inside (see figure on page 4). The CSF is designed to remove floating debris, surface scum, chemical contaminants, and sediment from stormwater by allowing it to pass through layers of specially tailored compost. The porous structure of the compost filters the physical debris while it degrades the chemical contaminants. Scum baffles along the side of the unit trap large floating debris and surface films.

Typical CSF Unit



The CSF bioremediator removes contaminants from stormwater by allowing water to flow through layers of specially tailored compost.

This innovative stormwater filtration and bioremediation system uses a relatively small volume of specially tailored compost made from leaves. The compost is formulated to remove over 90 percent of all solids, 85 percent of oil and grease, and between 82 to 98 percent of heavy metals from stormwater runoff. A CSF typically has low operating and maintenance costs and has the ability to treat large volumes of water—up to 8 cubic feet per second. When the compost filter is no longer effective, it can be removed, tested, recomposted to further remove any contaminants, and used in other compost applications, such as daily landfill cover since the metals are bound by the compost.

Disposal of VOCs and Odor Control

Compost bioremediation technologies also have been developed to remove VOCs that cause disagreeable or harmful odors in air. The removal process involves passing the contaminated air through a patented, tailored compost. The compost functions as an organic medium containing microorganisms that digest the organic, odor-causing compounds. Industrial facilities have made use of this compost technology to remove VOCs at the 99 percent level.

Billions of aerosol cans are manufactured and used annually in the United States in households, businesses, and industry. Many of these cans carry residues of paints, lubricants, solvents, cleaners, and other products containing VOCs. Disposing of used aerosol cans represents a significant expenditure, both to the communities that collect them through household hazardous waste programs and to the businesses and industry that generate, handle, treat, or store these wastes.

Activated carbon is one technology that traditionally has been employed to treat these cans prior to disposal. Canisters of carbon are used to physically adsorb VOCs from the cans. Activated carbon, however, does not destroy the VOCs, but merely stores them. Thus, once the carbon canisters become saturated, they, in turn, must be

Biofiltration vs. Bioremediation

Biofiltration implies physically separating particles based on their sizes. Bioremediation, by contrast, implies a biochemical change as contaminants or pollutants are metabolized by microorganisms and broken down into harmless, stable constituents, such as carbon dioxide, water, and salts.

disposed of. This adsorbtive compost technology is more suitable for some types of VOC-containing products than is activated carbon, which is a poor adsorber of acetone.

Vapor-phase biofilters using compost are gaining increasing attention as an alternative technology for treating aerosol cans. This growth is due, in part, to the high cost of conventional treatment and disposal methods, as well as to new regulations concerning VOC emissions from hazardous waste storage tanks and containers. Unlike conventional VOC control technologies, such as activated carbon, biofilters actually break down hazardous contaminants into harmless products. They also offer low capital, life-cycle, and operating costs—and require minimal maintenance and energy. The energy required to power a 100 cfm airflow unit, according to the manufacturer, is rated at 20 amps. At 8 cents per kilowatt hour, the cost of the requisite electricity is estimated at $1.80 per day. Additionally, according to one manufacturer, vapor-phase biofilters maintain a consistent VOC removal efficiency of 99.6 percent, even when exposed to heavy or uneven surges of toxics.

Control of Composting Odors

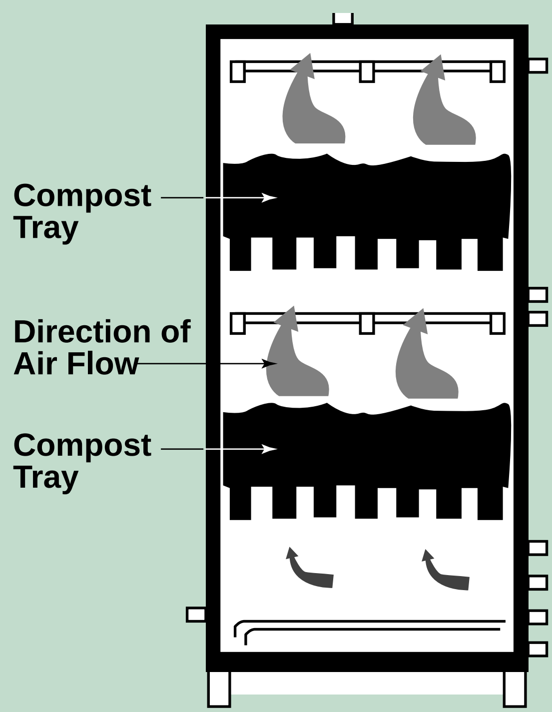
Rockland County, New York, recently announced construction of a composting facility with America's first large, industrial-sized, odor-control bioremediation system. The enclosed 55,000-square-foot facility will be fitted with a compost filtration system that can process 82,000 cubic feet of air per minute. The air will be treated using ammonia scrubbers, then forced into an enclosure stacked with compost and other organic materials that function together as an air filtration system. The system binds odorous compounds, which the micro-organisms in the compost then degrade. This system has allowed the Rockland County Authority to obtain a contractual guarantee of no detectable odor at or beyond the site property line from the contractor awarded the design, construction, and operating contract.

Biofilters in Municipal Use

By converting its disposal operation from strictly landfilling to one that utilizes a vapor-phase biofilter, the Metro Central Household Hazardous Waste collection facility in Portland, Oregon, saved nearly $47,000 in hazardous waste disposal costs over an 18-month period. The facility used vapor-phase

Vapor-Phase Biofiltration

One application of biofiltration technology involves placing punctured cans, contaminated rags, or other items in the lower chamber of the biofilter. Next, the entire unit is heated to vaporize the contaminants. A small amount of air is then injected into the system to draw the now gaseous contaminants through two separate layers of a compost-rich biomatrix. The bulk of the contaminants are absorbed by the biomatrix at the first level, where most of the microbial activity takes place. The upper level serves as a surge control layer (to treat heavy or uneven surges of VOCs). Micro-organisms living in the biomatrix metabolize the absorbed organics as food, converting the pollutants into carbon dioxide and water vapor.



In a vapor-phase biofilter, air draws volatilized contaminants upward through two trays of tailored compost. Micro-organisms in the compost metabolize the contaminants, converting them into carbon dioxide and water vapor.

Benefits and Disadvantages of Using Vapor-Phase Biofilters

Benefits		Disadvantages
• Low capital costs • Low operating costs • Limited energy and maintenance requirements • High reliability • Consistent pollutant removal	• Consistent destruction rates • No hazardous combustion-related byproducts • Destroys VOCs, and thus does not require secondary disposal (unlike activated carbon)	• Requires consistent loadings • Requires more square footage of space than conventional disposal methods

biofilters to remediate over 38,000 aerosol cans. As a result, it lowered its disposal costs from $505 per loose-packed drum to $265 per drum (from $2.35 per can to $1.30), since the cans were no longer hazardous and did not need to be handled as such.

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For More Information

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