United States
Environmental Protection
Agency

Solid Waste
and Emergency Response
(5306W)

EPA530-F-97-047
October 1997
www.epa.gov

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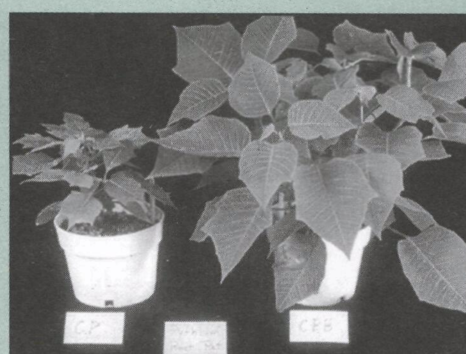
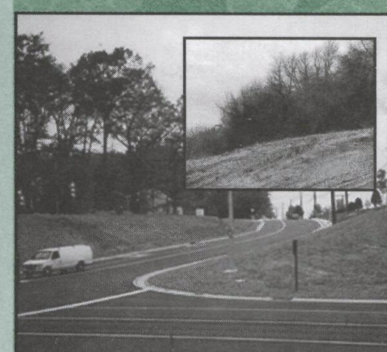
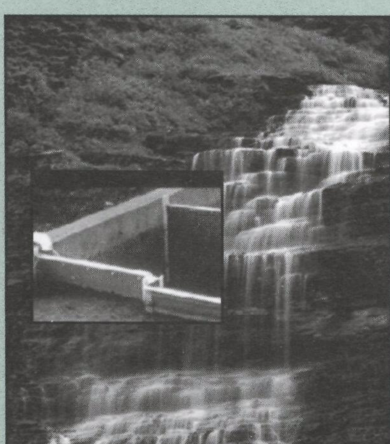
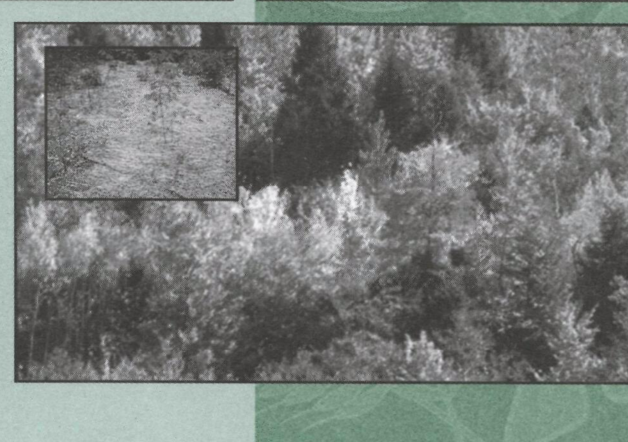
Compost—New Applications For an Age-Old Technology









What Are the Environmental Benefits to Using Compost?

The use of compost can result in a variety of environmental benefits. The following are a few of the most important benefits in three main areas.

Soil Enrichment:

- Adds organic bulk, humus, and cation (positively charged ions) exchange to regenerate poor soils.
- Suppresses certain plant diseases and parasites.
- Increases soil nutrient content and water retention in both clay and sandy soils.
- Restores soil structure after natural soil microorganisms have been reduced by the use of chemical fertilizers.
- Reduces fertilizer requirements by at least 50 percent.
- Solves specific soil, water, and air problems, when specially tailored.

Pollution Remediation:

- Absorbs odors and degrades VOCs.
- Binds heavy metals and prevents them from migrating to water resources, being absorbed by plants, or being bioavailable to humans.
- Degrades or completely eliminates wood preservatives, petroleum products, pesticides, and certain chlorinated and nonchlorinated hydrocarbons in contaminated soils.

Pollution Prevention:

- Avoids methane production and leachate formation in landfills by diverting organics from landfills into compost.
- Prevents pollutants in storm-water runoff from reaching water resources.
- Prevents erosion and silting on embankments adjacent to creeks, lakes, and rivers.
- Prevents erosion and turf loss on roadsides, hillsides, playing fields, and golf courses.

Believe it or not, compost can:

- Cost-effectively remediate contaminated soils similar to those found at brownfields and Superfund sites.
- Remove solids, oil, grease, and heavy metals from stormwater runoff.
- Capture and destroy 99.6 percent of industrial volatile organic chemicals (VOCs) in contaminated air.
- Degrade or completely eliminate wood preservatives, petroleum products, pesticides, and certain chlorinated and nonchlorinated hydrocarbons in contaminated soil.
- Drastically reduce the need for pesticides and fertilizers.
- Facilitate reforestation, wetlands restoration, and habitat revitalization efforts by amending contaminated, compacted, and marginal soils.
- Provide cost savings of at least 50 percent over conventional soil, water, and air pollution remediation technologies, where applicable.
- Utilize 70 percent of the organic waste generated in the United States as feedstock for various composts.

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EPA530-F-97-042
October 1997
www.epa.gov

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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.

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

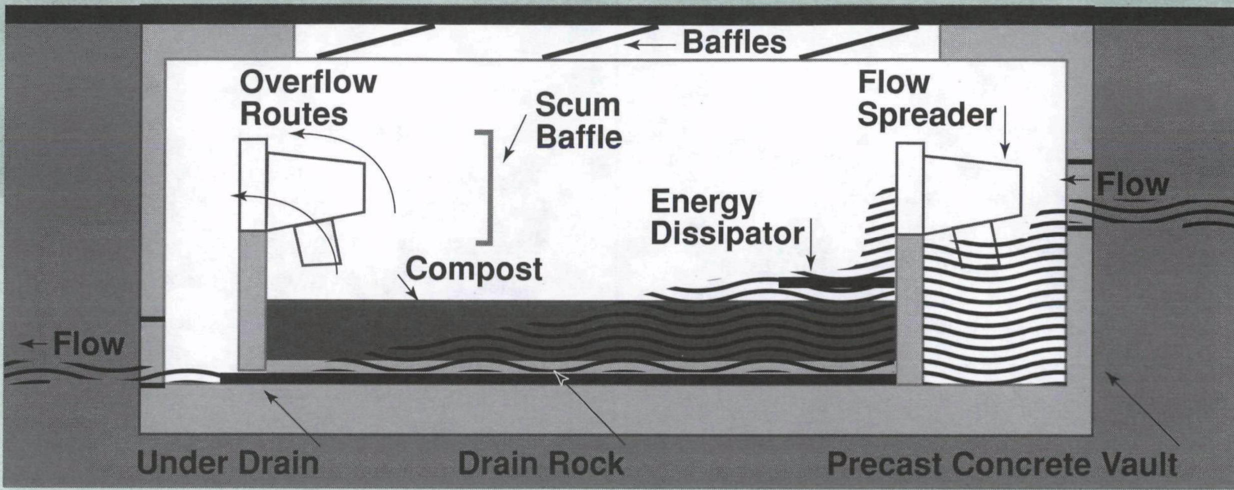
Stormwater runoff is excess water not absorbed by soil after heavy rains. It flows over surfaces such as roads, parking lots, building roofs, driveways, lawns, and gardens. On its journey to larger bodies of water (streams, lakes, and rivers), municipal and industrial stormwater can carry a wide range 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

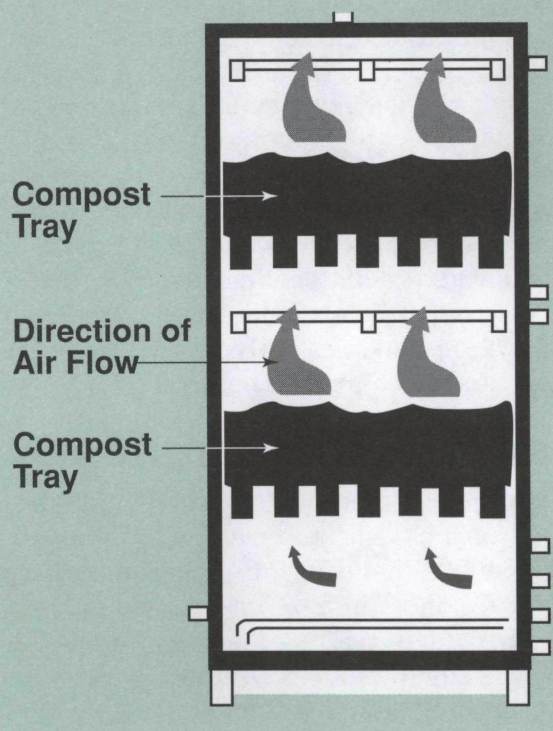
Rockland County, New York, recently announced construction of a composting facility with America's first large, industrial-sized, odor-control bioremediation system. The enclosed 55,000-square-foot facility will be fitted with a compost filtration system that can process 82,000 cubic feet of air per 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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EPA530-F-97-043
October 1997
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Innovative Uses of Compost
Erosion Control, Turf Remediation, and Landscaping

Compost has been viewed as a valuable soil amendment for centuries. Most people are aware that the use of compost is an effective way to improve plant growth. Compost-enriched soil can also reduce erosion, alleviate soil compaction, and help control disease and pest infestation in plants. These beneficial uses of compost can increase healthy plant production, help save money, reduce the use of chemical fertilizers, and conserve natural resources.

Compost used for a specific purpose or with a particular soil type works best when it is tailor-made or specially designed. For example, compost that is intended to prevent erosion might not provide the best results when used to alleviate soil compaction, and vice versa. Technical parameters to consider when customizing a compost mixture include maturity, stability, pH level, density, particle size, moisture, salinity, and organic content, all of which can be adjusted to fit a specific application and soil type.

Compost Technology to Control Erosion

According to the U.S. Department of Agriculture, the United States loses more than 2 billion tons of topsoil through erosion each year. Erosion occurs when wind and rain dislodge topsoil from fields and hillsides. Stripped of its valuable top layer, which contains many essential nutrients, the soil left behind is often too poor to sustain good plant growth. Eroded topsoil can also be carried into rivers, streams, and lakes. This excess sediment, sometimes containing fertilizers or toxic materials, threatens the health of aquatic organisms. It can also compromise the commercial, recreational, and aesthetic value of water resources. As a result, preventing erosion is essential for protecting waterways and maintaining the quality and productivity of soil.

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Controlling Erosion in Construction and Road Building

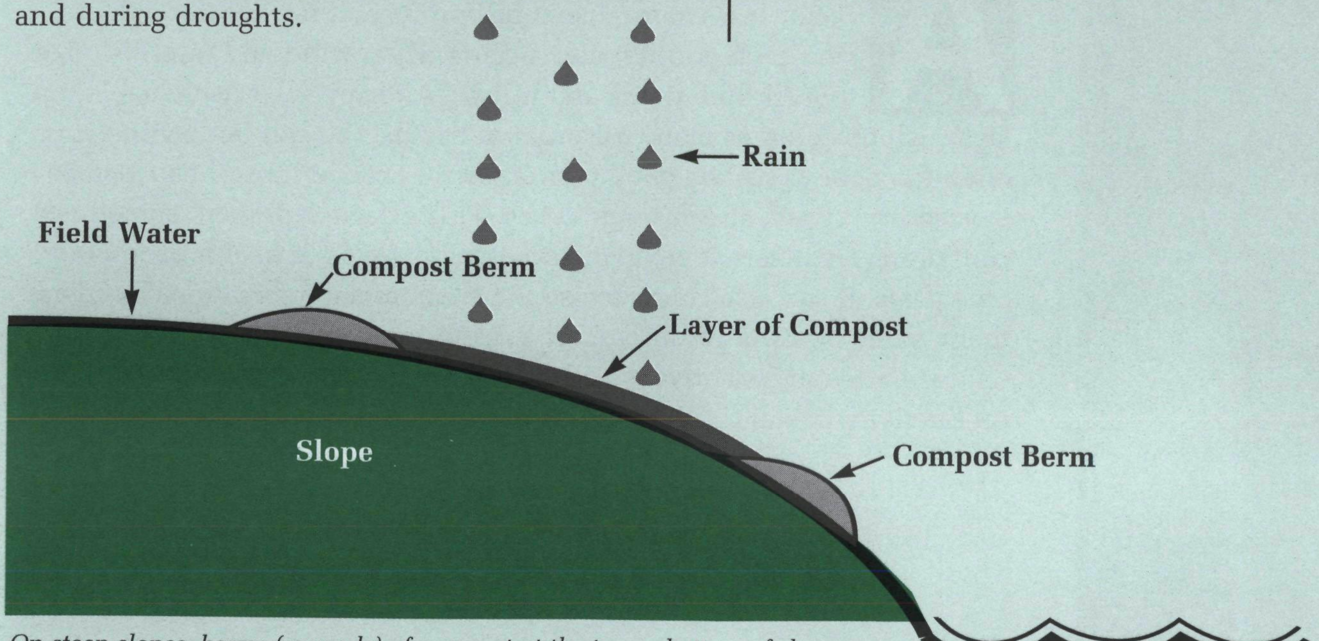
Erosion is a naturally occurring process; however, it is often aggravated by activities such as road building and new construction. At the beginning of some construction projects, all vegetation and topsoil is removed, leaving the subsoil vulnerable to the forces of erosion. On steep embankments along roads and highways, compost can be more effective than traditional hydromulch at reducing erosion and establishing turf because compost forms a thicker, more permanent growth due to its ability to improve the infrastructure of the soil.

Depending on the length and height of a particular slope, a 2- to 3-inch layer of mature compost, screened to 1/2 to 3/4 of an inch and placed directly on top of the soil, has been shown to control erosion by enhancing planted or volunteer vegetation growth. On steep slopes, berms (mounds) of compost at the top or bottom of slopes can be used to slow the velocity of water and provide additional protection for receiving waters. Because of its ability to retain moisture, compost also helps protect soil from wind erosion and during droughts.

Controlling Erosion in Road Construction

The Federal Highway Administration (FHWA), of the U.S. Department of Transportation and the U.S. Environmental Protection Agency, recently conducted an erosion control demonstration project that compared mature yard trimmings compost that met FHWA specifications with hydromulch, a substance traditionally used for controlling erosion on roadside embankments. The purpose of the study was to determine the effectiveness of mature yard trimmings compost compared with hydromulch in establishing Fescue grass.

The project site was at a newly constructed intersection in suburban Washington, DC. Two embankments with steep slopes were selected. The first embankment had a 2 to 1 slope; the second had a 3 to 1 slope. A hydromulch/fertilizer treatment also was applied to a section of each of the slopes. Adjacent to these sections, 2-1/2 inches of mature yard trimmings compost was spread. On the 2 to 1 slope, a small amount of fertilizer was also applied, while the 3 to 1 slope was left unfertilized. Fescue grass seed was added and covered with a thin layer of compost to conceal the seed from birds.



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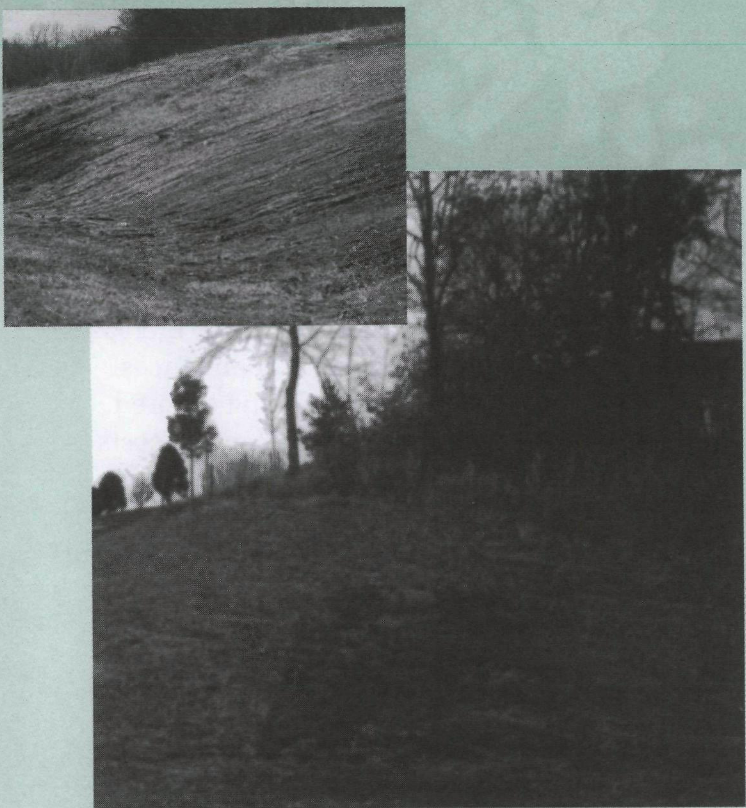

Photos courtesy of The Federal Highway Administration, Office of Environment & Planning, and Federal Lands Highway Program

Embankment adjacent to new intersection. Top left photo shows hillside before seeding. Photo at right shows grass cover. Compost-treated plot displays darker green color and thicker growth.

Results of the project revealed that compost used alone produced better results than either of the areas treated with hydromulch or the area treated with compost and fertilizer. While the areas with the hydromulch/fertilizer combination showed quick initial vegetative growth, the areas treated with only compost persevered within 6 months, out-performing the traditional method by establishing a thick, healthy vegetative cover. The growth in the compost/fertilizer plot was superior to that found in the hydromulch/fertilizer plots. A possible explanation for compost alone out-performing the area treated with compost and fertilizer is that chemical fertilizers often increase soil salinity, which in turn could negatively affect the beneficial micro-organisms in compost and inhibit the establishment of healthy grasses.

Using Compost to Remediate Turf Grasses

Providing safe, uniform playing surfaces for recreational activities, such as golf, football, soccer, and other field sports, requires intensive turf management. Recreational turf grasses are subjected to extensive wear and tear, making them difficult to manage and highly susceptible to turf diseases, pests, and soil compaction. To address these problems, turf managers traditionally use a combination of fertilizers, pesticides, fungicides, and aeration techniques that usually result in high costs and potential for negative environmental impacts.

Some turf managers are now using compost to replace peat moss in their topdressing applications based on its proven success in suppressing plant disease. Compost, when properly formulated, unlike peat moss, is teeming with nutrients and micro-organisms that stimulate turf establishment and increase its resistance to common turf diseases, such as snow mold, brown patch, and dollar spot. For example, after 3 years of using compost as a topdressing, the Country Club of Rochester, New York, has nearly eliminated the need for fungicide applications for such diseases.

Alleviating Soil Compaction

Soil compaction is another persistent landscape management problem, particularly in areas of heavy traffic, such as parks, zoos, golf courses, and athletic playing fields. Compacted soil impedes healthy turf establishment by inhibiting the movement of air, water, and nutrients within the soil. Bare soil, weeds, increased runoff, and puddling after heavy rains are the most obvious signs of a soil compaction problem.

Traditional methods for alleviating soil compaction—aeration, reseeding, or complete resodding—are labor-intensive and expensive, and

What Are the Benefits of Using Compost?

Soil Enrichment:

- Adds organic bulk and humus to regenerate poor soils.
- Helps suppress plant diseases and pests.
- Increases soil nutrient content and water retention in both clay and sandy soils.
- Restores soil structure after reduction of natural soil microbes by chemical fertilizer.
- Reduces or eliminates the need for fertilizer.
- Combats specific soil, water, and air problems.

Pollution Remediation:

- Absorbs odors and degrades volatile organic compounds.
- Binds heavy metals and prevents them from migrating to water resources or being absorbed by plants.
- Degrades, and in some cases, completely eliminates wood preservatives, petroleum products, pesticides, and both chlorinated and nonchlorinated hydrocarbons in contaminated soils.

Pollution Prevention:

- Avoids methane production and leachate formation in landfills by diverting organics for composting.
- Prevents pollutants in stormwater runoff from reaching water resources.
- Prevents erosion and silting on embankments parallel to creeks, lakes, and rivers.
- Prevents erosion and turf loss on roadsides, hillsides, playing fields, and golf courses.

Economic Benefits:

- Results in significant cost savings by reducing the need for water, fertilizers, and pesticides.
- Produces a marketable commodity and a low-cost alternative to standard landfill cover and artificial soil amendments.
- Extends municipal landfill life by diverting organic materials from the waste stream.
- Provides a less costly alternative to conventional bioremediation techniques.

provide only short-term solutions. Some turf managers are starting to use compost and compost amended with bulking agents, such as aged crumb rubber from used tires or wood chips, as cost-effective alternatives. Incorporating tailor-made composts into compacted soils improves root penetration and turf establishment, increases water absorption and drainage, and enhances resistance to pests and disease. Using tailored compost can also significantly reduce the costs associated with turf management. Research conducted at a U.S. Air Force golf course in Colorado Springs, Colorado, for example, indicated that turf grown in areas improved with tailored compost required up to 30 percent less water, fertilizer, and pesticides than turf treated conventionally.

Greening the Links

The U.S. Army Golf Course Operations Division at Fort George Meade, Maryland, and the U.S. Environmental Protection Agency began a 3-year pilot demonstration in 1995 to determine the effectiveness of compost amended with crumb rubber in alleviating soil compaction, erosion, and turf disease problems. The golf course superintendent estimates that using compost technology would save nearly $50,000 a year in maintenance costs.

Photo courtesy of U.S. Army, Fort George Meade, Maryland

At the U.S. Army Golf Course at Fort George Meade, Maryland, erosion can clearly be seen on the untreated right side of the path, while rubber amended compost is helping keep erosion in check on the left.

Mature yard trimmings compost amended with crumb rubber was incorporated into compacted soils at 13 different locations around the two golf courses. Many of the selected sites included areas adjacent to, or at the end of golf cart paths, on slopes surrounding greens, or in tee boxes. These sites were selected because of their susceptibility to compaction and erosion caused by heavy traffic and water runoff. The compost mixture was tilled into the soil to a depth of about 3 to 5 inches and then uniformly seeded. To act as a control, one of the plots was amended only with crumb rubber.

In the first year of the pilot, course operators reported that healthy, green turf grass took hold at most of the sites, with no signs of compaction or erosion. Results were particularly impressive in eroded ditches along cart paths. The areas treated with the compost mixture showed full growth of turf grasses and total abatement of erosion, whereas the plot amended only with crumb rubber showed few signs of improvement.

Using amended compost can significantly reduce the costs associated with turf management.

Using Compost in Landscaping Activities

Supplies of high-quality, low-cost topsoil are declining, particularly in urban areas where the demand is greatest. Compost is, therefore, becoming particularly important in applications requiring large amounts of topsoil. Increasingly, compost is being used as an alternative to natural topsoil in new construction, landscape renovations, and container gardens. Using compost in these types of applications is not only less expensive than purchasing topsoil, but it can often produce better results when trying to establish a healthy vegetative cover.

After a lawn or garden has been established, maintaining it can be a challenge for both home gardeners and commercial landscape contractors. While aeration, topdressing, and chemical fertilizer applications are some of the techniques commonly employed in landscaping applications, compost can be a successful alternative. When used as a topdressing, or periodically tilled into the soil, compost can stimulate plant growth, reduce pests and plant infestation, and improve soil structure.

Compost is also an effective landscaping mulch. Placed over the roots of plants, compost mulch conserves water and stabilizes soil temperatures. In addition, compost mulch keeps plants healthy by controlling weeds, providing a slow release of nutrients, and preventing soil loss through erosion. Landscapers and gardeners also use compost as mulch because its dark, rich color accents the vibrant colors of flowering plants.

Landscaping Constitution Gardens

In 1973, the U.S. National Park Service used a compost mixture made of digested sewage sludge, wood chips, leaf mold, and a small amount of topsoil to transform a badly compacted 40-acre tract of land located in Washington, DC, into a landscaped park. This project is one of the earliest successful large-scale landscaping applications using compost.

The original plans for the park renovations included planting azalea beds and thousands of annuals around a 6-acre lake. However, the site assessment revealed that the soil was almost as hard as concrete, with little pore space for plant roots and for water infiltration. The soil was too low in nutrients for healthy plant growth. In addition, the water table was high, causing flooding and root rot in existing plants.

Park Service staff spread over 9,400 cubic yards of the compost mixture over the site. Fertilizer, woodchips, and seed were added, and the soil was tilled to a depth of 2 feet. Impressed by the hardiness and beauty of a stand of hardwood trees along the area's western edge, Park Service staff decided to plant several varieties of native trees rather than the planned azalea beds. Data taken 3 years after the project ended indicated that most of the nearly 2,000 trees initially planted had flourished in the park.

Photo courtesy of U.S. National Park Service

More than 9,400 cubic yards of compost was used to remediate heavily compacted soil at Constitution Gardens in Washington, DC.

Photo courtesy of U.S. National Park Service

Three years after compost was applied, the vegetation at Constitution Gardens flourishes.

The compost use in this project not only improved the quality of the existing soil, but also saved taxpayers over $200,000. Park Service staff also reviewed other options for remediating the soil at the park, including the purchase of topsoil to spread over the existing poor soil. If the Park Service staff had chosen to use topsoil, the cost of the project would have doubled.

Using Compost for Rooftop Gardens

Several years ago, officials at Pace School in Pittsburgh, Pennsylvania, proposed building a playground and garden for their students. They soon discovered, however, that the only space available was on the school's roof, so they designed a unique rooftop garden.

Plans for the garden included building large, 6-foot deep planters. Before the planters were constructed, several important factors had to be taken into consideration. The planter mix used had to be light enough for the roof to withstand the weight, yet dense enough to prevent rapid evaporation caused by the wind and summer heat. In addition, the planter mix had to be able to endure freezing temperatures in winter, and provide adequate drainage to prevent the planters from overflowing during rainstorms.

Photo courtesy of AgRecycle Inc.

Tailor-made compost was the key to success for the rooftop garden at Pace School in Pittsburgh, Pennsylvania.

To meet these special needs, the school decided to use a tailor-made mature compost blend, chosen because its bulk density is much lighter than soil-based mixes. The compost mix is also extremely absorbent, maintains good drainage, and protects plant roots from climatic fluctuations.

A local compost producer tailor-made a mature yard trimmings compost mixture to meet the project's specifications. A layer of polystyrene packaging peanuts was placed in the bottom of each planter box to enhance drainage, and a 5-foot layer of the compost mixture was placed on top.

Four years after the project began, the school continues to use its rooftop garden for a number of activities, including teaching science classes and gardening methods. The compost has performed very well as a growing medium and continues to produce beautiful, healthy plants that both the students and teachers can enjoy.

Using Compost in Landscape Maintenance

Each year, millions of people visit Point State Park in Pittsburgh, Pennsylvania. Heavy traffic and 12 continuous years of chemical fertilizer applications caused the park's grassy areas to become increasingly compacted, eroded, and depleted of vital nutrients.

After considering several options, park officials decided to aerate the grassy areas and apply a special blend of mature yard trimmings compost and fire calcined clay. This compost mixture was designed to alleviate compaction, add nutrients to the soil, and to improve water-holding capacity. Workers spread a 1/4-inch topdressing of the compost mixture and then uniformly applied grass seed. Soon after the compost was applied, park officials noted that the turf was healthier and that the soil no longer exhibited signs of compaction.

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October 1997
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Innovative Uses of Compost

Disease Control for Plants and Animals

Compost technology is a valuable tool already being used to increase yields by farmers interested in sustainable agriculture. Now, professional growers are discovering that compost-enriched soil can also help suppress diseases and ward off pests. These beneficial uses of compost can help growers save money, reduce their use of pesticides, and conserve natural resources. In the poultry industry, composting has also become a cost-effective method of mortality management. It destroys disease organisms and creates a nutrient-rich product that can be used or sold.

Plant Disease Control

Each year, more than 10 percent of the vegetables planted in the United States are lost to root rot alone, according to researchers at the University of Florida's Tropical Research and Education Center. Additional crop losses are caused by other soilborne plant pathogens, such as the micro-organisms that cause ashy stem blight and chili pepper wilt. Compost can help control plant disease and reduce crop losses. Disease control with compost has been attributed to four possible mechanisms: (1) successful competition for nutrients by beneficial micro-organisms; (2) antibiotic production by beneficial micro-organisms; (3) successful predation against pathogens by beneficial micro-organisms; and (4) activation of disease-resistant genes in plants by composts.

Scientists have enhanced the natural ability of compost to suppress diseases by enriching it with specific disease-fighting micro-organisms or other amendments. This amended or "tailored" compost can then be applied to crops infected by known diseases. Research has shown that tailored compost significantly reduced or replaced the application of pesticides, fungicides, and nematicides—which could adversely affect water resources, food safety, and worker safety.

Printed on paper that contains at least 20 percent postconsumer fiber.

The use of tailored compost can also be more cost-effective than chemical soil treatments, such as methyl bromide. Soil treated with compost retains irrigation water better, which lowers water costs. Chemicals also must be applied more often than compost. In addition, some chemicals have re-entry requirements that prohibit workers from entering a field immediately after chemicals have been applied, reducing worker productivity.

Compost Impedes *Pythium* Root Rot

Dr. Harry Hoitink of The Ohio State University, has conducted compelling research on compost's effects on plants afflicted with *Pythium* root rot. As the photo below illustrates, the application of tailored compost had a dramatically positive effect on plant growth and impeded the spread of the disease.

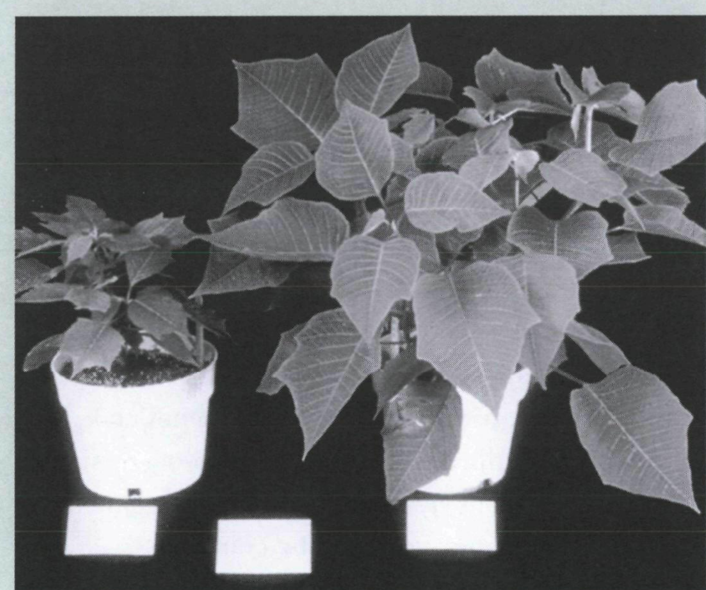

Photo courtesy of Dr. Harry Hoitink, University of Ohio

The plant on the right was treated with compost. The plant on the left was not and suffered the effects of Pythium *root rot.*

Dr. Hoitink views the disease-suppressive characteristics of compost as a reason to consider widening compost applications, "Those who believe composting is not practical for large acreages would find Brazil interesting. I visited a sugar cane farm of some 150,000 acres where the bagasse [stalks left after harvest] was composted and applied back on the land. Every acre got a treatment once every 5 years with 15 percent increases in yield. Some of that increase is apparently due to a suppression of disease organisms."

Compost Combats Chili Wilt

Researchers from New Mexico State University applied a compost made from municipal wastewater sludge and yard trimmings to chili crops in a field known to be infested with *Phytophthora* root rot, or chili wilt. Four different quantities of compost were applied: 10, 20, 30, and 50 tons per acre. Another section of the field, where no compost was applied, was used as a control area. Data collected included damping off disease effects, plant height, chili wilt infection, and yields.

The study showed that salt content in compost plays an integral role in suppressing diseases and increasing crop yields. The 10-ton and 20-ton compost applications provided the greatest suppression of chili wilt and the highest yields. The 50-ton treatment resulted in the poorest yields. The control acreage and the 30-ton application also produced poor yields. The losses in the 30- and 50-ton acreages were attributed to high salt concentrations in the compost, which weakened the plants and made them more susceptible to chili wilt. For optimal results, therefore, salt concentrations in compost should be measured and application rates adjusted accordingly. Plant salt sensitivity requires a tailored compost controlled for salt concentration.

Compost Abates Ashy Stem Blight and Root Rot

University of Florida researchers tested the effects of Agrisoil (compost made of mixed municipal solid waste) and Daorganite (a heat-treated biosolids mix), on test plots in a field in Homestead, Florida. The Agrisoil compost was applied at rates of 36 tons per acre and 72 tons per acre, and the Daorganite sludge was applied at rates of 0.67 tons per acre and 1.33 tons per acre. Sections of the field also were left untreated as a control. Six weeks after the materials were incorporated into the soil, researchers planted bush beans throughout the field. A second crop, black-eyed peas, was planted following the bean harvest, and Agrisoil compost and Daorganite were applied at the same rates as in the bush bean project. The field was also fertilized according to accepted local agricultural practices.

The health and yields of the bush bean crops were significantly improved by compost. Beans grown in the Agrisoil compost were larger and healthier. Yields from the 36 and 72 tons per acre application areas were both 25 percent higher than control area yields. Beans grown in the Daorganite mix showed low yields similar to those grown in the control areas. In addition, ashy stem blight severely affected beans grown in both the control and Daorganite-treated areas, but not the plots with Agrisoil compost.

The health and yields of the black-eyed pea crops grown in compost were also significantly improved. These crops had greener foliage and were larger than those grown in the control or Daorganite-treated plots. Yields from the compost-enriched areas were more than double the control yields in the 72 tons per acre application sections and also significantly higher in the 36 tons per acre sections. By comparison, yields in the Daorganite-treated areas were only slightly higher or comparable to those in the control sections. *Rhizoctonia* root rot severely affected plants in the Daorganite-treated and control areas, but the disease was considerably less prevalent in the compost-enriched areas.

In this particular study, yields and disease infection proved to be directly related in both the bean and pea crops. Mature Agrisoil compost was more effective at disease suppression than the Daorganite heat-treated biosolids mix. Thus, yields were uniformly higher in the Agrisoil-treated areas than in the Daorganite-treated and control areas.

Mortality Composting

More than 7.3 billion chickens, ducks, and turkeys are raised for commercial sale in the United States each year, according to U.S. Department of Agriculture's National Agricultural Statistics Service. About 37 million birds (18-25 percent) die from disease or other natural causes before they are marketable. As more poultry is consumed, these numbers are expected to climb.

Composting is a viable and cost-effective option for disposing of poultry mortalities as compared to incineration or burial. Pathogens in poultry carcasses are destroyed during composting by the high temperatures (130-155 degrees Fahrenheit) inherent in the process.

During composting, various odor control techniques can be used. As a result, this type of compost is not only safe for crop application, but it also can be safely sold by farmers. In fact, selling excess compost could even be a source of additional income for farmers. Markets for high-quality compost include professional growers (such as horticultural greenhouses and nurseries), homeowners, turf growers, and crop farmers (such as corn and wheat farmers). Professional growers alone purchase $250 million per year in compost products.

Pest Control

Compost also can eradicate some types of pests, such as parasitic nematode (worm) infections, in addition to its use in controlling disease. Specially formulated (tailored) compost can include chemicals that actually kill nematodes or prevent their eggs from hatching. Most types of compost help control parasitic nematodes by providing nutrients to the soil, which encourage the growth of fungi and other organisms, which, in turn, compete with or destroy nematodes. Compost also contributes to plants' basic health, making them less susceptible to pests.

Compost's ability to halt soil nematode invasion was identified by the staff of Dr. Herbert Bryan of the University of Florida. While studying plant response to different compost applications and irrigation rates, the staff, who had a background in nematology, noted the unexpected results while conducting routine observations. "Where compost was used, even without a fumigant, there was a significant reduction in rootknot nematodes," said Dr. Bryan.

Later research by Dr. Tom Obreza, a soil and water scientist at Southwest Florida Research and Education Center, turned up similar results. Dr. Obreza's experiment consisted of growing tomatoes in composts from several different sources and comparing them to control plots treated with the usual fertilizers. Dr. Obreza found no disease problems in any of the plots except one. Dr. Obreza noted, "We had a little invasion of rootknot nematode in one corner of the field. The infection was evident in the plants right up to the compost treated plots and stopped right there. The difference was as plain as night and day."

Biopesticides (Tailored Compost)

Biopesticides are becoming effective alternatives to chemical pesticides. Biopesticides are made by adding controlled amounts of pest-fighting microorganisms to compost, which results in "tailored" compost with a specific pesticidal capability. Biopesticides must be registered with the U.S. Environmental Protection Agency (EPA) and undergo the same level of testing as chemical pesticides to determine their effectiveness and their safety for public health and the environment. Although one type of tailored compost that is inoculated by a patented process is already registered as a biopesticide with EPA, many more are expected to follow suit.

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Innovative Uses of Compost
Composting of Soils Contaminated by Explosives

Introduction

Soil at more than 30 munitions sites across the United States is contaminated with explosives. The U.S. military has discovered that the composting process, and the use of finished (mature, cured) compost can effectively remediate munitions-contaminated soils. To incorporate such soil into the composting process, the soil is excavated and mixed with other feedstocks. The end-product is a contaminant-free soil, containing nutrient-rich humus that can enhance landscaping and horticultural applications. Composting costs considerably less than soil excavation and incineration, the traditional method used for these cleanups.

The Umatilla Army Depot in Hermiston, Oregon, has successfully used composting to convert 15,000 tons of contaminated soil into safe soil containing humus. By using composting instead of incineration, Umatilla saved approximately $2.6 million. Clean-up goals for Umatilla were established at concentrations of less than 30 milligrams per kilogram for 2,4,6-Trinitrotoluene (TNT) and Royal Demolition Explosives (RDX). The project exceeded these expectations by achieving nondetectable levels of explosives. Contaminant byproducts were either destroyed or permanently bound to soil or humus.

The success at Umatilla indicates that composting of explosive-contaminated soil is a cost-effective and environmentally sound clean-up method. Millions of dollars could be saved if the composting process were used rather than conventional incineration to clean up contaminated soils at these and other military operations in the United States. Other sites using composting for explosives include the U.S. Naval Submarine Base in Bangor, Washington; the Navy Surface Warfare Center in Crane, Indiana; and the Sierra Army Depot in Herlong, California.

How Contamination Occurred at Umatilla

Over a 15-year period during the 1950s and 1960s, workers at Umatilla used water and steam to clean TNT, RDX, and other explosives out of decommissioned 500- and 750-pound bombs. In the process of cleaning these bombs, more than 80 million gallons of explosive-contaminated "pink water" (named for its characteristic color) were washed into two 10,000 square-foot lagoons. When the water evaporated, workers excavated and transported the residual solids to another area and burned them. While the use of evaporative ponds was the accepted wastewater disposal technique at the time, it caused an unforeseen problem. Contaminants seeped into the soil and the ground water underlying the evaporation lagoons. In 1987, Umatilla was put on the Superfund list for hazardous waste cleanup because of TNT and RDX levels of 4,800 parts per million.

How Composting of Explosive-Contaminated Soils Works

Through the process in which compost is made, naturally occurring micro-organisms break down the explosive contaminants in the soil. Using the contaminants as "food," the micro-organisms convert them into harmless substances consisting primarily of water, carbon dioxide, and salts. In addition to this food source, micro-organisms require nutrients, such as carbon, nitrogen, phosphorous, and potassium, in order to thrive, digest, and reproduce. To provide these nutrients in sufficient quantities, soil amendments, such as manure and potato waste, were added to the contaminated soil at Umatilla.

Before beginning work at Umatilla, extensive tests were performed to determine the best mixture of contaminated soil and soil amendments to be used in the composting process. Numerous factors influence what mix of these ingredients provides micro-organisms with the optimum environment in which to live. The most important factor is the carbon to nitrogen ratio. Other factors influencing the choice of soil amendments include moisture, pH, degradability, percentage of organic matter, and availability of specific soil amendments. The composting feedstocks used at Umatilla were 30 percent contaminated soil, 21 percent cattle manure, 18 percent sawdust, 18 percent alfalfa, 10 percent

Photo courtesy of Bioremediation Service, Inc.

Workers, using highly specialized mixing equipment, turn steaming windrows of soil amendments mixed with explosive-contaminated soil from the Umatilla Army Depot.

potato waste, and 3 percent chicken manure. In other geographical areas, substitutions may be made depending on the cost and availability of ingredients.

Large, temporary mobile buildings were constructed to control fumes and ensure optimum conditions for the composting process. The mixture of contaminated soil and soil amendments was placed into windrows. Workers, using highly specialized mixing equipment, turned these steaming piles three times daily to: (1) ensure that the compost received sufficient oxygen; (2) release trapped heat, water vapor, and gases; and (3) to break up clumps. Treatment time for a 2,700-cubic-yard batch of soil was 10 to 12 days.

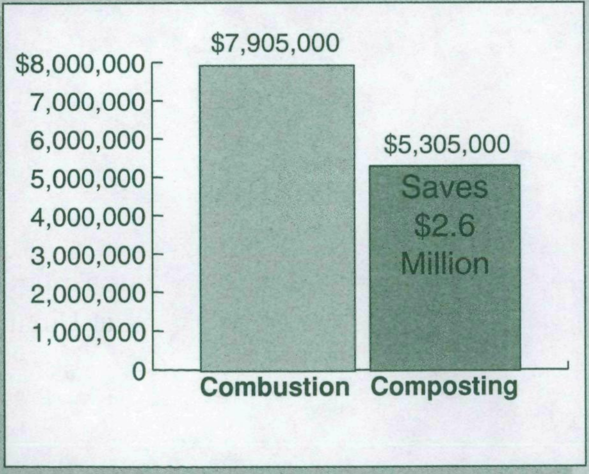
Benefits of Composting Explosive-Contaminated Soils

Composting of explosive-contaminated soils has significant economic and environmental benefits. At Umatilla, composting saved an estimated $2.6 million over incineration for cleanup of the entire site. Clean-up costs at Umatilla were estimated to be $527 per ton for combustion and $351 per ton for composting, resulting in a savings of $176 per ton.

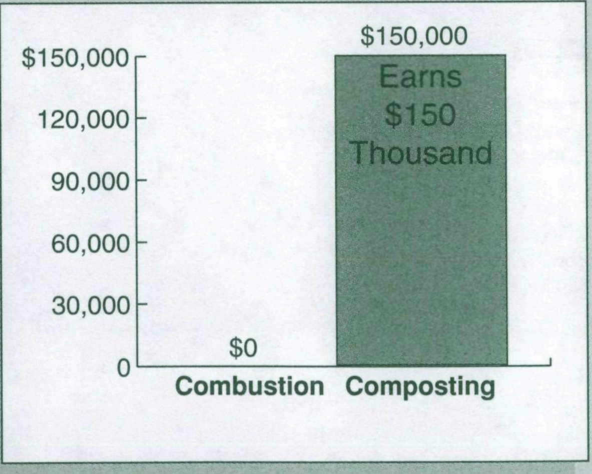
In addition, the end-product of the composting process, humus-rich soil, generally sells for at least $10 per ton, resulting in potential revenues of $150,000. Together, the savings ($2.6 million) and potential revenue ($150,000) from using the composting process to remediate explosive-contaminated soil could be $2.75 million. By contrast, the end-product of combustion has limited commercial value, and represents minimal potential revenue.

Combustion Versus Composting at Umatilla Army Depot

COST Total Clean-up Cost for 15,000 Tons of Contaminated Soil*



BENEFIT Value Added from Sale of 15,000 Tons of Treated Soil



Savings and Revenue From Composting $2,600,000 + $150,000 = $2,750,000

* *Based on information contained in "First Production-Level Bioremediation of Explosives-Contaminated Soil in the U. S." by David D. Emery and Patrick C. Faessler, Bioremediation Service, Inc.*

Photo courtesy of Bioremediation Service, Inc.

Large, temporary buildings controlled fumes and ensured optimum conditions for the composting of explosive-contaminated soil at the Umatilla Army Depot.

The U.S. Army Corps of Engineers has estimated that if composting were used to clean up the remaining U.S. munitions sites, $200 million could be saved.

While incinerators use large quantities of fossil fuel, a nonrenewable resource, only a small amount of fuel is needed for the machines that stir composting windrows. Incinerating soil at hazardous material disposal facilities results in ash that must be handled and disposed of as hazardous residue. By contrast, composting produces a nutrient-rich product comparable to an enriched top soil that can be used in landscaping and agricultural applications. In fact, tests on plants grown in remediated soil showed no toxic effects from the contaminants and that the contaminants were no longer present. According to Dr. Michael Cole, an expert in the degradation of organic contaminants in soil, composting, more than any other soil cleanup technique, results in an enriched soil end-product and restores the earth to a better condition than before it was contaminated.

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Innovative Uses of Compost

Reforestation, Wetlands Restoration, and Habitat Revitalization

The native plants that inhabit America's countrysides—from the sunflowers on the Great Plains to the oak seedlings in the Appalachians—are a source of great beauty. But the plants within a habitat contribute much more to their surroundings than mere beauty. They provide a vital food source for many members of the habitat. They enrich the air through the gases they produce and minerals they exchange. Even when plants die, they continue to support grasses, flowers, and trees by becoming part of the humus, or organic material in soil, that is so vital to living plants.

Unfortunately, much of the organic material in the soils in the United States has been stripped by natural and man-made stresses such as erosion, flooding, and logging. But barren soils can be restored with the help of compost. Compost adds the missing infrastructure, humus, and nutrients that plants need to re-establish themselves in decimated areas.

Organic matter in the soils of wetlands in the United States has decreased steadily over the last three centuries. According to Dr. Donald Hey, an expert in flood plain management, over 100 million acres of U.S. wetlands have been drained, and our watersheds now contain only about half the amount of organic matter they contained in the 17th century. As a result, annual floods have worsened, ground water quality has deteriorated, and wildlife diversity has declined. Compost, with its high organic content, can absorb up to four times its weight in water and can replace essential organic material in wetlands.

In addition to wetlands restoration, compost also can help restore forests and revitalize habitats. Compost can play an important part in reforestation efforts by providing an excellent growing medium for young seedlings. In the same way, compost can help to revegetate barren habitats, providing the necessary sustenance for native wildlife populations. By enhancing the chemical and mineral properties of soil, compost facilitates native plant growth, which provides food for native and endangered animal populations.

Reforestation:

Nantahela National Forest and the Qualla Cherokee Reservation

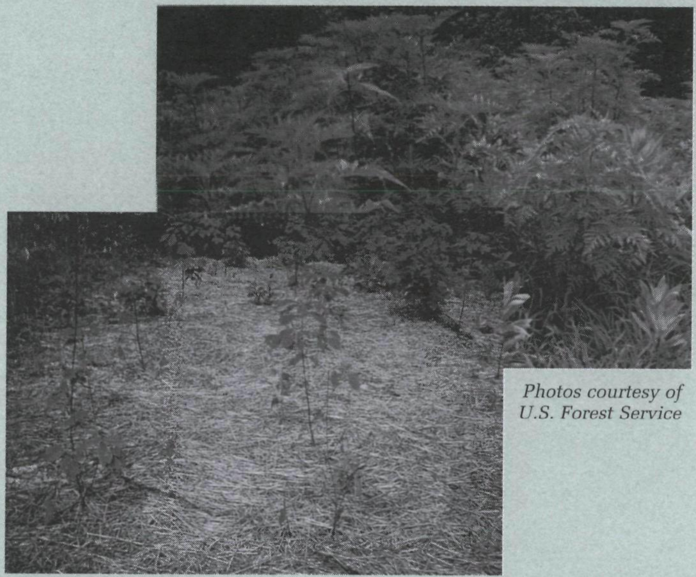
In 1996, the U.S. Forest Service, Bureau of Indian Affairs, Cherokee Tribal Council, and the U.S. Environmental Protection Agency (EPA) launched a 3-year, joint study (1995-1998) to test the effectiveness of straw compared to three different kinds of composts in stimulating tree seedling growth and reducing soil erosion. The three composts, made from yard trimmings, municipal waste water sludge (biosolids), and municipal solid waste (MSW), were used as a 2-inch mulch on white pine softwood, chestnut oak, and chinese chestnut hardwood seedlings.

Photo courtesy of U.S. Forest Service

U.S. Forest Rangers and Cherokee workers cleared plots for the compost study.

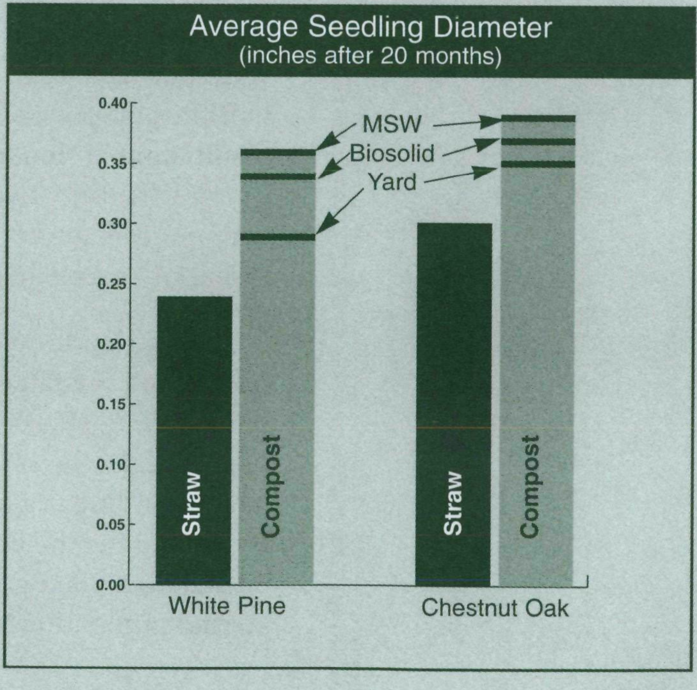
The project was carried out at three different sites within the Cheoah Ranger District, Nantahela Forest and the adjoining Qualla Cherokee Reservation at Cherokee, North Carolina. U.S. Forest Rangers and Cherokee workers cleared and planted the plots for this study. The study sites were chosen because they contained compacted, eroded areas or disturbed steep slopes. Each of the three composts and the straw were tested on two plots each, and the seedling types were grown on each plot.

After 20 months, results showed that height, diameter, and survival rates for seedlings planted in the composted test plots exceeded the straw test plots. In addition, volunteer revegetation by herbaceous plants was remarkable in the composted plots. After 30 months, erosion was evident in the straw plots but not in the composted plots.



Photos courtesy of U.S. Forest Service

Seedlings planted in compost mulch flourish and show greater growth than seedlings planted in straw mulch.



Habitat Restoration:

Patuxent Wildlife Research Center Project

Dr. Matthew C. Perry, a habitat management scientist at the Patuxent Wildlife Research Center in Maryland, in cooperation with the EPA, is leading a 2-year study (1996-1998) to show the value of using composts to restore wildlife habitats. Past military and farming operations at Patuxent degraded native plant populations, resulting in a serious decline of many animal populations in the area. The aim of the new study is to revegetate a 4.8-acre site with native plants in an effort to restore the food sources for indigenous wildlife populations, including songbirds, game species, small mammals, amphibians, reptiles, and insects.

The study is comparing the effectiveness of two compost materials, one made from municipal wastewater sludge (biosolids), and the other made from yard debris. These two soil treatments, with two types of controls, were randomly assigned to eight plots and replicated twice. Control plots received no compost and were of two types: one that was planted with a hand-collected mixture of native grasses and legumes and one that was not planted. Plots with compost were also planted with the native plant mixture.

Preliminary results, in the late fall of 1996, indicated the greatest revegetation of plots occurred in areas treated with compost made from yard debris; but, all of the plots with compost had superior growth compared to the control plots.

Photo courtesy of the Patuxent Wildlife Research Center

Piles of compost await spreading on a degraded area of Patuxent Wildlife Research Center.

Regaining Wetlands:

Clean Washington Center Project

At a site in Everett, Washington, the Clean Washington Center sponsored a 2-year project, from 1994-1996, to test two types of compost in the restoration of damaged wetlands. The restoration site consisted of two large wetlands joined by a culvert 550 feet long and 18 inches deep. Decades ago, a sawmill sat in the sandy area between the wetlands. Once the mill was torn down, the area was left relatively barren, which made the railroad tracks and bike path adjacent to the upper wetland prone to flooding. The project utilized compost extensively to keep the adjacent railroad tracks and bike path from flooding.

The project's construction team deposited a yard debris compost and a mixed compost made of biosolids and yard debris into 14 separate test plots. A control plot containing no compost was also developed. Workers then introduced a selection of indigenous wetland plant species into each plot and monitored the growth of the plants every six months, through 1996.

The project showed that the compost enriched soils closely mimicked the natural wetland substrate. In addition, the plants in both compost test plots exhibited 20 percent more growth, and a 10 to 15 percent higher survival rate than the control plots. The site also handled the flow of 1996's heavy winter rains quite well, and the railroad tracks and bike path did not flood.

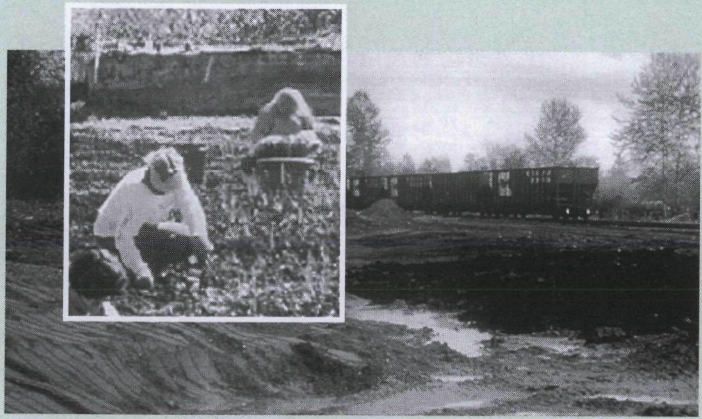


Photo courtesy of the Clean Washington Center

Damaged wetlands near railroad tracks in Everett, Washington, flooded the tracks constantly. Restoration with compost prevented flooding and helped support the native beaver population.

Des Plaines River Flood Plain

Dr. Donald Hey, an expert in flood plain management, tested the value of using compost to restore 37 acres of wetlands in a project he conducted on the banks of the Des Plaines River in northern Illinois. He and his staff used compost to encourage the growth of native plants in four marshes. One portion of the marshes, functioning as a control, was not treated with compost.

Positive results were observed within 2 years of incorporating compost into the soil along the river. Flood storage of the area—the ability of the soil to absorb and contain the excess water from floods—had improved dramatically compared to the control area. River water quality also improved significantly, with reduced nitrogen values and fewer suspended solids in rehabilitated areas of the river. In fact, the revitalized soil and plant life removed 90 to 95 percent of the nitrogen and suspended solids from the water.

References

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For More Information

This fact sheet and other information about solid waste issues are available in electronic format on the Internet at http://www.epa.gov/osw; select "Reduce, Reuse, Recycle." Use Internet e-mail to order paper copies of documents. Include the requestor's name and mailing address in all orders. Address e-mail to: rcra-docket@epamail.epa.gov.

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