Water Quality Division

Environmental Protection And Enhancement with Compost

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Environmental
Quality

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DEQ is a leader in restoring, maintaining and enhancing the quality of Oregon's air, land and water.

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Acknowledgment

This document was originally developed to be a companion to the PowerPoint presentation to the Oregon Department of Transportation for their May 22, 2001 Geo-Hydro Conference in Hood River by Dave Kunz and Dennis Jurries of the Oregon Department of Environmental Quality, John Forseid of Metro, and Dan Sullivan of Oregon State University.

Forward

This document is a summary of various compost related research and information. It is intended to indicate Best Management Practice relating to compost.

The conclusions from reviewing the research are that:

- More research is needed. Findings in past research usually carrying justifications for why the project research data did not consistently result in data that was anticipated before the project was undertaken.

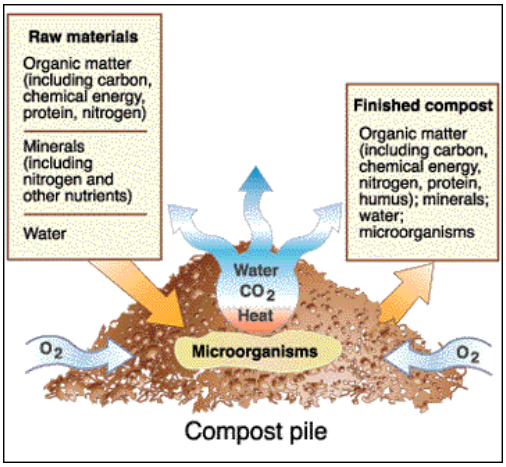
- Virtually no data exists or can be found that demonstrates the ability of compost soil enhancement to remediate compacted or engineered filled soils. Although visual observations from several projects indicate this to be a fact.

- Although project data is available to demonstrate the benefits of compost tea for maintaining, improving, and fertilizing vegetation, no data was found to support the assumption that compost tea will improve porosity and drainage of compacted soils.

- Limited data was found to support removal efficiencies of pollutants through the use of compost.

- More data is needed on the effectiveness and the duration of the effectiveness of compost berms in controlling turbidity and total solids in runoff.

The potential for compost to benefit the environment at a cost effective rate and do so as a sustainable resource is great. Visual results of various projects indicates that compost is a beneficial nutrient source for vegetation, greatly increases porosity of compacted soils, reestablishes beneficial biological co0lonies in compacted soil, and is an effective erosion and sediment control for runoff in storm water.



This document is a compilation of research projects into the beneficial uses of compost that have occurred in the past ten years or so. Originally, it was to be focused on the benefits that compost could bring to construction and post construction sites with respect to the environmental concerns associated with storm water runoff. As review of documentation progressed, it became clear that the benefits of compost touched on so many environmental benefits other than storm water that it was felt that they should also be mentioned. So, this document summarizes compost benefit information concerning storm water pollution control, soil remediation, and air pollution control. The benefits of compost for landscaping will only briefly be mentioned as it is felt that most people have seen or experienced this application of compost and have some familiarity with it.

Table of Contents

Page
History 1
Healthy Soil - Background 1
Soil Biota 2
Construction - Soil Concerns 6
Erosion and Sediment Control
Compost Berm 7
Compost Blanket....9
Compost Sock 11
Vegetation Establishment 12
Compost Installation Methods 12
Lessons Learned....13
Conclusions....13
Compost as a Soil Amendment....14
Compost Tea 15
Compost Water Filtration System (Industrial/Commercial)....16
Compost Air Filtration System 18
Compost in Bioremediation 19
References....21

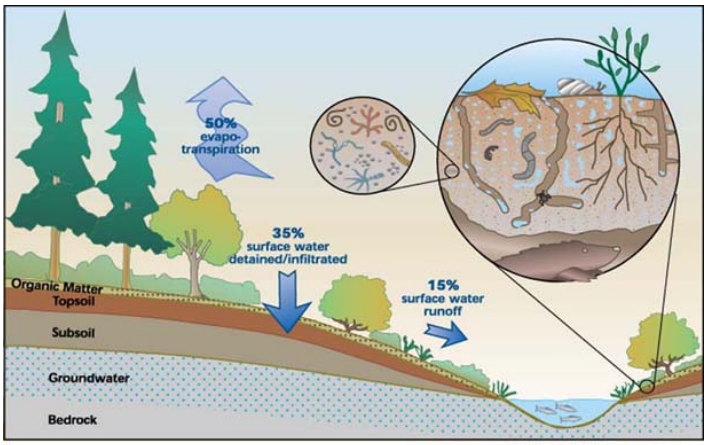
History:

Composting can be traced to a Roman farmer and scientist, Marcus Cato, about 2,000 years ago. Marcus Cato believed that compost was a fundamental soil enhancer, essential for maintaining fertile and productive agricultural land.

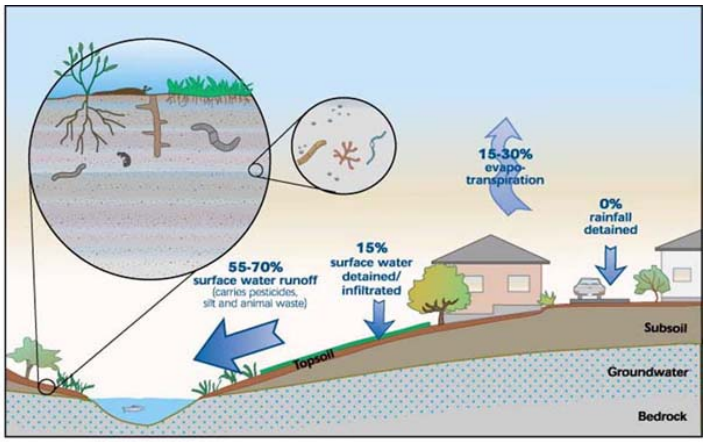
Healthy Soil - Background:

Construction activities have at least two aspects that have caused adverse impacts to the environment in the past. These aspects are: long term increased storm water runoff due to engineered soil compaction and to vehicle traffic, and storm water runoff during the construction itself.

In order to begin to understand either of these aspects, it is necessary to look at the soil before construction, during construction, and after construction.



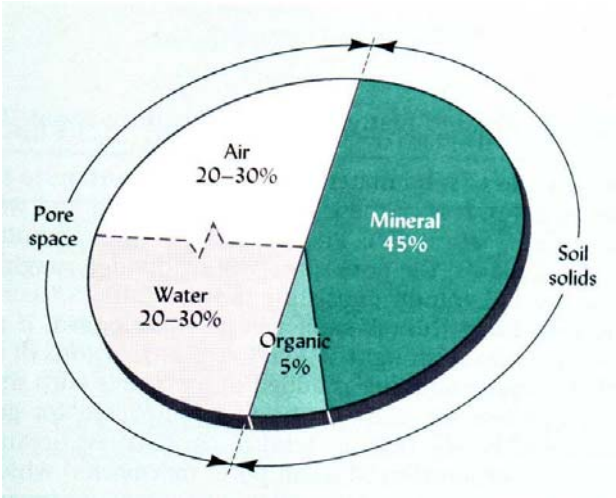
Native Soil



Disturbed Soil

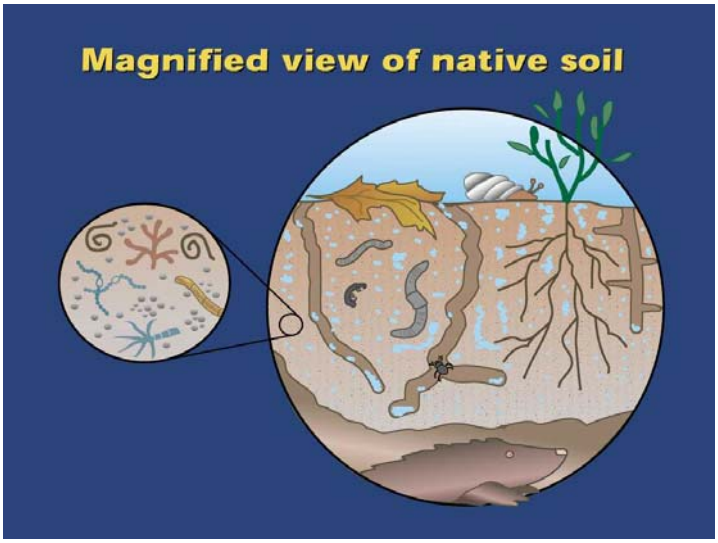
An undisturbed site typically has 40 to 55% pore space in the undisturbed soil. The bulk density of the soil is between 1.1 and 1.4 grams/cubic centimeter (g/cc). Rain or snowfall results in about 50% evapotranspiration, 35% infiltration, and 15% surface water runoff. After construction, the same site may end up with 15 to 30% evapotranspiration, 15% infiltration, and 55 to 70% surface water runoff. Soil bulk density typically increases to between 1.5 and 2.0 g/cc. This is a 20% reduction in infiltration and a 40 to 60% increase in surface water runoff.

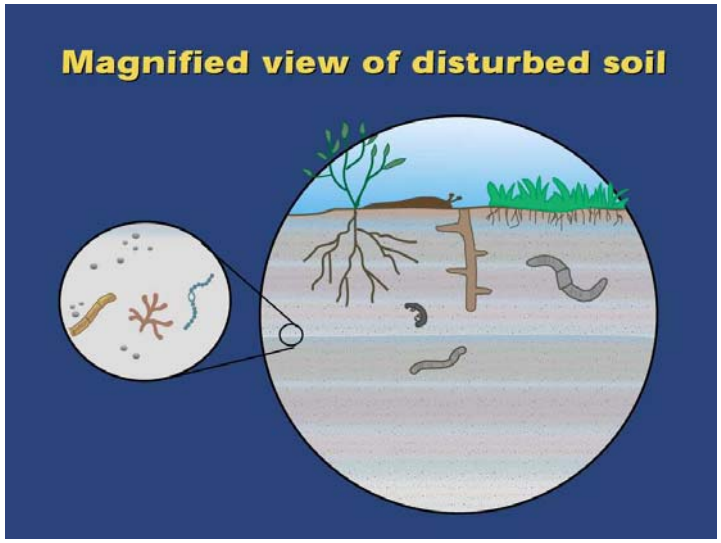
The pore spaces in the soil are the main pathways for water infiltration. Their loss in the soil takes decades to replenish, if then. An example of the pore space can readily be observed by digging a hole in undisturbed soil then filling the hole back with the soil removed. The result is an incompletely filled hole. This is also an observation that can be made when building a fence. Even with the posts in the ground there is usually insufficient dirt to fill the post holes.



Soil Make-up

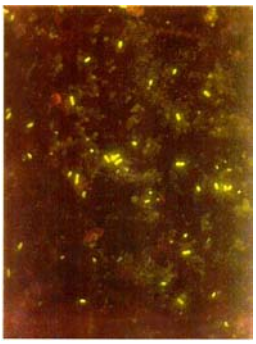
Soil Biota:



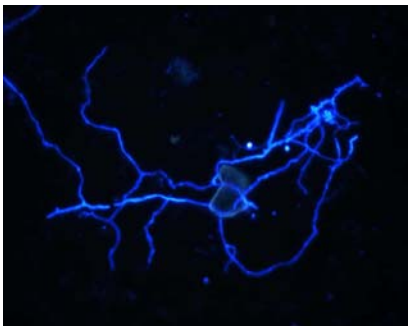


Biological activities are essential for good soil productivity. Soil invertebrates, such as mites, nematodes, and collembola, and soil microbes, such as bacteria and fungi, recycle all the carbon, nitrogen, and other mineral nutrients in plant and animal residues into forms that can be used by plants. The top 8 to 12 inches of soil account for most of the biological activity, nutrient cycling, and roots. This depth of soil is called the rhizosphere. Compaction of the soil disrupts the established balance of the rhizosphere by destroying organisms and since these are air breathing organisms, eliminating or decreasing the amount of oxygen available for growth and color establishment. See "Creating Healthy Productive Soil" by Dr. Jill Clapperton for further information on the rhizosphere and health soil.

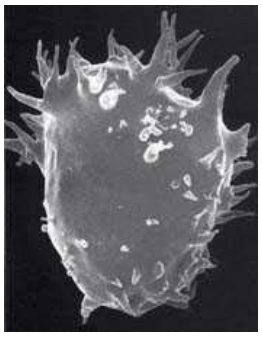
A cup of undisturbed native topsoil can contain:



200 billion Bacteria



100,000 meters of Fungi



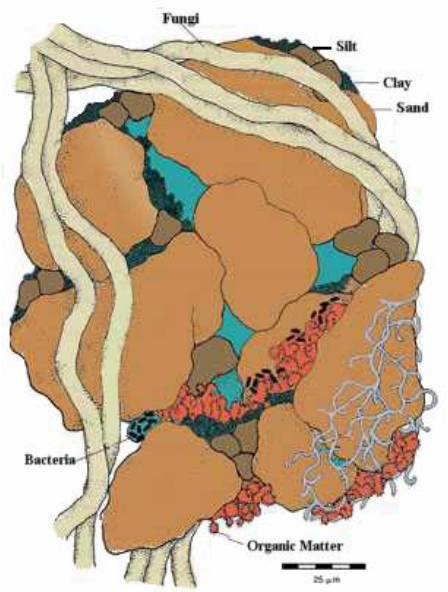
20 million Protozoa

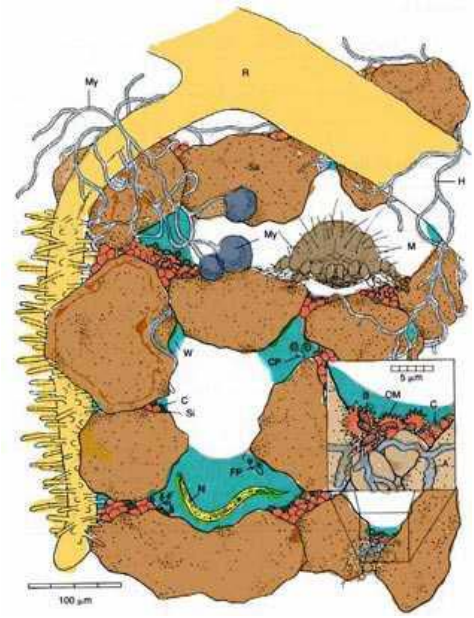
100,000 Nematodes

Earthworms <1

50,000 Arthropods

Soil contains macroflora, microflora, macrofauna, mesofauna, and microfauna.





Idealized views of soil structure

C-clay
W-Water
M-Mite
R-Root

S-Sand
N-Nematode
B-Bacteria
OM-organic matter

Si-silt
My-Myccorhizae
H-hyphae

Compaction of soils kills most of the beneficial biota and removes the air spaces in the soil that the aerobic biota need in order to live and thrive. Surface plantings, fertilizer, and other nutrient supplements typically only help the first few inches of soil to develop a new biota. Chemical fertilizer addition can actually kill or restrict the development of this biota. The biota is necessary for healthy vegetation.

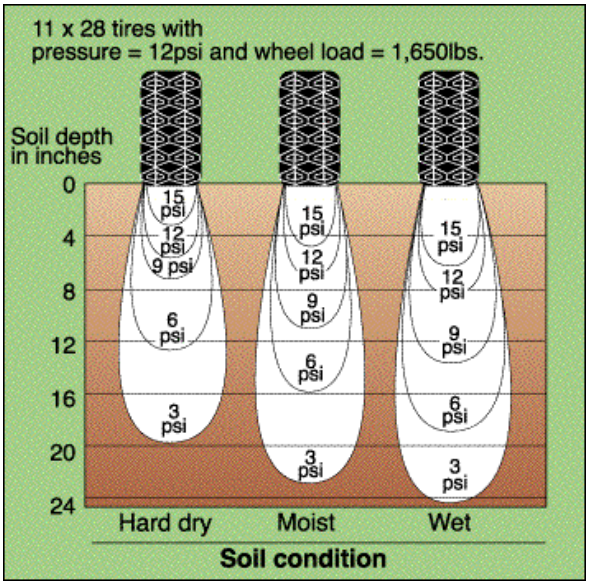
A more complete discussion on the soil biota can be found in "The Soil Biology Primer" available in text only at http://www.statlab.iastate.edu/survey/SQI/SoilBiology/soil_biology_primer.htm#Contents, or a version with graphics and pictures can be ordered for $6 at http://www.swcs.org/t_pubs_books_primer.htm.

Compacted soil also stresses the root structure of newly planted vegetation. It makes it difficult for root penetration. Thus newly established vegetation typically becomes stunted and remains smaller than vegetation established in undisturbed soil. With the lack of porosity in the soil, shrubs, trees, and bushes remain root-bound and the root ball may become water logged and essentially drown in some areas.

Vehicle traffic on undisturbed soils can have a similar effect of that of compressed fills. The result from vehicle traffic can be observed from a historical perspective if one looks at the Oregon Trail.

Mule pulled wagons plied the Oregon Trail from 1841 to 1869 on a regular basis. Some stretches of the Oregon Trail like the stretch from Nyssa to Vale through Keeney Pass still show stunted vegetation resulting from the passage of the mules and the three thousand pound plus wagons.

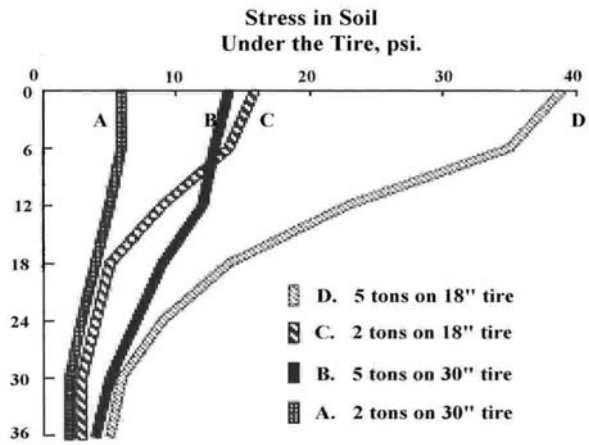
Another example of compaction comes from wildlife and man's tendency to walk the same pathway. Trails, especially as evidenced in the forests, become recessed below surrounding ground level and vegetation, if any, becomes stunted. Pets walking through



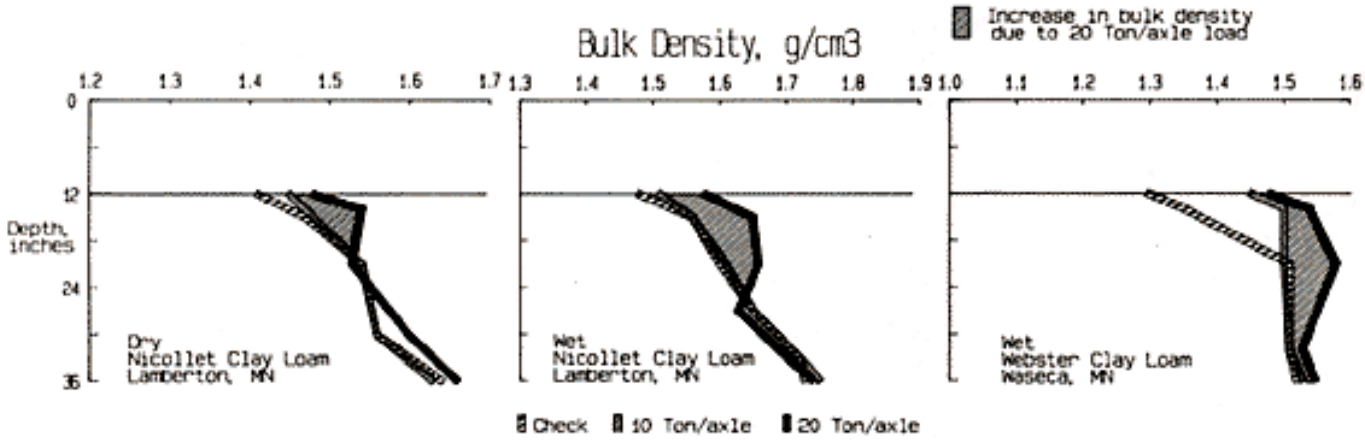
yards sometimes tend to wear paths through the lawn.

Localized compaction of soils from wheeled and tracked vehicles occurs up to 30 inches below the soil surface. The amount of compaction is dependent up on soil moisture content, soil type, and load distribution. The wheels or tracks tend to push soil particles into the voids or pores in the soil. In wet soil the compaction is more severe than in dry soils.

The figure on the right shows a typical relationship between soil loading and the depth of the impact of the soil compaction.



Soil bulk density, dry weight of soil removed from a known volume hole, is the measurement of the compaction of the soil. For any location the measured change in bulk density will give the relative amount of compaction. Caution should be exercised in trying to relate different sites using bulk densities due to the possible soil type change and other characteristics that may be dissimilar between the two sites.



The above graphs show the difference in bulk densities for slightly different soil types and in the case of the first two graphs, the difference in one site for dry and wet soil conditions for depths below 12 inches. Notice that compaction of wet soil is better than 34% higher than that for the same dry soil.

Compaction of the soil makes it more difficult for vegetation to deep root and so the vegetation ends up being stressed to the degree that it is restricted in growth or in some cases dies out.

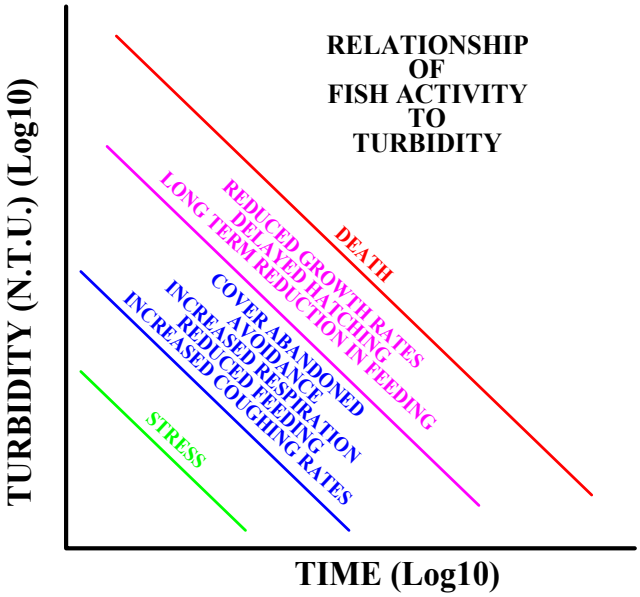
Construction Soil Concerns:

Other than the affect that soil compaction has on runoff, there is the effect that is caused during construction from the lack of vegetation on storm water runoff. To better understand this, it is necessary to understand storm water runoff better.

Storm water runoff contains sediment, suspended solids, turbidity or dissolved solids, and other pollutants. Sediment and suspended solids can usually be controlled using conventional sediment controls such as sediment traps (settling basins) or filters such as sediment fences.

Most pollutants transport attached to soil particles. With sediment and suspended solids controlled, the remaining concern is the dissolved portion generally referred to as turbidity. Turbidity consists of submicron sized soil particles which are usually negatively charged. Once turbidity is formed it can be very difficult to do anything about economically.

As to the environment aspects of soil particles other than those with attached pollutants, the impact to fish and other aquatic animals are paramount. Sediment can silt spawning beds and kill of aquatic animals that fish feed on. It can also raise stream temperatures to ranges in which the fish and other aquatic animals can not survive. The impact of turbidity on fish and aquatic animals involves a relationship between the level of turbidity and the duration of the turbid event. This can be shown in the graph on the right.



Studies in the Northwest on salmonid show similar results. In many streams there are periods when the water is relatively turbid and contains variable amounts of suspended solids. Larger juvenile and adult salmon and steelhead appear to be little affected by ephemerally elevated suspended solids associated with storms (Bjornn and Reiser 1991). However, older juveniles may avoid turbidity levels associated with severe erosion (70 NTU). Berge and Northcoate (1985) reported that the feeding and territorial behavior of juvenile coho is

disrupted by short term exposures (2.5 - 4.5 days) at a turbidity of 60 NTU.

Studies reported by Lloyd et al (1987) describe rainbow trout avoidance of turbid water above 30 NTU. The avoidance of turbid water has been documented by both field and laboratory studies. Bilby (1982) observed coho salmon avoidance at water turbidity levels above 70 NTU. The avoidance behavior has been associated with the fish's ability to see. Several studies discussed by Lloyd et al (1987) suggest significantly reduced angler success at turbidities ranging from 8 - 50 NTU which suggests a reduced ability of the fish to locate prey. Lloyd (1987) cites Buck, 1956, Tebo 1956, Bartsch 1960, Oschwald 1972, Ritter and Ott 1974, and Langer 1980 as providing additional descriptions of reduced angler success associated with Turbidity. The USEPA (1977) reported that cutthroat trout abandoned redds, sought cover and stopped feeding when a turbidity of 35 NTU was encountered for two hours. In addition USEPA (1977) reported reduced growth and feeding at 50 mg/l TSS.

Summary of Turbidity (NTU) Cited Impairment Thresholds	
Turbidity	**Impairment**
5-25	Reduced primary production
8 (8-50)	Reduced angler success
11-49	Emigration (salmonids)
(3-30)	Cough response/Avoidance (salmonids)
21	Reduced salmonid population density
25	Reduced feeding and growth in salmonids, prolonged exposure
30	Trout avoidance
35	Redds abandoned
50	Juvenile displacement
60	Feeding and territorial behavior disrupted
70	Avoidance by older salmonids

Erosion and Sediment Control:

Compost Berm:

Lane County, Eugene, OR

A compost berm can be used as a stand alone erosion and sediment control or be combined with a layer of compost covering a slope. The minimum dimensions of a compost berm are height of 12 inches and a width of 24 inches. Coarse grade leaf compost works best for controlling turbidity. Medium and coarse grade, yard debris can also be effective at controlling sediment and total suspended solids. Storm water flow into the berm should be in sheet flow. Too high of water retention or too high of velocity flow behind the berm will cause a blow out of the berm unless the compost is held in place by say an open weave geotextile fabric. Berms should be placed in similar locations as those chosen for sediment fencing, straw bales, and etc.

ODOT on U.S. Highway 26 at Sylvan Hill

All types of vegetative compost can greatly reduce total phosphorus and heavy metals except zinc in runoff.

Compost berms should seriously be considered for use over consideration of using sediment fencing. Studies such as those conducted by W & H Pacific and CH2M-Hill, 1993, indicate that the performance of sediment fencing as a control for sediment and Total Suspended Solids (TSS) is highly questionable. In the project conducted at the St. Johns Landfill by W & H Pacific and CH2M-Hill, 1993, Sediment fencing reduced Total Solids (TS) in the runoff by 39% but coarse grade mixed yard debris compost berm decreased TS by 83%. A study performed by Dr. Ed Caine of the Snohomish County Department of Planning and Development Services, 2001, showed no decrease in turbidity with sediment fences but a 67% reduction in turbidity using Compost Berms.

Compost Berms cost approximately 30% less installed than sediment fences. This does not take in to consideration the additional cost of removal and disposal of the sediment fence or the cost of dispersing the compost in the berm once the construction is completed. The new 1200-C and 1200-CA Construction Storm Water Discharge Permit requires the removal of all temporary erosion and sediment controls at job completion.

LockDown Netting™:

LockDown NettingTM installed on steep (1.5:1 or steeper) or rocky slopes with compost blown into the netting can stabilize the slopes quickly. The netting is installed from the top-to-bottom not side-to-side of the slope and anchored along the edges and center with 6 inch or 8 inch sod staples. Cotton or synthetic netting is available. The compost should be blown in at greater than two inch depth. Without the netting compost must be blown in and compacted to much greater depths of six inches or more.

Compost Blanket:

ODOT - Sylvan Hill

Amazon Channel - Lane County - Eugene

Compost covers, blankets, have been successfully used on slopes exceeding 1:1.4.

Beef Bend Road in Washington County

Altamont Subdivision in Clackamas County

Nelson Hill, Medina, Washington

St. Johns Landfill Test Site, 1993

The study by W & H Pacific and CH2M-Hill, 1993, showed that Total Solids could be reduced in the runoff by 99.94% by using medium grade mixed yard debris compost over that from bare ground. This was on a 34% slope.

SoilDynamics applied an enhanced compost mixture called EssentialSoil™ to a slope exceeding 100% in Medina, Washington to a depth of 12 to 15 inches with great success. SoilDynamics tested the EssentialSoil™ mix at the San Diego State University's Soil Erosion Research Laboratory. The slope used was 50%. A 12 inch depth of the enhanced compost was used. Total Solids was reduced from that of bare soil by 98% and runoff as measured from three consecutive 10 year storm events (Los Angeles) was 77%.

Compost Sock:

Compost Socks are tubular mesh material with compost blown in to form a sock. They are blown to length by tying a knot in the beginning end, blowing the sock to length, cutting the sock, and tying another knot. The sock is either 12 inches or 18 inches in diameter when filled. The sock material Filterexx Soxx™ comes in cotton or a synthetic material. The cotton is used when the sock is to decompose or deteriorate in about one year's time and the synthetic in several years time. When used in a stream as a check dam the sock material comes with a skirt to be installed downstream to protect the downstream area from undercutting. The filled sock is fairly heavy and forms a good contact with asphalt or concrete surfaces. The socks can be removed and repositioned.

San Diego State University Test Apparatus

Turbidity results using compost have been mixed. Usually the reasons for high turbidity in various studies has been explained to be due to unanticipated problems from the test site setup. The W & H Pacific study showed a 55% reduction in turbidity in the runoff over that of bare ground from the St. Johns Landfill site which was justified as being with minimal site preparation interference with the results of the study. It should be noted that mature compost should be used when trying to control turbidity. The ionic capture of the colloidal soil particles which cause turbidity can be offset by the release of tannins or tannic acid from immature compost.

Vegetation Establishment:

Various studies have established that vegetation establishment is more rapid and more complete when just compost was used. The addition of fertilizers with the seed and compost usually resulted in slower growth and less complete coverage of the vegetation than with just seed and compost. In both situations the vegetation and coverage was superior to bare ground or to normal hydroseeding.

In compost blanket thickness of four inches and greater when seed is to be added, it is better to apply the compost in lifts of two inches. Seed mixed with compost in the first lift of compost will germinate, grow and usually provide good coverage well into the colder non-

germinating season. This is probably due to the insulating aspect of compost and the further composting that can occur after application which generates some heat.

Compost Installation Methods:

Compost can be applied to a site by mechanical/manual, conveyor, or blower methods. The moisture content of the compost can greatly effect some of these methods. Too wet an application of compost can impair the ability to manually or mechanically spread the compost on the site.

Compost Conveyor System

Compost Blowing

Manure Spreader

Lessons Learned:

1. Never install compost over soil that has a tackifier applied.
2. Extend compost over the crest or above the site at least 6 feet.
3. Ensure that no concentrated flows enter the composted slope by using compost berms or other methods.
4. Coarse grade mixed yard debris seems to work best.
5. A compost blanket thickness of at least 2 inches should be applied.
6. A mature compost should be used in order to reduce or eliminate turbidity due to tannin release and to maximize pollutant removal.

Conclusions:

- The use of compost for erosion and sediment control is beneficial and effective.
- Compost berms can be more effective than sediment fences in controlling Total Solids in the storm water runoff from a site.
- Compost soil amendment can decrease the runoff from a site in addition to providing benefits to vegetation. Compost soil amendment may also significantly reduce the size of any required water detention facilities.
- Additional research is needed to provide data on compost berms ability to control turbidity. What is the total weight of dissolved solids that a given volume of compost will retain before breakthrough will occur?
- Additional research is needed to provide data that would indicate that compost tea helps in alleviating soil compaction at greater than shallow soil depths.
- Additional studies are needed to better document the benefits of compost amendment of soils on slopes. Past studies seem to have justifications as to why the data did not reflect what was anticipated in the results.

Compost as a Soil Amendment:

Since vehicle traffic and engineered fills compact the soils thereby reducing or eliminating the pore space and the biodiversity of the soil, a method must be used to regain that porosity and biodiversity or increased runoff will occur and new vegetation will be restricted.

Effect of Soil Compaction

Using compost to amend soils increases the porosity of the soil and adds beneficial organisms and nutrients back to the soil.

Amending Soils in the Kingdom of the Netherlands for Tulip Bulb Fields

Bulb growers in the Kingdom of the Netherlands (Holland) remove the clay topsoil mix it with agricultural residue and manure and let it compost. After composting it is spread over the sandy land and mixed to a depth of approximately 10 inches. This provides good drainage and structure for tulip growing.

In the U.S. compost amending is usually performed by spreading four inches of compost on the surface and tilling it in to a depth of eight inches of compacted soil for a total depth of twelve inches. The general rule is a 2:1 soil to compost by volume ratio of mixture. The soil should be pre-tilled to loosen it before the compost is placed on top. Tilling the compost into the soil should be accomplished by tilling it twice, the second time perpendicular to the first.

To loosen up compacted soil to greater depths deep tilling equipment can be used to till to 24 inches of depth or more. Caution should be exercised in the selection of the equipment to use because of the concern for the weight of the equipment recompacting the soil and for the time of year that this process takes place. The latter part of the dry season is best.

The benefits of using compost as a soil amendment are:

- Incorporation of organic matter improves the structure of the soil;
- Increased moisture holding capacity;
- Increased moisture retention ability;
- Source of nutrient supply for vegetation;
- Vegetation greens up faster and better than in unamended soils;
- Healthier vegetation established;
- Increased storm water retention;
- Reduced irrigation requirement; and
- Increased pollutant retention.

It should be noted that in the Pacific Northwest, soil amendment with compost in excess of 30% by volume in poorly draining areas (shallow sloped) should not be attempted as this

will likely result in water logging and be detrimental to lawns or other vegetation. In poorly draining areas a subsurface collection system (French Drain) may have to be designed and installed to prevent this water logging. Excessively steep slopes may have to be terraced to provide gentler slopes.

Compost Tea:

Compost Tea is the liquid that is derived from soaking compost in water. Compost Tea has been shown in research and in several test projects to greatly improve vegetation resistance to disease, enhance root growth, reestablish the soil biota, and generally provide nutrients to vegetation. It is suspected that the use of compost tea can penetrate compacted soils and help reestablish the pores need for good infiltration. Further research is needed to establish or disprove this.

Since compaction of soils restricts root growth, bushes and trees need deep penetration techniques in order to provide health deep root structures. A devise called a Grow Gun could be used to fracture compacted soils to greater depth and compost tea could then be injected through the Grow Gun into these fractures to provide the biota for the healthy root growth. The Grow Gun uses compressed air to fracture soils in an average of twelve feet diameter coverage areas. Granular or liquid additives can then be injected through the Grow Gun. This method has been used for several years to rescue trees that become diseased or that develop root related problems resulting from compaction of the soil around the root structure during construction activities.

The benefits of compost tea are:

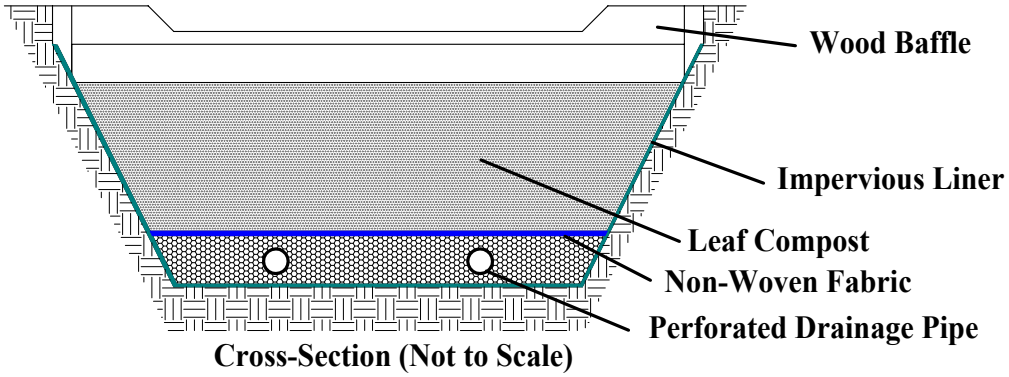
- Increased disease suppression;
- Nutrients for plants and food resources for microorganisms;
- Injection of microorganisms into the soil which increases the retention of nutrients, recycles nutrients into plant-available forms, and accelerates decomposition of plant material and toxins:
- Increased nutritional quality of plant produce;
- Reduced negative impacts of chemical-based pesticides, herbicides, and fertilizers on beneficial microorganisms; and
- Improved plant growth.

Compost Tea is made by placing mature compost in a fine mesh bag and soaking the bag in water for from eighteen hours to one week. The volume of the compost should be a maximum of ½ the volume of the water container. Frequent stirring or an air bubbler should be used in the water to ensure sufficient oxygen is present so that the solution does not go anaerobic.

Compost Water Filtration System (Industrial/Commercial):

In 1992, W & H Pacific completed a project to develop and test an alternative method for treating storm water runoff. The specific pollutants addressed were heavy metals, turbidity, suspended solids, total volatile suspended solids, chemical oxygen demand,

total phosphorus, total kjeldahl nitrogen, and settleable solids. The project was based upon knowledge that humic compounds (decayed vegetative matter that provides nutrients for plants and increased water-retention for soil) are stable, insoluble, high molecular weight bio-polymers which act as polyelectrolytes (similar to ion-exchange resins in activity).



The drawing above is similar to the cross-section of the device used. The side slopes were 2:1 and the base of the cross-section was 10 feet. Two compost filtration cells with a settling chamber forebay upgradient, located just after the discharge pipe completed the system. 120 cubic yards of leaf compost was used in the two treatment cells. The longitudinal slope of the filtration system was 2% and the total length of the compost cells was 100 feet.

Prior to the instillation of the filter both mixed yard debris and leaf compost were lab tested to determine if there was a difference in their ability to bind pollutants. The lab tests indicated that leaf compost was more efficient at binding some of the heavy metals such as lead, cadmium, chromium, copper, nickel, and iron.

The results of the investigation showed average first flush reduction efficiencies of:

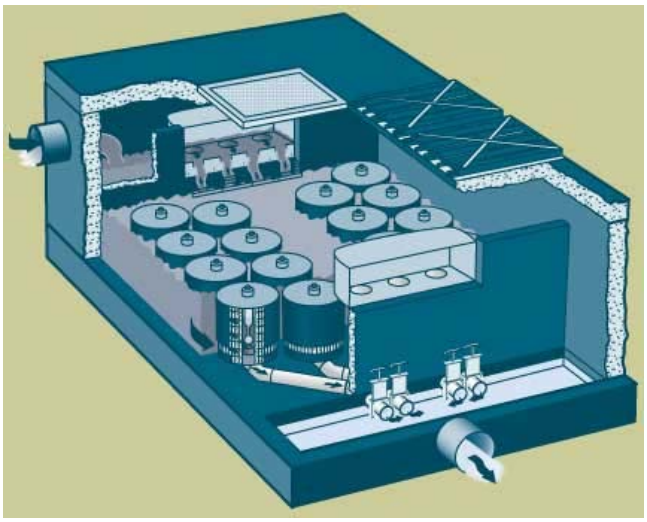
Turbidity	93%	COD	90%
Total Volatile Suspended Solids	97%	Settleable Solids	98%
Total Phosphorus	77%		

The mean removal rates were:

Turbidity	84%	COD	67%
Total Volatile Suspended Solids	89%	Suspended Solids	95%
Settleable Solids	96%	Total Phosphorus	40%
Zinc	88%	Copper	67%
Aluminum	87%	Iron	89%
Petroleum Hydrocarbons	87%		

Several commercial manufacturers are presently marketing compost filters. Stormwater Management of Portland, Oregon is one of them.

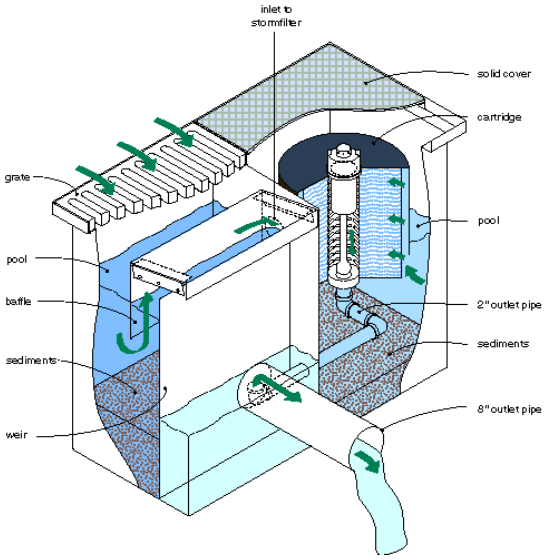
Cartridge



Cartridge Vault System

Catch Basin Stormfilter illustration for Stormwater Management, Inc.

Roof Drain System



Catch Basin System

Compost Air Filtration System:

Compost for vapor filtration has come in to use in the United States in the last ten years or so. In Europe, compost filtration for vapors and odors has been in use since the 1960's.

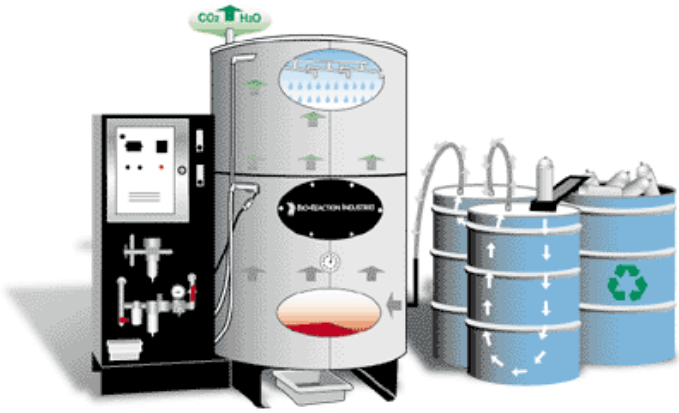
The theory behind the use of compost for vapor remediation and treatment is based up on the biota present in the compost. Compost Vapor Biofilters operate by passing the contaminated air stream through multiple beds of various types of compost (including mixed yard debris compost), peat, soil and/or other permeable material, which acts as an

attachment site for microbial fauna. The microbes use the organics as a food source converting the pollutant into carbon dioxide and water vapor. This sorption and biological destruction can occur rapidly once it has reached a steady state level. These filters typically have a low pressure drop across the filter beds and are self regenerating through out their life.

Compost vapor biofiltration is effective at reducing of eliminating odors from sewage treatment plants, volatile organic compounds, ketones, hydrogen sulfide, and petroleum hydrocarbons. They are generally considered effective for relatively low constant concentrations of pollutants in the 5,000 ppm and under range with surges over 20,000 ppm. European biofilters have developed reliable systems treating up to 200,000 cfm. In the Netherlands, they are considered "**B**est **A**vailable **C**ontrol **T**echnology". Moisture and a food supply for the microorganisums as well as a somewhat restricted ambient air temperature (80 degrees F to 100 degrees F optimum operating temperatures) must be fairly constant or the microorganisums will die off. Three years to twenty years of life for the compost beds have been obtained depending on pollutant concentration and other factors.

Removal efficiencies can be:

Gasoline Vapors	99+%
Solvent Vapors	98+%



Bio-Reaction Industries, LLC of Tualatin, Oregon has developed several systems (two shown above) for removing solvents and petroleum hydrocarbons form rags, aerosol cans, drums, paint sludges, and etc. Two of their units are shown above with arrows showing the direction of vapor flow.

Compost in Bioremediation:

Bioremediation of contaminated soils has taken several diverse paths.

- Compost has been used in-sutu in a process called phytoremediation;

- Soil farming in which compost is used as a starter in order to compost contaminated soils at an aboveground site which may or may not be the same as the site being remediated; and

- Land farming in which contaminated soil is tilled in lined plots within the adjacent soil.

Phytoremediation is a process in which compost is tilled in to contaminated soil and vegetation is planted which is specially selected for its ability to uptake or consume the pollutant of concern.

Soilfarming is an aboveground composting of contaminated soils. Contaminated soil is removed from the ground and placed upon an impervious material in wind rows. Compost, fertilizer, and or other additives are tilled into the rows. The rows must be kept moist and aerated. Ambient temperature needs to be in a range that will not significantly slow or stop the bioremediation process. Also, pH may need to be adjusted.

Landfarming is an in-sutu or in-the-ground process similar to soil farming. Contaminated soil is removed from the ground, the pit is lined with an impervious barrier to prevent leaching of the contaminants in to the surrounding noncontaminated soil, and the contaminated soil is replaced into the pit mixed with compost and/or other additives to encourage bioremediation. Eighteen inch deep pits are generally the limit due to the necessity of frequent tilling and the availability of tilling equipment to reach deeper into the soil.

Pollutants addressed in these remediation processes are mainly petroleum hydrocarbons but others have been addressed with great success also. MTBE, heavy metals, pesticides, herbicides, creosote, and PCP have been treated with these methods. The efficiency of pollutant removal has varied depending on the pollutant involved.

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