Erosion & Sediment Control Using Organics

Compiled By
Recycle Florida Today - Organics Committee
in conjunction with
Florida Organics Recycling Center for Excellence

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INTRODUCTION

The FORA Division of Recycle Florida Today (RFT) is comprised of public and private sector producers of recycled organic products including mulches, composts, and soil amendments with the shared goal of promoting the beneficial use of organics. With the cooperation of FORCE we are providing the enclosed studies and articles that detail the many uses of organics in erosion and sedimentation control. The FORA Division of RFT is committed to promoting the benefits of using organics in erosion and sedimentation control throughout the state of Florida. The full reports of all abstracts are available upon request.

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RETURN TO INDEXES

A Historical Review on How Compost Helps Reduce Sediment and Prevent Erosion

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University research, private research, field demonstrations, and now commercial use of compost for erosion and sediment control show it works better than most BMP's available today, yet it continues to suffer an identity crises. Here are the facts after reviewing some of the commonly referenced papers that have been available over the last several years.

Abstract

According to the U.S. Department of Agriculture, the US loses more than 2 billion tons of topsoil each year through erosion. – (USEPA, 1997). The link between soil quality, sediment control, erosion, and eventually water quality has widespread impacts on our sustainable future. Stormwater runoff pollution is 80% of water quality violations in many states and is the first line of defense when it comes to creating proactive, sustainable cultures (Governor Barnes, 2001).

Worldwide, estimates indicate erosion may cost us as much as $400 billion annually. There are literally hundreds of products to control sediment and erosion. Very few commercial products involve the use of compost and the composting industry is suffering from an awareness problem relating to the benefits of compost in environmental applications. One of the main identity problems is credible sources that claim compost works. This article focuses on the review of these papers indicating the effectiveness of the use of compost.

Phase II NPDES will become effective in March of 2003 and promises to deliver some very strong regulations which should favor the use of compost because of its' proven effectiveness and local availability. Compost is available in every major city in the US. Phase II has several key points, which should be noted - most importantly is that the requirement for a stormwater management plan dropping from five acre minimums to one acre. This potential five-fold increase will immediately have an impact erosion control tools used in the field and on sites that are inspected. Many builders will not be able to get a building or occupancy permit without an approved stormwater management plan. It is important that local permitting agencies recognize that compost can be used as an effective BMP.

Composters should be happy about Phase II because of the opportunity it holds for developing a new market in erosion and sediment control. Erosion prevention (keeping soil from moving off of slopes) is about 90-98% effective when compost blankets are used. Trying to control the mud and sediment once moving (Sediment control) is normally less than 50% effective when using other commercially BMP's like silt fence, but is more effective when compost filter berms are used. Therefore, compost blankets and berms should become a leading tool, especially for challenging projects.

The effectiveness of Filter berms and Compost blankets are reviewed in this paper and presentation. This builds a basis of science and neutral third party research with generic

information about compost that is convincing evidence that compost in general works well as an erosion control technology. Beyond this scientific backdrop, we will present a number of field projects that visually support what the research findings and the technical review have shown in summary. During 2001, we conducted over 100 field projects using compost for erosion control in a total of 18 different states. We will present the best photos of these projects in combination with the data and statistics from the research review. We will also include recent developments in the containments systems being used for compost in commercial developments, which allows compost to be used in direct water flow, where loose compost cannot be used. We will conclude this session with a list of information that is still needed in the research arena, including a prioritized 'punch list' of crucial data that may be holding back further development of the erosion & sediment control market for the use of composted products.

Introduction

According to the U.S. Department of Agriculture, the US loses more than 2 billion tons of topsoil each year through erosion. – (USEPA, 1997). The link between water quality, sediment control, erosion, and eventually water quality has widespread impacts on our sustainable future. Stormwater runoff pollution is 80% of water quality violations in many states and is the first line of defense when it comes to creating proactive, sustainable cultures (Governor Barnes, 2001).

Worldwide, estimates indicate erosion may cost us as much as $400 billion annually. There are literally hundreds of products to control sediment and erosion. Very few commercial products involve the use of compost and the composting industry is suffering from an awareness problem relating to the benefits of compost in environmental applications. One of the main identity problems is credible sources that claim compost works. This article focuses on the review of these papers indicating the effectiveness of the use of compost.

Phase II NPDES will become effective in March of 2003 and promises to deliver some very strong regulations which should favor the use of

Reasons to use compost for erosion control as blankets and filter berms

- Construction can run it over and it still works – and it is easy for them to fix with a shovel
- Re-use of material afterwards makes it twice as good – in landscaping or seeding activities
- It works better than standard BMP's like silt fence and straw bales
- Berms offer more actual filtration than coir rolls, silt fence or straw bales
- Compost is annually renewable
- Compost is 100% recycled
- Compost is all organic & all natural
- It helps create an annual market in all municipalities that generate compost of some kind
- Compost is critter friendly – aquatic wildlife can negotiate berms but not silt fence
- Compost is a biobased product while silt fence is a petroleum based product
- Compost provides chemical, biological and physical filtration while other provide physical
- Compost is less expensive when construction, maintenance, removal and disposal costs are considered

compost because of its' proven effectiveness and local availability. Compost is available in every major city in the US. Phase II has several key points, which should be noted - most importantly is that the requirement for a stormwater management plan drops from five acres to one acre. This five-fold increase will immediately have an impact on sites that are inspected. Many permit issuers are saying at this point, they will not be giving out permits without a stormwater management plan up front. This may be easier to manage and could definitely hold up the permitting process.

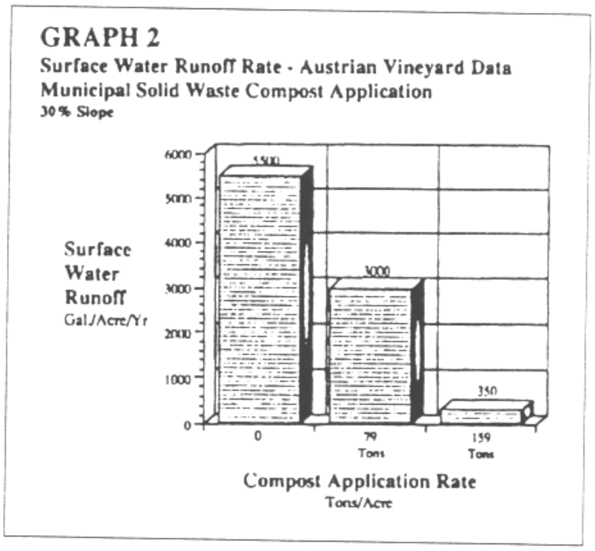
Composters should be happy about Phase II because of the opportunity it holds for developing a new market in erosion and sediment control. Erosion prevention (keeping soil from moving off of slopes) is about 90-98% effective. Trying to control the mud and sediment once moving (Sediment control) is normally less than 50% effective when using other commercially BMP's like silt fence. Therefore, compost blankets should become a leading tool, especially for challenging projects.

W&H Pacific

Demonstration project using yard debris compost for erosion control, June 30, 1993

This report is considered by many to be the landmark paper on using compost for erosion control because it points out several items that are crucial to this developing marketplace. There are over 70 references and many projects (including many of my own field demos) have been tailored after this simple project design and report. Bill Stewart, as one of this projects investigators, has gone on to show many benefits of treating stormwater with compost (pelletized compost filters) as well as using compost for treating aerosols via biofilters.

Two main themes brought out in Stewarts' work include issues relating to vegetation establishment. One problem with vegetation establishment currently is that most construction site soils are heavily compacted. As such, they offer little means for water penetration and have normally high runoff rates (see graph below). Compost applications, in the form of compost blankets, slow down water, allowing greater infiltrations. When seeding with the use of compost blankets, huge performance differences exist over any current leading method. The industry standard, hydroseeding, is sure to lose market share to compost seeding technologies because of these results. Compost offers moisture holding capacity, slow release nutrients, complete coverage of seed, and a depth of ¼" to 2" which hydroseeding cannot offer. Finally, the layers of seed that germinate in a 2" deep compost blanket that is seeded are tremendously beneficial because they offer a matting effect and can withstand harder and longer intensity rainfalls than the hydroseeding counterparts.



(Source: Stewart, 1993)

Based on the work by W&H Pacific, they determined: "Based on the results, all three yard debris composts are at least as effective as the conventional erosion control measures currently specified (i.e., silt fence). The erosion effectiveness of the composts, measured in terms of soil loss (suspended solids), was better than that measured from sediment fences…" (Stewart, 1993).

Many people confuse TSS with turbidity. Turbidity is "a measurement of the clearness or transparency of water. In addition to soil particles, colloidal organic matter in particular will scatter or absorb light and thus prevent its transmission, resulting in increased turbidity. Turbidity is measured in NTU units. The turbidity of a clear lake will have a turbidity of 20 to 25 NTU." – (Stewart, 1993).

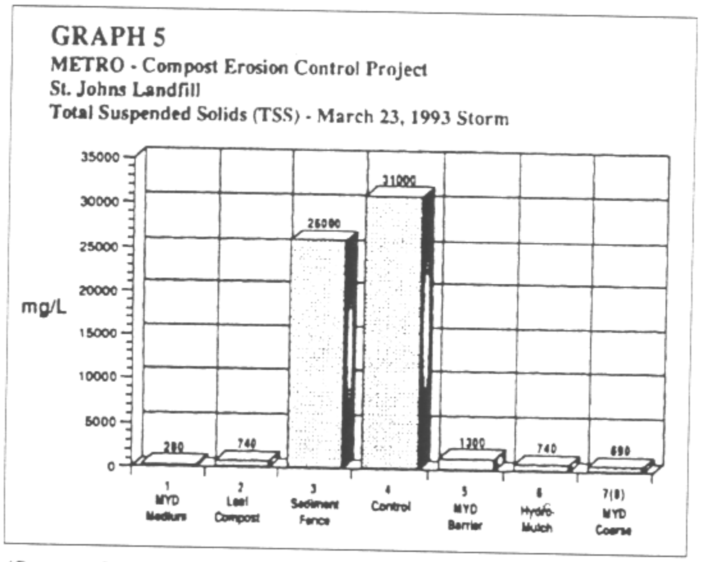
How do compost blankets stay on steep slopes? Just look at any material yard the next time it rains and you are sure to see the conical piles consistently perform in preventing and resisting erosion. The soil piles next to them become rilled and begin eroding after the very first rain event. This is due to the compost acting like a shingle roof on the slope. Think of compost as a wet bunch of paper towels overlapped on a slope, two or three layers deep. Because compost does not roll, it resists erosion. Soil is round and when it begins to roll downhill with the force of water behind it, the combination acts like a sandblaster to other soil in the way. The fibers of compost also have the ability to interlock with one another and this interlocking mechanism allows materials to hold slopes and some amount of directional flow of water. Even fine ground materials have this interlocking system, on a smaller scale.

The W&H Pacific study included three types of yard debris compost, coarse, medium and fine and also included leaf humus. These are the most common types of compost available today in most metropolitan areas, where urban wastes have been turned into valuable products via the compost process. Our company has repeated not only the types of products used in the initial study, but also basically the same type of demonstration set up in the field. Although we did not collect data, the visual results are obvious when comparing to other BMP's in the field that are properly installed.

As the Stewart work continued to study various key elements about the benefits of compost use for erosion, it indicates a tremendous opportunity in the reducing of both suspended and settleable solids from entering waterways (see graph below)

The graph shows the impact of control plots as well as sediment fence (silt fence). Note the comparison of any compost application, including blankets or berms (MYD barrier) is over 10 times as effective as using silt fence. This is what the new Phase II regulations will be targeting, so the use of compost as a tool is bound to become more popular.

Other chemical binding properties were noted by the Stewart study: "At a construction site, in addition to its erosion control benefit, a good quality compost is capable of binding and removing pollutants from storm water runoff including oil and grease, fuel from accidental spills, heavy metals, herbicides, pesticides, and other potentially hazardous substances associated with construction or pre-construction activities", (Stewart, 1993).



(Source: Stewart, 1993)

Concerns with movement of nutrients and heavy metals has not been widely documented with the use of compost for erosion control applications. Testing for this requires precise science, controlled conditions, and normally significant funding. Stewart placed a high importance on using mature compost. The majority of the scientific community agrees that mature compost helps prevent movement of some nutrients (Nitrogen) because it is largely contained in the organic form. However, due to the amount of water passing through compost filter berms, there is more research needed in the area of nutrient transfer, leachability of nutrients and heavy metals. When compost is used in situ, or in soil, it has more complex binding relationships with the parent materials. When used as a compost blanket or filter berm, the bonding relationship can only occur at the compost soil interface because the material is not mixed into the parent soil.

"These data indicate that the composts tested do not release heavy metals significantly greater than that released by soils and, in fact, can result in a reduction in heavy metal runoff from soils which contain higher quantities of these elements. However, it is important to note that compost quality and background heavy metal quantities in the compost is a factor to be carefully evaluated." (Stewart, 1993).

Quilceda-Allen Watershed erosion control program – Water quality monitoring report.

Although the regs for the burying depth of silt fence varies, most states require some depth to be achieved. Because this practice is not inspected heavily (or often from the vehicle), installers are able to 'get away with' not trenching in the silt fence. Without the trench and weight on the bottom of the fence, the silt fence may simply allow sediment and water to run underneath. More recent studies indicate that the fine particles in some of the soils are finer than the openings on the sediment fence and are not affected at all. "When the bottom of the silt fence is properly buried, then the silt fencing acts as a water barrier, but the turbidity is not reduced. A mulch berm provides filtration as runoff passes through" – (Caine, 2001).

The project included compost berms along with coir rolls and other possible BMP's for controlling erosion. "When used in conjunction with appropriate ground cover, silt fencing is assumed to provide stormwater runoff with adequate turbidity treatment. Monitoring of water quality from actual construction sites, however, indicated that silt fencing did not provide adequate water quality treatment." – (Caine, 2001).

According the results from Snohomish County, berms also absorb water more than we originally thought, which may give them higher density when wet. "By blowing the compost to form the berm, the compost had a lot of pore space. Consequently, the berm absorbed a volume of water equal to approximately 30% of the volume of the berm. It took approximately 17-26 minutes after water flowed onto the berm for water to percolate through the berm and the water was released at a very slow rate and at multiple locations along the length of the berm." – (Caine, 2001).

In the data, comparisons show that a mulch berm reduced turbidity compared to silt fence and coir fiber rolls used as BMP's. In fact, the mulch berm reduced the turbidity to 33% of the entering level while the silt fence and coir roll remained at 100%. – (Caine, 2001).

Settling of water is a leading mechanism for getting sediment out of water and sediment ponds or detention/retention basins are leading recommendations among engineers when all other items fail. A sediment pond allows water to settle out over a long term prior to discharge back into the waterway being protected. However, there are problems with this design as well because in severe events (remember, designs for capacity do not include severe events) the overflow of these ponds occurs sooner and the water goes directly into the protected watershed. In some cases, the detention area or pond allows the water to heat and the extra temperatures play havoc with aquatic life downstream due to temperature increases. "Water released from detention ponds, however, exceeds existing allowable thermal limits between May and October". – (Caine, 2001).

The Snohomish county project had a very clear purpose for the endangered species act and saving the Salmon that were endangered from sediment… "The purpose of this project is to reduce the sediment input into streams and wetlands in the Quilceda-Allen watershed, thereby improving the water quality in the streams and decreasing sediment clogging of fish spawning gravels." –(Caine, 2001).

Compost – New Applications for an Age-Old Technology. USEPA, 1997.

Another landmark publication was produced in 1997 by the USEPA. The familiar green publication is perhaps best known for putting compost on the map for all of the remedial properties compost provides in various application technologies. The publication is available on the EPA web site and has been widely distributed in the US.

According to USEPA, "Depending on the length and height of the slope, a 2-3 inch layer of mature compost, screened to ½ to ¾ of an inch and placed directly on top of the soil, has shown to control erosion. On steep slopes, berms of compost at the top and bottom can be used to slow down the velocity of water and provide additional protection to the receiving waters" (USEPA, 1997).

Our company has verified these results in the field in at least ten different states where we have worked on projects. Most notably, even when the slopes are not covered with compost blankets, compost filter berms still reduce overall erosion because they allow run-on water to be converted from rills back into sheet flow down the slopes and the overall velocity is reduced as well.

When used as a filter berm, compost is 'natures coffee filter', leaving the residue from stormwater behind in a tell tale thin film that is easy to see on the berm surface after water drains through or subsides. Many people confuse filtration, bioremediation and biofiltration. Chemicals trapped by the coffee filter mechanism of the berms are often remediated. "Biofiltration implies physically separating particles based on their size. Bioremediation, by contrast, implies biological change as contaminants or pollutants are metabolized by microorganisms and broken down into harmless, less stable constituents, such as carbon dioxide, water and salt"- (USEPA, 1997). Depending on the concentration, there is very good chance that compost can bioremediate some of these compounds within the berm *while it is filtering out more sediment.*

There is little research on this particular topic, however, EPA has recognized that the need for 'prescription' composts that are specially made to remediated particular spills or situations are definitely a possible common product in the future. "The metal binding capacity of compost can be improved by the addition of inorganic materials. For example, the addition of soluble iron and phosphate salts to compost increases lead immobilization as a result of forming complex lead-iron-phosphate minerals. Similarly, research by several investigators indicated that some clay minerals interact with lead to form lead containing minerals in which the bioavailability is remarkably low. Addition of such clay may enhance the ability of compost to decrease lead availability" – (USEPA, 1997).

The prescription process for special problems in the environmental contamination game are just beginning to unravel. Brownfields contaminated with heavy metals and unable to establish vegetation also pose huge opportunities due to the ability of compost to establish vegetation. Phytoremediation, (the use of plants to help immobilize or degrade compounds), can also be a tool with the use of compost. "Difficulties in establishing plants in toxic, contaminated matrices, and in compacted and barren materials that are not conducive to plant growth…can be overcome with the addition of compost." – (USEPA, 1997).

As Phase II is implemented, perhaps many of the prescription products will evolve to target specific cleanup concerns. Compost has proven effective in degrading or altering many types of contaminants, including chlorinated and non-chlorinated hydrocarbons, wood preserving chemicals, solvents, heavy metals, pesticides, petroleum products and explosives. The contaminants are digested, metabolized, and transformed into humus, inert byproducts like co2 & water and salts (USEPA, 1997).

At worst case, compounds absorbed or adsorbed by compost as stormwater passes through could be remediated by composting the materials at a compost site if the product can be collected and transported to the compost site after it's effective life at the construction site.

Costs for the application of compost are issues that vary around the country and with each type of application technology. We hope to cover costs more thoroughly in another report issued later this year.

Performance specifications for wood waste materials as an erosion control mulch and filter berm, and use of wood waste materials for erosion control.

Another study was recently completed by Dr. Ken Demars for the New England Transportation Consortium in March of 2001. This study was unique in that the design called for the use of glass beads of a known size and an erodable soil from a field test site, which was mixed with water and passed through the testing apparatus (a tilt table with controlled irrigation). The suspended solids of the effluent, including a portion of the glass beads, which were analyzed, were used as a measure of filter effectiveness.

The study points out some excellent mechanics of how berms work. "There are two aspects of filtration: retain the soil particles and allow the water to drain away. The retention of particles is a function of the opening sizes in the berm and the sizes of the soil particles. The opening sizes in the berm are in turn related to the sizes of the wood particles (mulch). The ultimate filtration achieved is actually a function of both the opening sizes and the particle sizes. A berm will retain certain sized particles, the retained particles will in turn retain smaller sized particles." – (Demars, 2001). The Demars study concluded that the mulches used were more effective than geosynthetic silt fence or hay bales.

The particle sizes finer than the #20 mesh sieve were found to be important because they affected the size of port openings in the mulch through which suspended solids may be transported. (Demars, 2001). This means that in filter berms the ideal percentage of fines vs. coarse materials, regardless of weather or not it is mulch or compost, need to be considered for trapping suspended solids in the #20 mesh sieve size area.

Demars' work included trying dry products and wet products, thinking the moisture would assist in removing a higher percentage of fines. Adding moisture helped when the tests included Pine Bark Mulch, but did not improve when Ground Stump Mulch was used (Demars, 2001)

Compost filter berms are somewhat three-dimensional. As the face of these berms clogs with sediment, the 'coffee filter' mechanism is apparent. Demars found where the filter cake was developed on the face of the berm, some of the flow would pass over the top of the cake and into the berm where no cake had yet formed (Demars, 2001). This is obviously similar to water rising up the height of silt fence except that compost has depth that can also filter water inside the berms. As these berms clog, the face of the berm becomes more saturated with soil particles, and water flow rises over this layer to the next available filtration area. We believe this three dimensional situation gives berms their effectiveness compared to other one-dimensional, gravity oriented BMP's.

There is a limitation to the system design, however. The limitation of the filtration process is that the smaller particles reduce the permeability of the system so that the reduced permeability will eventually cause the system to be overtopped during severe rain events, allowing some sediment to escape (Demars, 2001). We have seen this in the field and the regulatory field simply wants to make sure berms are maintained as silt fence or other BMP's are maintained throughout the life of the project.

A study commissioned by the New England Transportation Authority (Demars, Long & Ives, 2000) indicated that wood waste materials are effective in minimizing erosion when applied to the soil surface as a blanket with a thickness of at least 3/4 inches or greater. The untreated control in these experiments produced over 50 times the sediment than the treated surfaces (Demars, Long & Ives, 2000). The study went on to further indicate other benefits: Wood waste materials were particularly effective at reducing runoff during storms under ½ inch by absorbing rainwater (Demars, Long & Ives, 2000). This is critical and data from the Bill Stewart work in 1993 suggests the same reduction in runoff water. A reduction in runoff water absolutely increases water infiltration, and cannot help but benefit efforts towards re-vegetation and initial seed germination. These would be especially crucial items for those projects that just need a little more rain to allow germinated seed to fully establish.

Demars also studied filter berms made from wood waste and found they were more effective than either hay bales or geosynthetic silt fence at controlling erosion. Both hay bales and silt fence released one order of magnitude more sediment than the wood waste filter berm (Demars, Long & Ives, 2000). Of course, wood waste is not compost. The purpose of this study was to determine if the physical properties of wood waste would assist in erosion and sediment control, similar to the project conducted by the same team with compost in 1998. The wood waste materials still underwent a litany of tests, including a solvita test for stability. The previous work in 1998 resulted in a CONEG specification recommending that erosion control materials should be very stable to stable which was not the case for the fresh ground wood waste materials (Demars, Long, & Ives). A particular test in this research shows similar data in the 10-fold effectiveness claim for the performance of wood waste filter berms. In this case, the wood waste filter berms were 8x as effective as silt fence and 10x as effective as hay bales, when the data is compared directly (Demars, Long & Ives, 2000).

USCC Soil-Water Connection

A leading handout from the US Composting Council entitled, the Soil-Water Connection has been widely referenced and has a number of solid references relating to erosion control using compost. "Research in Kennebec, Maine has shown that surface-applied compost performs as well or better than traditional erosion control techniques. A yard trimmings compost – spread two to four inches over the surface (a compost blanket) – outperformed a jute mat and ground wood waste for erosion control at five sites", (USCC, 1997).

Compost was as effective as the standard erosion materials used for protection, but surpassed them in cost effectiveness, vegetation establishment, and slope protection. Costs for compost applications were about 1/3 of the cost of traditional synthetic blankets (USCC, 1997)

Compost applied as erosion control tools are often incorporated into the soil after use, offering further benefit and environmental impacts that we are not measuring currently. "Soils rich in organics store, degrade, and immobilize nitrates, phosphorous, pesticides, and other substances that can become pollutants in air or water. Compost, because it adds organic matter to soil, has the ability to bind pollutants to soil systems, reducing both their leachability and absorption by plants (USCC, 1997).

Note the majority of this article deals with research regarding composted products. The US Composting Council has a program entitled the Seal of Testing Assurance, under which many of the products used for erosion control are enrolled. Composting of the materials prior to application offers numerous benefits. There is a growing interest in using mulch for many of these applications and although mulch may physically perform some of the same functions as compost, it cannot offer the diverse microbial remediation properties nor the chemical bonding or scrubbing action compost provides. Other concerns about mulch or woody materials being composted are real and are related more to health and safety concerns.

Why compost first?

Weed Seed Problems

If the material is not composted, you could end up weed seeds like Kudzoo, purple loosestrife, dock, velvetleaf, wild cucumber, or other recognized noxious weeds being spread onto your slopes. Weed seeds are normally killed dufing the composting process. Kudzoo is a real problem in much of the Southeast and grows rampant along expressways where it takes over like a jungle. The last thing we need is a mechanism to assist its' natural spread and composting helps to make sure we will not spread noxious weed seeds. Reasons given by growers for not wanting to use un-composted green materials in California include fear of disease and weed seed problems (CIWMB, 2000). The Southeast recently reported estimated losses of $35.5 Billion from the infestation of alien weeds (Environmental Status and Trends in the Southeast, 2000).

Insect larvae or egg problems

The health and safety factors compost provided during proper heating is important. The grinding process alone does not necessarily destroy insect larvae, so composting makes sure the cycle is broken. Consider the spread of Gypsy Moths, Borers or other pests that are now causing quarantine restrictions on shipping of nursery stock from state to state. Many of the mulch materials, especially those from yard wastes or land clearing debris include the infested feedstocks which can rapidly spread once used as a mulch. Composting this feedstock first is a key quality control ingredient. Examples of losses indicate this is a severe problem as the Southeast estimates they lose $20 Billion per year from foreign insects (Environmental Status and Trends in the Southeast, 2000).

Disease or fungi problems

Fungi and diseases can also be spread but this is even a more serious nature. Cankers, blights, and other diseases, when introduced to a new area via a carrying mechanism like non-composted organics, could easily find a home and become a huge problem. Again, quarantines already exist for many of these problems. Woody wastes from diseased trees, tree trimmings from line clearing companies and other horticultural wastes all may contain some form of infested feedstock that needs to be composted to be safe.

To limit the spread of pitch canker, an endemic disease of Monterey Pine in the coastal area around Santa Cruz, it is recommended that uncomposted materials not be transported to other forested areas in the state (CIWMB, 2000). Estimates in the Southeast are significant, including $6.5 Billion in annual losses due to diseases (Environmental Status and Trends in the Southeast, 2000).

Vegetation establishment is normally the goal, EVENTUALLY

Regardless of the initial reason for using any kind of a commercially available BMP on slopes, the eventual goal is normally to allow native vegetation to grow and permanently stabilize the slope. Using mature compost allows application of known materials, which enhances plant growth. In tests conducted at the Texas Transportation Institute, Hydraulics and Erosion Control Field Laboratory, vegetation establishment was around 50% when tackified wood chips were used (CIWMB, 2000). As a result, this product was disallowed under the Texas DOT standards. Another project at Caltrans used green material mulch and the distinction was made clear. "The materials utilized were variously called "mulch" and "composted mulch" but were, in fact, not compost. Composted materials are those that have undergone thermophillic decomposition and organic matter stabilization", (CIWMB, 2000).

Conclusions

Compost is the only 'silver bullet' (if there was only one) to combat many of our environmental challenges and is actually the least expensive opportunity for us to revert to a sustainable culture. Immediately after understanding the benefits of compost when used for erosion control, we wonder about the natural extension into wetlands, and other environmental applications. Of course we realize compost must be used in a BMP approach, integrated with other effective tools, which are also effective at achieving our erosion reduction goals.

Future immediate research needs include understanding how various types of compost perform when screened to a number of particle sizes. Many regulators have expressed concern about berms ponding water when fine composts are used. We need answers to questions about nutrient leaching, binding capacities for all of the chemicals that we could target applications for cleaning up and what type of fertilizer, if any, if needed when compost blankets are used. What is the permeability of various types of compost used for filter berms? How long of a slope can effectively drain to a compost berm before needing to add more berms to handle the flow? Is the system currently used (i.e., seed, fertilizer and straw) generating more 'leachate' than the proposed system using compost products because of the nutrients immediately available in commercial fertilizers? If so, can we promulgate regulations shifting to the new proposed practices? How long will that take? Is compost approved in every state as a BMP?

Due to the number of various composts available, and to the number of soils and rainfall capacities that are in every city, this research will take a long time. However, the en mass conclusions are that for the main types of compost produced currently (yard trimmings, biosolids, etc), it is an option that performs at least as well as the other tools currently available for erosion and sediment control.

BioCycle is currently researching the development of a technical resource guide that includes categorical listings of research reviews available for each of the following categories: Soil-

water interactions, erosion and sediment control, bioremediation and bio-filtration, vegetation establishment and site stabilization, and wetland establishment and remediation. We would like to hear from you on each of these topics heading regarding successful field projects as well as scientific resources, publications or reports that we may be unaware of. Please contact the editor via email.

Rod Tyler is owner of Green Horizons, a consulting firm specializing in erosion control and Filtrexx International, LLC, which also provides products to the Erosion Control industry and can be reached by info@filtrexx.com or www.filtrexx.com

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Article 55

Technical Note #81 from Watershed Protection Techniques. 2(3): 418-423

Keeping Soil in Its Place

Perhaps the most critical stage at a construction site is when soils are exposed both during and after clearing and grading. Erosion of these exposed soils can be sharply reduced by stabilizing the soil surface with erosion controls. For many contractors, erosion control is just shorthand for hydroseeding. However, a wide range of erosion control options are available, including mulching, blankets, plastic sheeting, and sodding, among others.

In this article, the performance, costs and constraints of these often-confusing erosion control options are compared. Guidance is provided on when each method should be used or avoided. In addition, the article outlines options for effective erosion control under challenging site conditions, such as the non-growing season, steep slopes, drought, concentrated flows, stockpiles and poor soils.

Effectiveness of Erosion Controls

Four recent studies evaluated the effectiveness of 15 erosion controls (Table 1). With a few exceptions, suspended solids load reductions were on the order of 80 to 90%. This suggests that erosion controls are extremely effective, when compared to the 60 to 70% sediment removal typically reported for most sediment controls.

Benefits of Erosion Controls

Erosion controls have benefits beyond controlling erosion. First, they can improve the performance of sediment controls. Controlling erosion reduces the volume of sediment going to a sediment control device. Consequently, less treatment volume is reduced by sedimentation and "clean out" frequencies are lower. In addition, many erosion controls can lower surface runoff velocities and volumes, preventing damage of perimeter controls.

Table 1: Sediment Removal Efficiency of Surficial Erosion Controls

Erosion Prevention Techniques	Sediment Reduction (%)
Straw (1.25 tons/ ac)[1]	93.2[a]
Straw (2 tons/ ac)[2]	89.3[b]
Fiber mulches (about 1.0 tons/ac)[3]	65.0 - 97.1[b]
Fiber mulch (at least 1.0 tons/ac)[4] 3% tackifier	91.8[c]
Fiber mulch (1.25 tons/ ac)[1] fertilized, seeded	89.1[a]
Filber mulch (1.25 tons/ ac)[1] fertilized, seeded 90 gal/ac tackifier	85.9 - 99.1[a]
70% wheat straw/30% coconut fiber blanket[2]	98.7[b]
Straw blankets[3]	89.2-98.6[b]
Straw blanket[1]	92.8[a]
Curled wood fiber blanket[1]	28.8[a]
Curled wood fiber blanket[3]	93.6[b]
Curled wood fiber blanket[2]	93.5[b]
Jute mat[1]	60.6[a]
Synthetic fiber blanket[1]	71.2[a]
Nylon Monofilament blanket[2]	53.0[b]
Mixed Yard Debris (410 cy/ac)[4]	95.0[c]
Leaf Compost (410 cy/ac)[4]	85.9[c]

[a] TSS load reduction [b] Soil load reduction [c] TSS event concentration reduction

[1] 24% slope gravelly sandy loam for 13 storms over two Washington winters. (Horner *et al.*, 1990)

[2] 9% slope silt loam soil. Subjected to 5.8", one hour simulated storm. (Harding, 1990)

[3] 30% slope clay loam soil; subjected to 3.1", 1/2 hour simulated storm. (Wall, 1991)

[4] 34% slope clay cap and top-soil mixed slope. Five March Oregon storms. (W+H Pacific and CH2M-Hill, 1993)

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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.

Controlling Erosion in Construction and Road Building

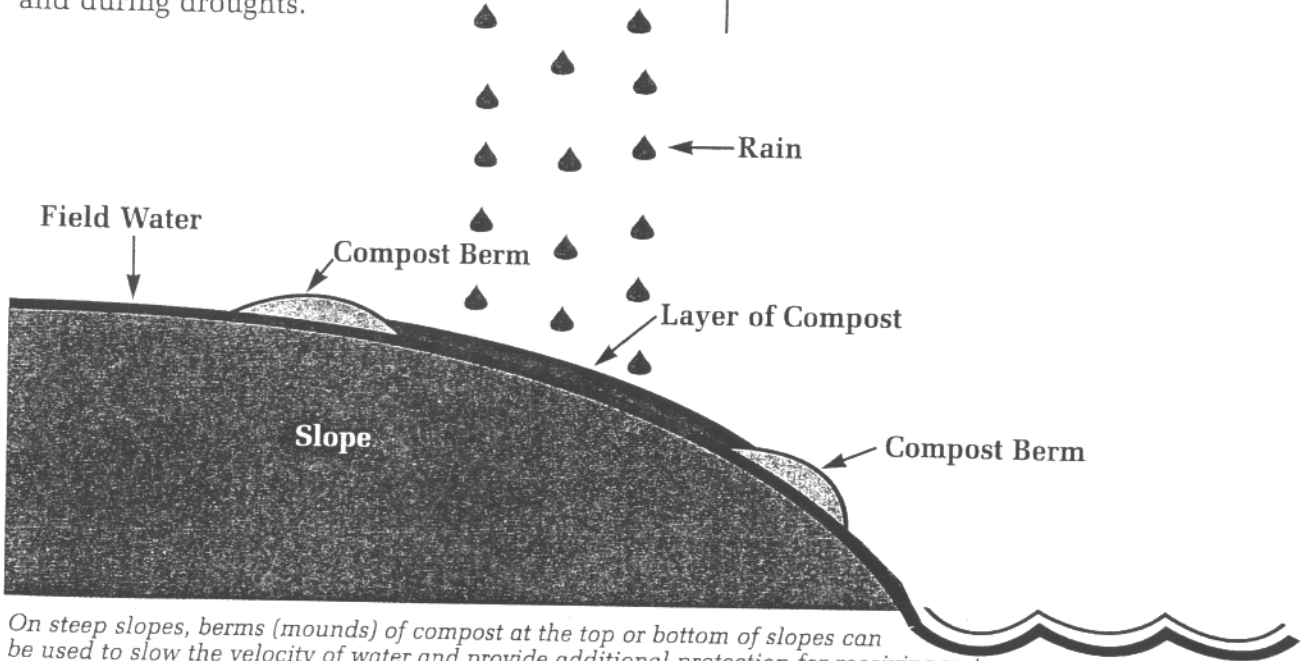
Erosion is a naturally occurring process; however, it is often aggravated by activities such as road building and new construction. At the beginning of some construction projects, all vegetation and topsoil is removed, leaving the subsoil vulnerable to the forces of erosion. On steep embankments along 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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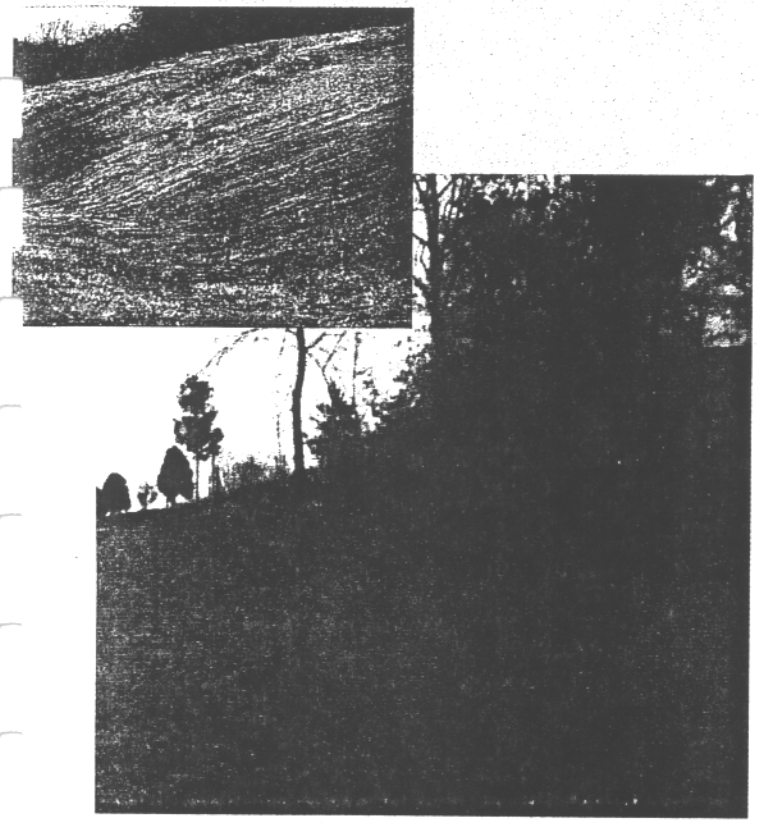

Photos courtesy of The Federal Highway Administration, Office of Environment & Planning, and Federal Lands Highway Program

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.

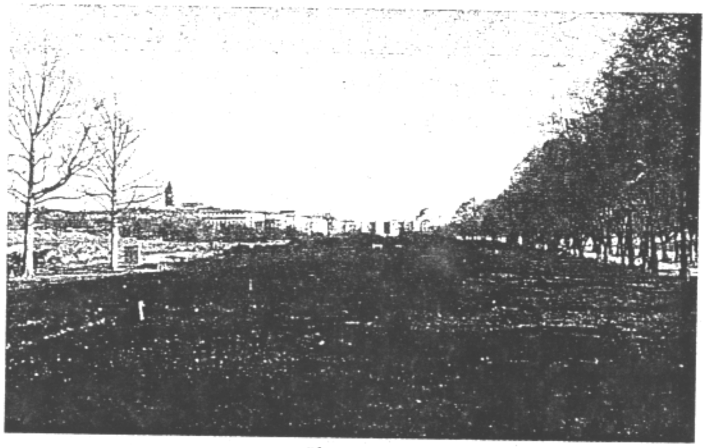

Photo courtesy of U.S. National Park Service

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

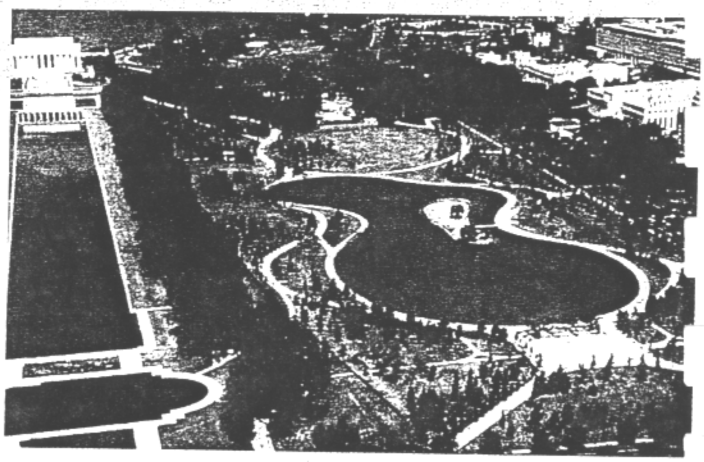

Photo courtesy of U.S. National Park Service

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.

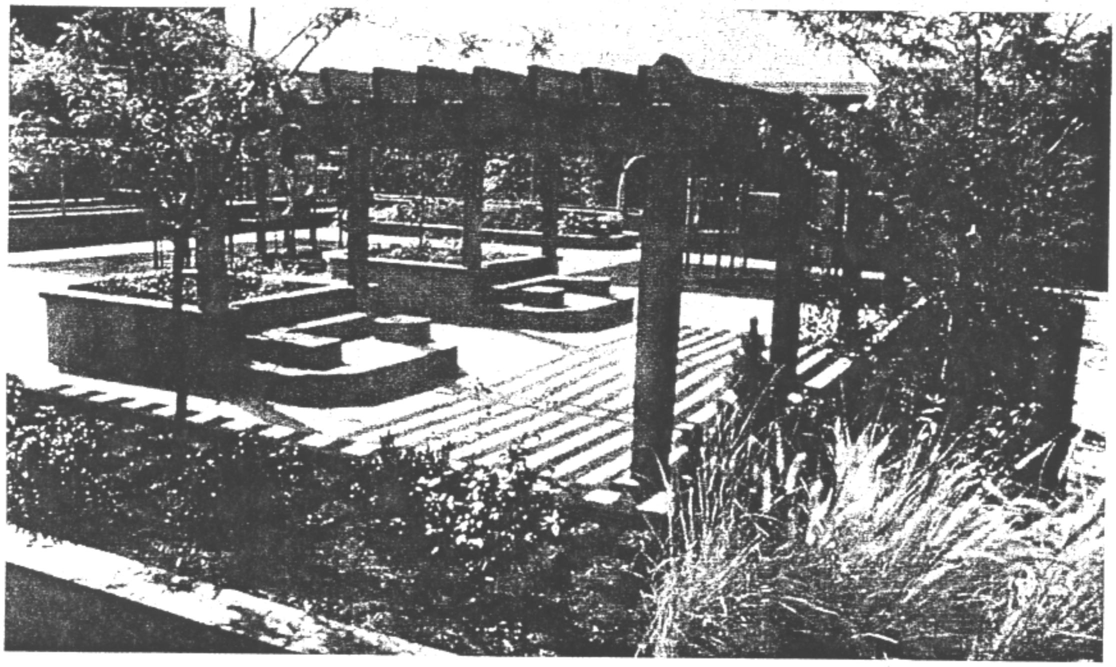

Photo courtesy of AgRecycle Inc.

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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Erosion Control and Environmental Uses For Compost

Rod Tyler, Bill Stinson, and Wayne King
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INTRODUCTION

For the last ten years, the use of compost in environmental applications and markets has been increasing at a steady rate. Although environmental uses for compost appear to be an absolutely huge market, there are limited numbers of successful programs that have tapped this great market potential. Still, it is clear that with the invention of pneumatic application equipment, i.e., 'blower trucks', the future use of compost in some of these environmental applications will only increase.

Environmental applications include slope stabilization and erosion control, stormwater filtration, vegetation establishment, and replacement of silt fence with compost filter berms. Filter berms will be the focus of this paper, however we want to briefly point out the advantages of using compost in these other applications.

SLOPE STABILIZATION

In many slope situations, there is no real need to establish vegetation if a layer of mulch is effective in preventing erosion. But how long will the compost or composted mulch last? Will annual applications be required? The norm is to try and establish vegetation, regardless of the severity of the slope. As a result, using compost for slope stabilization and erosion control has met some barriers in the field in that it may not be readily accepted unless seeding is performed on top of the compost layer.

Using both seed and compost applications may or may not be more cost effective than current practices. Certainly, in severe cases where vegetation has not been able to established, compost may be the ONLY option left to try. In these cases, the state, county or local governing body will gladly try anything to keep from repairing the drastically eroding slope every single year. Our experience has shown the local officials will be glad to try any newfangled erosion control materials on their worst possible sites. This truly offers the composting industry a unique chance to quickly show how effective erosion control is with compost. In fact, our marketing motto for erosion control products has now become… "Give us your worst nightmare".

STORMWATER FILTRATION

Stormwater filtration is a relatively new use for compost. Although only a few commercial systems exist, the promise of using compost in filter systems lies in the effectiveness of capture rates compost offers compared to other filter systems. The added benefit is that compost can normally be purchased locally, is annually renewable, and there are good long term odds that this use will also become more mainstream in the next

10 years. This will be further enhanced by recent focuses on water quality and quantity issues in most of our growing communities.

VEGETATION ESTABLISHMENT

For vegetation establishment, compost is perhaps the number one soil amendment when used for turf. For other vegetation establishment, hydroseeding is still king. However, recent comparisons of costs for hydroseeding vs. vegetation establishment with compost and seed applied via a blower truck have proven favorable. In fact, if this combination proves to be as successful in the field as on paper, it will eventually replace part of the hydroseeding market. After all, what would you rather have – a hydroseeded lawn or a lawn seeded with ¼" of compost? For other environmental applications, like the slopes mentioned earlier, seeding is even more tedious than turf, so the likelihood of compost use increasing in these applications is nearly 100%.

FILTER BERMS REPLACE SILT FENCES

Silt fence has been used for erosion control on slopes and around the edges of construction sites for years. It is obviously the accepted standard. (By the way, who invented this stuff and is she now retired in a warm ocean climate somewhere?) Silt fence is used on nearly 100% of construction projects in the US, but there are some inherent problems with it's use. First, it just does not work as well as we originally thought it did. In fact, most officials at the state level will agree that it really does not work at all. Yet it continues to be used and is considered the standard for our environmental containment of silt and sediment.

Silt fence, by the way, is also a product made from petroleum resources, is hard to install properly, and is quite often left abandoned on job sites. Further, it prevents natural migration of aquatic animals like turtles and salamanders from area to area as they are disturbed during the construction process. In developing communities that are sensitive to endangered species or aquatic life, this has recently become a bigger issue of concern. Last but not least, silt fence, if it is picked up after construction is completed, needs to be properly disposed of in a landfill. What a waste.

HISTORICAL PERSPECTIVE

Compost, when properly installed in long filter berms, actually works better than silt fence in the function both were intended to perform: Keep both suspended and settlable solids out of our water sources when moving on the surface. Perhaps a historical review may help at this point.

In 1993, Bill Stewart conducted research which showed surprising results in a number of erosion applications on a local roadway that had extremely steep slopes. The research (regarded as one of the first major sources of info on this topic) also showed how ineffective silt fence was. In 1994, the Maine Waste Management Agency tested compost in Kennebec County to determine if the results were predictable. This followed with Clyde Walton from Maine DOT to be one of the first to specify compost filter berms on DOT projects in 1996. In 1997, USEPA recognized the use of compost for erosion control and specifically the use of filter berms as important methods to reduce environmental problems associated with erosion. CalTrans has been working on many projects for the last ten years and now has a very progressive program.

So why are we still using silt fence? Until the advent of the blower trucks, accessibility and efficient application of compost or composted mulch was hard to achieve. Manual application on 2:1 slopes would be nearly impossible. Application of filter berms around construction sites would require a bobcat, loader or other equipment and would simply be less efficient. However, the blower trucks are now becoming popular in nearly every major city in the US and with them comes the possible services relating to efficient applications of organic materials.

Reasons to use filter berms:

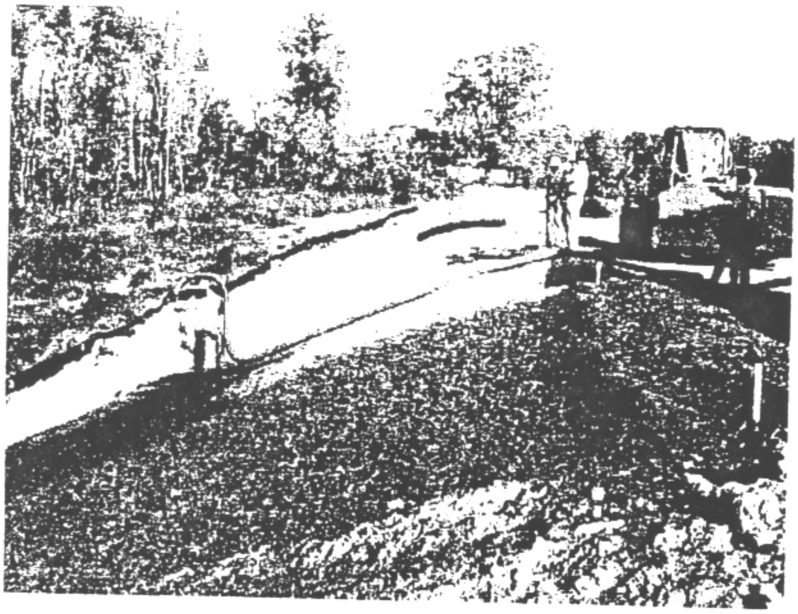
The compost amends native soil, assisting in vegetation establishment
The berms can be easily be incorporated into native soil when the job is completed, which means less hassles at the end of long projects
Incorporated material left on site provides better organic matter levels for seeding/planting
Filter berms are less expensive than silt fence
Filter berms are more effective in removing sediment and clearing up our waterways
Filter berms are more effective at removing chemical compounds from runoff
Compost is an annually renewable resource, all organic, and 100% natural

Reasons NOT to use silt fence:

Silt fence is ineffective in removing sediment and chemicals from runoff
Silt fence is hard to keep up during construction projects
Silt fence is often left on site after construction and is unsightly
Silt fence is a non-recycled material and needs to be landfilled
Silt fence allows a certain level of environmental damage on every project it is used on

How Organic Materials prevent erosion

What is so special about compost or composted mulch that allows it to perform the filtering function? Most experts in the field have noted they are surprised that filter berms hold up under heavy rains. When filter berms are used in combination with slope protection via a layer of compost or composted mulch, you can expect minimal erosion.



Filter berm at the top of a slope with compost

There are two main reasons these two applications assist in reducing erosion. First, filter berms reduce the speed of water flowing on a given slope. By preventing speed of water, which reduces also the speed of soil particles tumbling down the slope, overall displacement of other soil particles is reduced. Many applications have tried a series of filter berms down the slope which has worked well to slow the water down long enough to reduce erosion of the slope.

A layer of compost or composted mulch applied to the slope acts like a 'wet blanket' or a 'wet deck of cards' scattered randomly over the surface. Remember, soil particles are normally round and roll easily once displaced by water. As they gain speed and momentum, they displace other soil particles which channel together in faster moving water and this creates small rills. Rills lead to channels and channels lead to gullies. The rounder the soil, steeper the slope and greater quantity of water, the more erosion.

Compost and composted mulch prevents the soil from rolling or gaining this momentum and therefore covers it like a blanket. A secret of success in the field is making sure that water is not able to 'get under the blanket' at the top of the slope. If water is allowed to get under the layer of compost, and if the slope is steep, you can expect erosion and the compost or composted mulch will float away. However, if you have a filter berm at the top of the slope and keep the compost layer continuous over the 'shoulder' of the slope, the water will hit the slope and ride all the way to the bottom on top of the blanket of organic materials.

Organic materials are more flexible, lighter, and absorb more water than soils in general, so they also aid in helping water infiltrate into the soil underneath. For vegetation establishment, this is crucial to new seedling germination.

ECONOMICS

All the experts reviewing Bill Stewart's research have had the same comments. What about the cost? Until a mechanism of delivery was possible and predictably available via blower trucks, the use of compost and composted mulch for filter berms has been limited. Depending on the charge for installation and the cost of local compost or composted mulch products, filter berms can be significantly less expensive than silt fence. In other words, cost is not a real barrier to the use of filter berms.

In a study conducted in South Carolina with one of the very largest builders, we determined that silt fence would cost about $1.50 per linear foot of installed silt fence. This cost did not include the cost to remove the silt fence and disposal costs. However, it appears that many people in the field ignore these costs or simply consider the costs of retrieving silt fence as zero. When comparing the installation of a 1 foot high by 2 foot wide filter berm of compost, we found we could be very cost competitive (see cost spreadsheet at the end of this paper).

It is important to note that the costs we experienced in the project in South Carolina were perhaps the lowest we have found in the country. In general, the larger the contractor, the better price they have for silt fence installation. In other meetings with smaller contractors, we discovered that they were paying up to $4.50 per linear foot of silt fence, with an earmarked $2.00 per linear foot included for the removal and disposal of used silt fence.

In many markets, the cost of application matches the cost of the product. For instance, a $16 per cubic yard compost would cost $16 per yard for application. Many blower truck operators simply double costs of materials to arrive at an installed cost for organic materials. This is a good rule of thumb to use and when calculating the amount of compost or composted mulch required, we determined that one cubic yard will provide 20 linear feet of filter berm 1 foot high and 2 feet wide. This sized berm is adequate for the majority of silt fence replacements, which are actually demarcations of the work zone itself. Much of the silt fence installation, when performed on flat ground, is simply to show the perimeter of the active work zone.

Remember that on state jobs, where silt fences are used, that the monies to pay for installation and removal has to come from some tax base or government fund. It stands to reason for all of these agencies to band together and support compost use for filter berms because it can save the state money and it will most likely be a locally produced product. In every single case study we have done, the officials at the state level agreed that silt fence did not work to achieve the runoff and erosion reduction goals. Also, they pointed out that silt fence is not actually specified n many projects. Rather, the contractor has to submit an erosion control plan or water discharge plan that calls for some recognized method to reduce erosion.

Silt fence, because it is so common, is the leading tool used to respond. In other words, if local contractors put compost filter berms into their plan, the local officials would have to determine if this tool would be acceptable. Several agents confessed they could not shut a project down if we submitted filter berms as the chosen method, but if it failed, we would be forced to utilize another method.

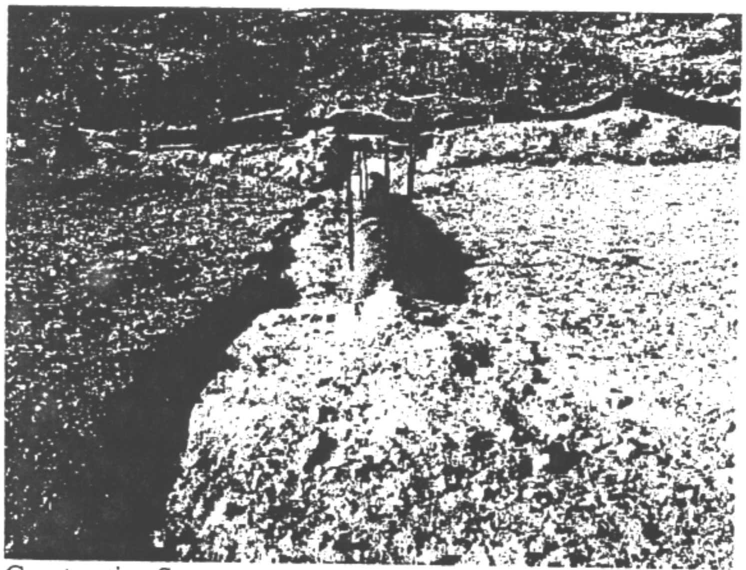
Real world benefits of using filter berms are during projects that are very dynamic. A day in the life of field construction is unpredictable and often times weather plays a spoiling role in the best laid plans of good contractors. When berms are disturbed at the top of slopes, as is shown in the photo below, we violate the cardinal rule not to let water under the berm or compost blanket. Without repair, erosion will set in and gullies will form. However, the new option with compost filter berms and blower trucks is to provide a 'Band-Aid' to these real world un-preventable construction scars. Trucks can quickly and efficiently return to sites and cover initial erosion that starts as a result of late completion of guard rail installation or other surface disturbances. This makes local officials very comfortable with the use of compost because it allows a faster remedy than waiting until the slope is eroded, getting a dozer to level it back out and reseeding. Remember, those are your tax dollars on state projects!

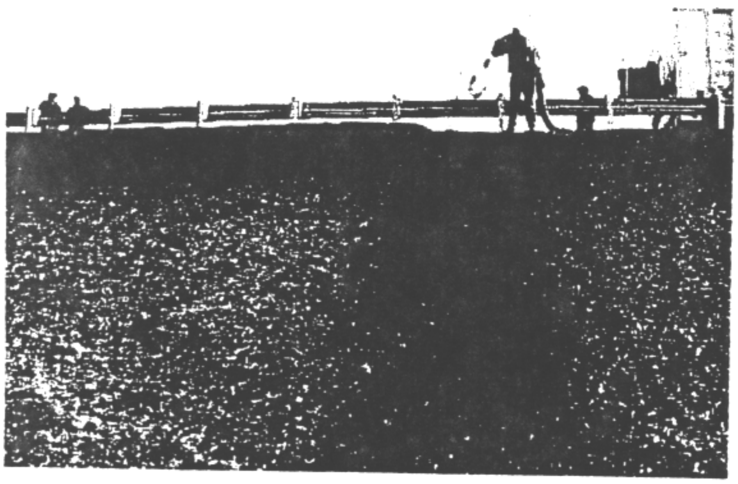
FIELD REPORTS

Two field projects have been completed recently which focus on the principle objectives outlined earlier: reducing erosion on slopes using compost blankets and replacement of filter berms using filter berms.

Richmond, Virginia

A project was coordinated in Richmond with the Virginia Department of Transportation to determine the effectiveness of compost for mulch and as filter berms. Due to the nature of the slopes, we did not gather much data on filter berms. *The berms installed at* the top of the slope were eliminated during the final phase of the project, which allowed us to examine the use of compost for repair in these types of situations. The 'construction scar' shown below is indicative of real life projects that have soil disturbances during their final phase and this can cause significant disturbance to the berm or allow water to get under the compost blanket. The photo on the right shows the 'Band-Aid' we used to fix the problem. This is clearly a low cost method compared to other options.

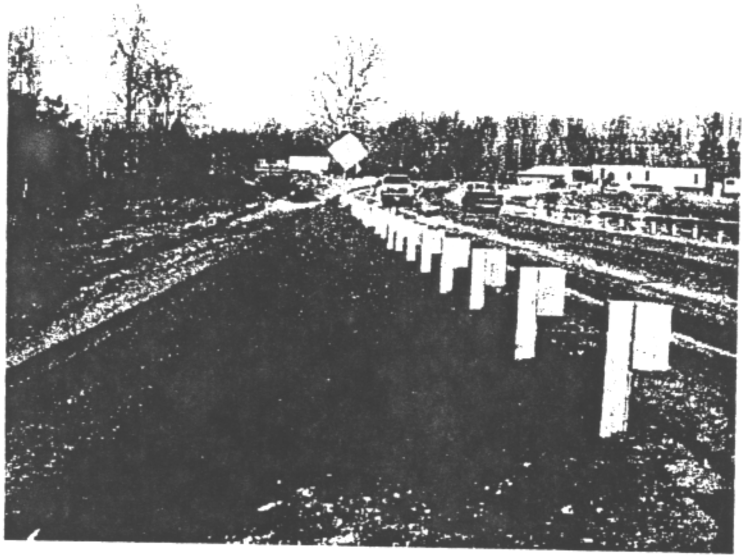

Construction Scar



Band-Aid for construction scar

Four other compost materials were used in two different applications (2" and 4" application depths). The slope was covered with these composts and eight treatment areas resulted. All of the composts were applied with a blower truck which allowed even, efficient application. One of the benefits we discovered by using a blower truck was that there is ample hose (500 ft) to reach most areas needing application. The materials used were a 2" minus compost, a ½" minus product, leaf compost ½" minus and recycled 'overs', a product common after screening ½" minus products. The overs were rather punky and a little on the larger side, but seemed to work adequately in the blower trucks.

The treatment areas ran the entire length of the slope for all eight treatments. We used the other side of the road, which had matching slope and soil type, as the control. The photos below show the erosion associated with the control area. This area had been a problem in the past for VDOT, so the project served a good purpose in showing how compost can impact even the worst erosion situations.



Treated slopes with compost

Untreated controls

The results of the project were similar for all four treatment areas – there was minimal erosion on all of the slopes except where the berms had been disturbed late into the process, allowing water to get under the mulch layer. Besides these areas, there was no noticeable erosion of soil from anywhere on any of the applications. Since we repaired the damaged areas with our 'Band-Aid' application, erosion has been minimal or non-existent.

The VDOT offices were tremendously cooperative in this effort and it is important for readers to understand that these projects take a lot of time and energy and a commitment from both parties to see it through to the final phase. VDOT has since hydroseeded the areas in an effort to understand how the treatment areas would respond. VDOT has concluded that there may be combinations of compost, filter berms and hydroseeding for the toughest erosion projects.

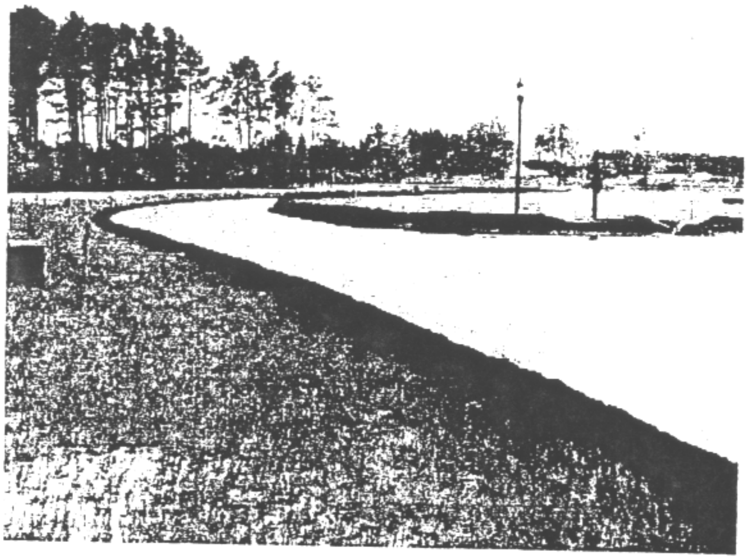
The final determination for the four materials used on the slopes was that the 2" application rates provided enough protection for the slopes to reduce erosion to acceptable levels. Obviously, a 4" application offers for protection, but there is concern that the costs for these materials and their application would be too high. The 2" application rates, however, are cost competitive with the repair costs experienced on these severe slopes and problem areas.

Sun City, South Carolina

DelWebb, a large developer in Sun City, South Carolina, ran several tests using compost for erosion control and filter berm replacement. This project provided much of the data and field results that we missed in the VDOT trial - mainly information about filter berms and the replacement of silt fences.

As a large developer, DelWebb is faced with constant environmental concerns. In the current project, they build up to 500 houses per year, with a total of 6,000 houses targeted in the local area. This requires a large disturbance on local soils, like any construction project. The state requires silt fence be properly installed around each new construction phase. DelWebb became interested in compost because of their environmental concern and their desire to use recycled products, where possible. DelWebb also has a strong commitment to local environmental issues, as well as being good stewards of the land as they develop large areas.

The photos below show the application of filter berms to replace silt fence on DelWebb property. We used the one foot high by two foot wide berm and they seemed to hold up well in most areas. In a few cases, where the berm became damaged from traffic or equipment, we simply asked DelWebb to fix the berm by adding a small amount of compost with a bobcat. This allows minimal maintenance to be performed with equipment normally already on most construction sites.



The final analysis of the filter berms at DelWebb is that they work well enough to consider using in all future construction. The company is currently analyzing costs and has asked to move to the next stage, which will be to use filter berms for an entire new development phase, or neighborhood. As these filter berms are placed, it will be an excellent test to determine how the berms hold up through an entire project rather than just for a couple of months. It is obvious that if the filter berms are more cost effective and perform better than silt fence that they will eventually be adopted as the norm for all construction projects with large developers like DelWebb.

ISSUES FOR THE FUTURE

We need to be conscious of the possible damage to the environment that our accepted practices are now causing. Is the use of silt fence causing more harm than good? Since we never have calculated the amount of materials which escape silt fence, there is a good chance that the amount of environmental damages are larger than we originally thought. We should be conscious of this as we support the new uses of compost and composted mulch in the applications outlined above.

Training and education is certainly a huge need in every state. Even though many states have reportedly worked with some type of compost, all of the state agents we worked with were hungry for information and eager to learn. All of them agreed to field trials during the first meeting, mostly out of frustrations with silt fence failures. As an industry, we need to develop easy to access data, project reviews, specifications, and architect drawings of filter berms and compost applications which satisfy our environmental goals.

In states which have annual printing of spec books for DOT or other agencies, compost use needs to be automatically included with the appropriate drawings. The US

Composting Council already has a good set of specifications to use for erosion control and due to the amount of requests, our offices recently developed CAD drawings to accompany a modified set of specs we make available to all interested parties. This information needs to be at every state office which can use these products.

Finally, nothing substitutes for field projects demonstrating the value of what has been discussed above. The three projects we coordinated helped us learn first hand about the issues, roadblocks and politics that are present in every single project you encounter. We would like to thank those involved for accepting our challenges to use compost and allowing us to demonstrate what others have found to be true. Compost is a versatile, useful product which reduces erosion when used as a filter berm or erosion control blanket.

There are several case studies that have been conducted including Texas, California, Ohio, and other states which have shown that compost has outperformed hydromulch and has reduced erosion by other standard methods used. It is clear we are just at the tip of the iceberg for market development in this area.

Tyler, King and Stinson are founders of Matrixx Organics Company, based in Richmond, VA. Specifications and drawings for filter berms can be obtained via email at rodndon@gte.net.

EPI - Grind-All SE			Del Webb Project				4/5/2000
Cost comparisons of various soil and mulch applications in the Landscape							
Application	**Product cost/ft**	**Product cost/A**	**Installation cost/ft**	**Installation cost/A**	**Total cost/ft**	**Total cost/A**	**Comments**
Sodding	$ 0.16	$ 6,970	$ 0.10	$ 4,356	$ 0.26	$ 11,326	Sod may not take first time
(per square foot)							
Compost & Seed Application		$ 3,200		$ 4,000		$ 7,600	$400 per acre for good seed
Features	One inch application with seed will smooth over rough spots, reduce final grading required.						
Benefits	Less prep costs, more control over window of time needed to complete job, lower costs						
(1.5 inches compost applied is $16.00/c.y. for material and $20.00/c.y. for installation = $36/c.y.total seed cost figured at $400/acre)							
				Total Savings per Acre:		$ 3,726	
Installation of Silt Fence	$ 0.60	n/a	$ 0.90	n/a	$ 1.50	n/a	Does not work - ineffective
(per linear foot of installation)							
Filter Berm Application (flats)	$ 0.80		$ 1.00		$ 1.80		
($16/yd product + $20/yd install at 20 linear ft. per cubic yard)							
Filter Berm Application (slopes)	$ 2.37		$ 2.96		$ 5.33		
($16/yd product + $20/yd install at 6.75 linear ft. per cubic yard)							
Features	Aquatic animals able to effectively navigate over berms, no cleanup needed, recycled product, living filter						
Benefits	Preservation of local environment, less cost, more aesthetically appealing, more effective at removing sediment						
				Total Savings per Year:			(need total ft. of silt fence)
Slope Stabilization/Naturalization							
($16 per yard for product and $20 for installation)							
Mulch applications - seed extra	$ 0.10	$ 4,320	$ 0.12	$ 5,400	$ 0.22	$ 9,720	
(2" application)							
Features	Not necessary to seed slopes, soil stays in place, less repair required, aesthetically appealing						
Benefits	Lower overall land mgt. Cost, more environmentally appealing, less erosion of valuable soil						
Installation of Landscape mulch	$ 15.00		$ 25.00		$ 40.00	(all mulch costs per cubic yard)	
(per cubic yard - manual application)							
Custom Mulch Application	$ 15.00		$ 20.00		$ 35.00		
Features	More even application, use 25% less materials, utilize less labor during peak times						
Benefits	More aesthetically appealing, employees do other tasks, less expensive overall						

CONTROLLING EROSION WITH COMPOST AND MULCH

Research trials by the University of Georgia evaluate how different composted feedstocks and woody mulches control runoff and nutrient loss.

Britt Faucette and Mark Risse

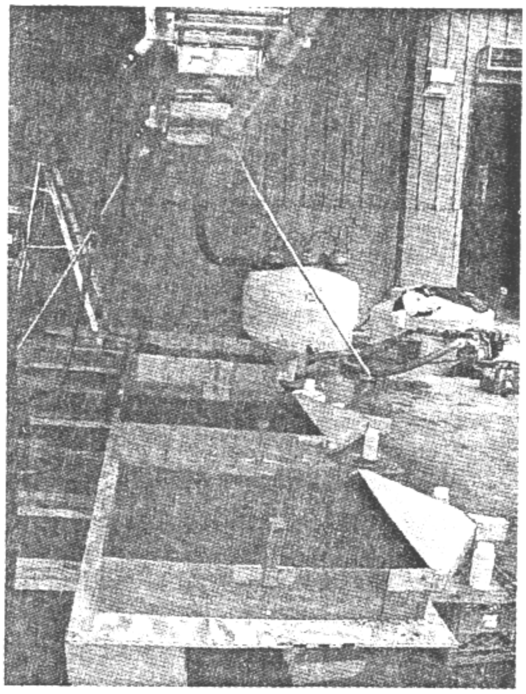
FEDERAL and state governments are moving ahead with major new regulations to control erosion and runoff from farms, construction sites, and roads to make more than 20,000 rivers, lakes, and estuaries safe for swimming and fishing. In 1990, The United States Environmental Protection Agency (EPA) Phase 1 Rules mandated land disturbing permits and pollution prevention plans for all construction sites over five acres. In 2003, Phase II will go into effect extending the storm water management plan requirement to any land disturbing practice over one acre.

As of August 1, 2000, Georgia enacted one of the nation's toughest regulations on erosion and runoff from construction sites in an effort to improve water quality in the state's surface waters, according to U.S. EPA officials. The new regulations label development zones as "point sources" requiring better erosion control practices and new permitting programs. The state can and has levied penalties up to $2,500 per day per violation of compliance with the new Erosion and Sediment Control Law. In addition, parties in noncompliance with the federal Water Quality Act can be fined up to $100,000 day.

The cumulative costs of erosion and sedimentation can be staggering. For example, the Clayton County Water Authority of Georgia says it paid over $30,000 last year to dredge one reservoir and the Metro Atlanta region pays an estimated $4,000,000 year to dredge sediment from reservoirs. Although soil loss rates from construction sites are ten to 20 times that of agricultural lands, much less research has been done in this area. In addition, turbidity and suspended solids concentrations from runoff are the most commonly cited water quality impacts during and immediately following highway construction projects.

COMPOST AS AN ALTERNATIVE

While little research has been done on the erosion and water quality impacts from these types of sites, what has been done evaluates the use of silt fences, hydroseeding sedimentation ponds, check dams, synthetic fiber mats and sediment barriers. Currently, the most common erosion control methods employed in Georgia include silt fences, hydroseeding, excelsior blankets and straw mats although the state is receptive to new technologies. Several recent studies have suggested that recycled organic materials and compost applications could be a superior and cost-effective alternative to current erosion and sediment control best management practices. The Georgia Department of Transportation and Georgia Soil and Water Conservation Commission only require that straw mats and mulches provide 70-75 percent soil surface cover, compost blankets in turn provide nearly 100 percent surface coverage when applied correctly. While conventional blankets and mats provide a ground cover, they do not protect the structural stability of the slope, as rilling and gullying are common underneath conventional mats and blankets. Compost blankets are designed and applied to prevent this from happening.



Each treatment was placed in a one square meter plot frame. A rainfall simulator applied water at an average rate of 3.5 inches/hour for one hour duration.

In response to various stakeholders in Georgia concerned with erosion control, compost markets and organics recycling, the Department of Biological and Agricultural Engineering at the University of Georgia has embarked on a multiphase, long-term research project to evaluate the environmental benefits and impacts of using compost in erosion and sediment control applications with particular emphasis on water quality issues. While there are many questions relating to the effectiveness of using composts and mulches in storm water management applications, the specific objective of the first phase of this research was to evaluate the runoff water quality and quantity from various types of composts and mulches, specifically looking at nutrient and sediment loss. This was primarily done to answer the question of which physical and chemical properties of the compost and mulch materials control erodibility and nutrient losses.

It should be understood that these trials were done under worst-case scenarios; the composts did not adhere to any published erosion control specifications and were exposed to extremely intense rainfall conditions. Follow up research is currently underway to assess vegetation establishment properties and to assess the system losses under natural conditions. These studies will evaluate both blankets and berms, include comparative treatments such as hydroseed and silt fence, observe the effects of vegetative establishment and growth, and look at long-term effects on soil quality parameters with particular attention given to the compost-soil interface.

COMPOST AND MULCH CHARACTERIZATION

Eleven treatments were chosen to represent each type of commercially available compost in Georgia. This included three poultry litter composts (PLC1, PLC2, PLC3), one uncomposted aged poultry litter (PL), an MSW compost (MSC), a biosolids compost (BSC), a food waste compost (FWC), a yard waste compost (YWC), a finely screened wood mulch (WMf), an unscreened wood mulch (WMm), an unscreened yard waste and wood waste mulch (WM2), and a bare soil (Cecil sandy clay loam) treatment. Table 1 and Table 2 depict the physical and chemical characteristics for each material. An analysis was also done on EPA 503 metals and all treatments were well below standards set for exceptional quality biosolids. All materials were tested as received at the University of Georgia.

Each replicate was placed in a one square meter plot frame at a depth of two inches. The treatment was placed on top of two inches of soil. The soils were prewet before compost and mulch blanket treatments were applied. The frames were placed on plywood which was tilted to a ten percent slope. An eight nozzle (V-jet nozzle operating at 60 psi) Norton rainfall simulator was used to apply rainfall at an average rate of 3.5 inches per hour for one hour duration. Runoff samples were taken directly from a flume at the base of the plot frame every five minutes once runoff began for a total of 60 minutes. The runoff samples were analyzed for total runoff volume, runoff rate, volatile solids (VS), total solids (TS), total phosphorus (TP), ortho-phosphorus (PO_4), total nitrogen (TKN), nitrate nitrogen (NO_3-N), and ammonium nitrogen (NH_4-4). Nutrients were only analyzed at the first flush (when runoff began) and at steady state (at the end of 60 minutes).

RESULTS — RUNOFF, SOLIDS AND NUTRIENT LOSS

All of the materials tested except the noncomposted poultry litter were effective at controlling erosion by reducing solids loss under these experimental conditions. All of the composted poultry litter treatments had significantly less nutrient loss, runoff and erosion than the poultry litter. The bare soil had significantly less solids loss than the aged poultry litter but significantly more than all the composts and mulches with the exception of one poultry litter compost. Their was no statistically significant difference in runoff and solids loss for the mulch and compost treatments, however the mulch treatments did have less loss. Low respiration rates and nitrate nitrogen concentrations in the treatments tended to erode less.

Indicators of ammonia and phosphorus losses included: soluble salt, sodium, potassium, respiration rate and nitrate nitrogen. While the poultry litter treatment tended to have the highest nutrient losses, some composts exhibited higher losses of nutrients than others. This may be the re-

Table 1. Physical characteristics of composts and mulches

Treatment	Moisture Content (%)	Volatile Solids (%)	Bulk Density (kg/m^3)	Respiration Rate ($g\ O^2/g\ hr$)	Aggregate Size (%>25mm)	Aggregate Size (%>9.5mm)	Aggregate Size (%>6.3mm)
PLC1	24	14	799	0.06	100	98	97
PLC2	27	25	751	0.10	100	94	87
PLC3	36	13	724	0.07	98	91	82
PL	26	26	877	0.34	99	96	93
MSC	41	36	461	0.04	100	99	98
BSC	21	46	562	0.04	100	99	73
FWC	51	18	751	0.05	100	95	89
YWC	42	27	615	0.05	100	97	91
WMf	26	33	446	0.06	100	99	98
WMm	32	67	213	0.02	100	80	55
WM2	48	47	363	0.03	92	65	51
Soil	18	5	1,453	0.14	100	100	99

All of the materials tested except the noncomposted poultry litter were effective at controlling erosion by reducing solids loss under these experimental conditions.

sult of many factors including particle size distribution, lack of vegetation, no opportunity for runoff to move into the soil, or method and length of composting. While the mulches generally had less nutrient losses than the other treatments, one of the main functions of controlling erosion is establishing a vegetative cover quickly and permanently. The nutrients that composts have should significantly aid in this process, research is currently underway to quantify changes in soil loss and nutrient loss with vegetative establishment and cover over time.

While this research needs to be followed up the with research already underway at the University of Georgia, there are many questions that still need to be answered including: How much can compost increase rainwater infiltration and reduce storm runoff volume; What is the optimum moisture content for composts to effectively be applied, reduce runoff and establish vegetation; What turbidity and suspended solids levels can be expected from compost surface applications; Are there water quality concerns related to nutrient loading from the runoff; If so, what types of composts should be avoided and/or how much buffer area should be maintained between compost application and surface waters; How effective are compost berms in filtering chemical spills and petroleum products in runoff; How steep of a slope can compost be applied; What type of compost establishes erosion control vegetation the quickest and provides a solid long-term vegetative cover.

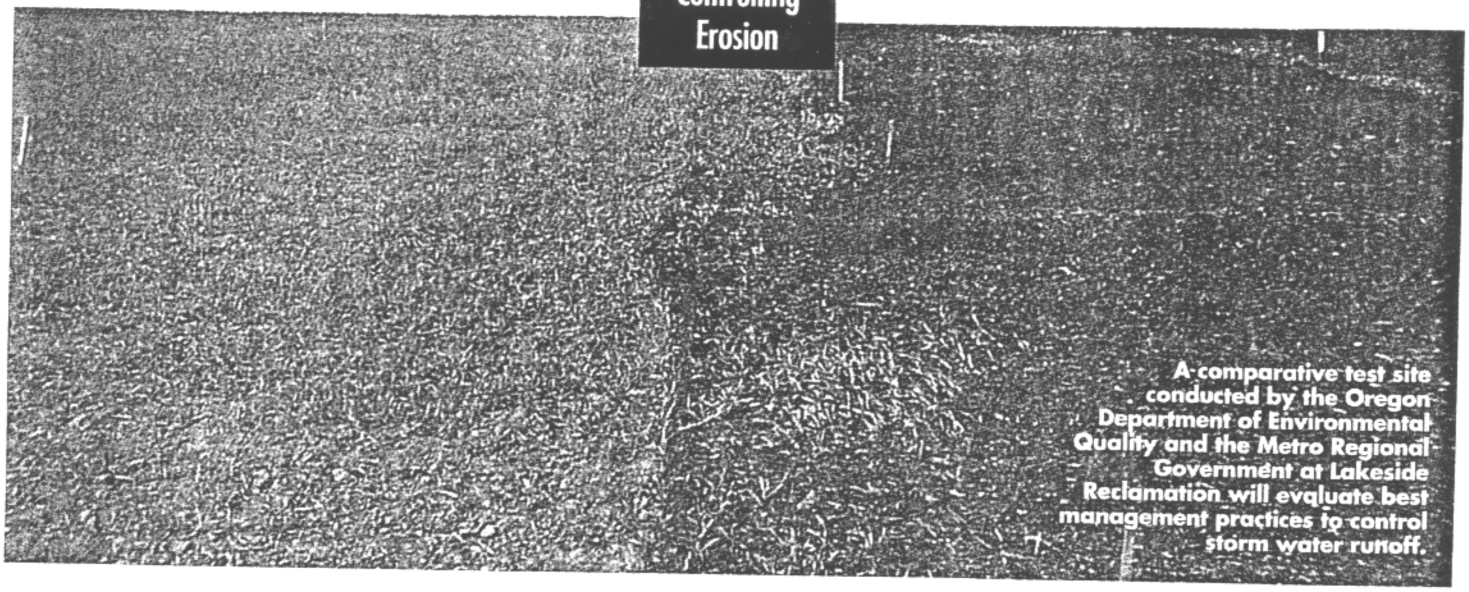
Other research questions are: What is the optimum range of particle sizes for water infiltration, runoff reduction, runoff filtration, particle movement reduction, and vegetation establishment and growth; What is the optimum depth for compost blankets and dimensions for compost filter berms — seeded and unseeded; and What is the most cost effective way to apply compost blankets and filter berms and is it cost competitive with the most common methods.

As is often the case, industry needs and consumer demand will steer the research. Most of the current specifications address some of these issues, none address them all. When developing future specifications, they should incorporate current research that addresses optimum application procedures, environmental impacts and economic feasibility. One of the goals of this research is to create an updated set of specifications for using compost in erosion and sediment control applications that will be accepted as a BMP by the Georgia Soil and Water Conservation Commission. In addition, the University of Georgia's Engineering Outreach Program and composters with Georgia Composting Association have been proactive in establishing demonstration sites throughout the state to educate and facilitate adoption and application of using compost in storm water management programs. ■

Britt Faucette and Mark Risse are with the University of Georgia's Biological and Agricultural Engineering Department in Athens. *The research collaborators would like to thank the U.S. Poultry and Egg Association, the Animal Waste Management Center at North Carolina State University, and the compost and mulch suppliers for financial and technical support.*

Table 2. Chemical characteristics of composts and mulches

Treatment	pH	Soluble Salts (mmhos)	C:N Ratio	Total Nitrogen %	Nitrate (NO^3-N) (ppm)	Ammonia (NH^4-N) (ppm)	Total Phosphorus (ppm)	Potassium (ppm)	Aluminum (ppm)	Calcium (ppm)	Magnesium (ppm)	Sodium (ppm)	Zinc (ppm)
PLC1	7.2	5.87	15	0.56	732	56	9,009	7,835	13,300	51,540	3,454	1,330	192
PLC2	8.3	7.13	27	0.62	200	357	9,015	8,450	19,170	38,750	2,800	2,217	213
PLC3	7.1	2.51	11	0.77	1	319	2,371	4,344	11,510	6,824	1,494	450	70
PL	7.1	20.60	9	1.74	4,876	35	13,830	14,990	2,347	29,810	3,494	4,660	261
MSC	8.3	5.03	23	1.18	210	1	3,186	2,571	9,357	18,270	1,718	2,700	372
BSC	4.9	7.65	13	1.09	1,460	116	8,086	4,872	11,670	6,028	1,705	283	202
FWC	7.7	0.80	29	0.46	1	63	622	2,622	11,760	3,715	1,093	151	41
YWC	5.0	0.11	36	0.39	74	245	351	1,868	19,240	483	1,043	44	39
WMf	6.0	0.25	113	0.16	21	21	192	1,076	11,280	1,954	651	50	21
WMm	5.6	0.20	637	0.09	1	42	74	578	756	1,065	204	28	8
WM2	7.0	0.24	139	0.18	4	28	141	773	2,383	1,761	275	42	27
Soil	5.0	0.11	9	0.08	88	172	351	1,868	19,240	483	1,043	44	39



A comparative test site conducted by the Oregon Department of Environmental Quality and the Metro Regional Government at Lakeside Reclamation will evaluate best management practices to control storm water runoff.

ORGANICS IN ACTION

COMPOSTED WOODY MATERIALS BECOME EROSION CONTROL PRODUCT

Oregon site has a yard trimmings composting system, a bagging line and side-by-side comparative plots demonstrating compost impact on steep slopes.

IN Beaverton, Oregon, Lakeside Reclamation, Inc. grinds incoming yard trimmings and other feedstocks which are composted and bagged for use in erosion and runoff control. The facility recycles over 25,000 tons of wood each year for multiple product use. Owned by Howard Grabhorn, the site includes a limited purpose landfill, composting area, retail products building and comparative erosion control plots that test the impact of compost applications.

Coarse wood chips are used to fill "biofilter bags" made from plastic netting — either nondegradable or biodegradable, depending upon customer preference. Finely ground materials are screened at least twice and marketed as horticultural compost, mulch or for animal bedding. "We get everything from stumps to leaves from franchised haulers in the region," says Grabhorn. Woody materials are then put through three grinders — a Diamond Z, Morbark and Duratech.

Also located at Lakeside Reclamation is a comparative test site conducted by the Oregon Department of Environmental Quality (DEQ) and Metro Regional Government using compost to control erosion from storm water runoff on steep slopes. This test is part of a larger project Dave Kunz of DEQ and John Foseid of Metro are running to evaluate best management practices to control storm water runoff. The test area is on a portion of a closed landfill that is permitted for alternative cover. The landfill is covered with about five feet of native clay and uses a mix of cottonwood conifer trees, along with ground cover, to uptake moisture on and at the base of the steep slopes.

The site is steep with about a 4.5 to one slope, and extends to about 100 yards wide and 40 yards from the top to the bottom of the slope. The test employs four plots of land on the slope, each 15 feet wide and running the entire length of the slope (about 110 feet). The first plot has an application of three inches of compost with grass seed mix. The second has one inch of compost with the grass seed, and the third — one inch of compost without the seed mix. The fourth is a control plot with only the clay cover and some hand broadcast grass seed mix. Plots one through three also have three compost berms on them: one at the top, one in the middle and one at the bottom of the slope. The berms are about four feet wide at the base and two feet high at the top. The berms are designed to absorb storm water and reduce the velocity of runoff on these steep slopes.

The berms will be regularly inspected for a full year, during both the rainy and dry seasons, to determine the effectiveness of runoff control and vegetation growth. On the control plot, existing rills and water channels are evidence of concentrated runoff that gather momentum going down the steep slope. With increased rain, the rills may deepen. The effects of the compost and the berms (on the test plots) should be in stark contrast to the control plot (i.e. no rills, gullies or channels).

Additional analysis will compare the control plot, seeded without organic amendments, to the three test plots that have different layers of compost and seed mixes. This test will provide information on the benefits of compost to clay in establishing and maintaining permanent ground cover on a slope. In this case, the ground cover is being used for erosion control. The data can also help determine the cost effectiveness of compost use for erosion control and ground cover health. ■

Three test plots will have different layers of compost and seed mixes, providing data on establishing permanent ground cover on a slope as well as cost effectiveness.

MARKETING A COMPOST BIOFILTER

LEAF COMPOST is pelletized and becomes the filtering mechanism for storm water control systems marketed nationally by a Portland, Oregon firm. According to Brendan Fitzpatrick of Stormwater Management Inc., the company uses a variety of filter media to target and remove pollutants from stormwater runoff. Its CSF Leaf Media uses leaves collected by the city of Portland, which are then composted and processed into "an organic granular media."

The system is described as a passive, flow-through storm water filtration process consisting of a concrete vault that houses rechargeable cartridges filled with a variety of filter media. As storm water passes through the cartridges, pollutants such as hydrocarbons and dissolved metals are adsorbed. The system is being used in roadway applications as well as at parking lots and commercial sites.

As explained in a 1995 *BioCycle* article ("Commercial Applications for Compost Biofilters,"), the concept of using relatively small volumes of specially processed compost housed in compact containment systems was developed by biologist William Stewart. System benefits cited were that the filter requires less land area for installation, operates effectively with much lower hydraulic gradients, and typically produces more consistent results than do swales or detention ponds.

EROSION CONTROL SITE TOURS AT BIOCYCLE WEST COAST CONFERENCE

REGISTRANTS at the *BioCycle* West Coast Conference -- March 5-7, 2001 in Portland, Oregon will tour operations and compost erosion control tests at Lakeside Reclamation. "By reintroducing organic amendments to disturbed soils, we can increase groundwater absorption of rain up to 125 percent more than those without organic amendments," says David Kunz, Oregon Department of Environmental Quality.

The conference field trip will also include inspection of a site in Portland to see how pelletized leaf compost is used in storm water filter systems. The compost filtering system is used to remove nonpoint source pollutants, including sediments, oil, soluble metals and excess nutrients.

For registration details on the *BioCycle* West Coast Conference, see pages 15, 16, 17 of this issue or call (610) 967-4135.

REPLACING CONVENTIONAL METHODS

COMPOST FILTER BERMS AND BLANKETS TAKE ON THE SILT FENCE

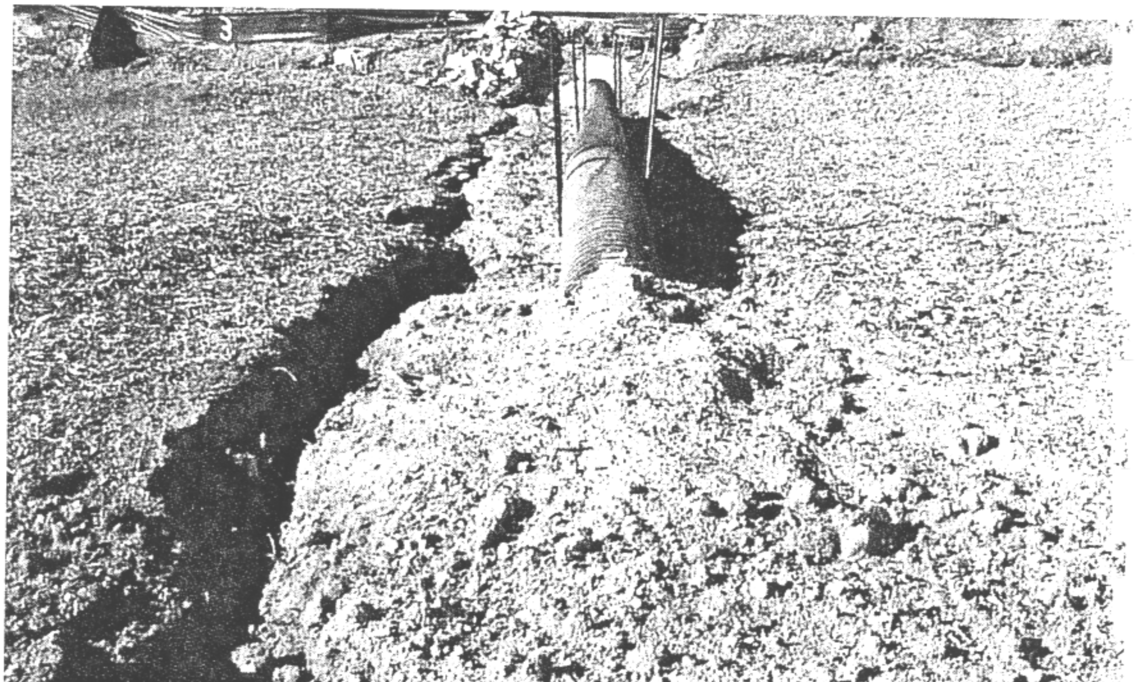
The success of compost and composted mulch in erosion control projects is creating a groundswell of excitement among state and local departments of transportation, construction companies, landfill managers and contractors.

Rod Tyler

FOR THE last ten years, the use of compost in environmental applications and markets has been increasing at a steady rate. Environmental applications include slope stabilization and erosion control, storm water filtration, vegetation establishment, and replacement of silt fence with compost filter berms. This article focuses primarily on compost filter berms with and without compost application.

Silt fence — a sediment-trapping practice utilizing a geotextile fence, topography and vegetation — has been used for erosion control on slopes and around the edges of construction sites for years. While it is not the only method accepted for slopes — and is often combined with other measures as the severity of slopes increase — it is the accepted standard for environmental containment of silt and sediment. Silt fence is used on nearly 100 percent of construction projects in the U.S., but there are some inherent problems with its use. First, it does not work as well as originally thought. Second, it has to be removed when the job is completed.

Compost, when properly installed in long filter berms, has been shown to work better than silt fence in keeping both suspended and settleable solids out of water sources moving on the surface. In 1993, Bill Stewart of Portland, Oregon conducted research which showed surprising results using compost in a number of erosion applications — including a "barrier" at the toe of the slope (essentially a filter berm) — on a local roadway that had extremely steep slopes (see "Yard Debris Compost for Erosion Control," December, 1993).



The research showed how ineffective the silt fence was in containing solids. On a 34 percent slope, total settleable and suspended solids in the water that passed through the silt fence was 32 ml/L and 26,000 ml/L, respectively versus the compost barrier (made from mixed yard trimmings) at 2.6 ml/L and 1,300 ml/L, respectively.

In 1994, the Maine Waste Management Agency tested compost in Kennebec County to determine if the erosion control results were predictable. This was followed in 1996 with Clyde Walton from the Maine Department of Transportation (DOT) becoming one of the first to specify compost filter berms on DOT projects. In 1997, the U.S. Environmental Protection Agency recognized the use of compost for erosion control — and specifically the use of filter berms — to reduce environmental problems associated with erosion. California's DOT, CalTrans, has been working on many projects for the last ten years and now has a very progressive program.

Until the advent of blower trucks, accessibility and efficient application of compost or composted mulch was hard to achieve. Manual application on 2:1 slopes would be nearly impossible. Application of filter berms around construction sites would require a Bobcat, loader or other equipment and would simply be less efficient. Now that a more optimal application method is available — combined with the positive results from trials and actual jobs — compost filter berms are positioned to be an effective competitor.

Compost filter berms have the following advantages: Amends native soil, assisting in vegetation establishment and can be easily incorporated when the job is completed; Can apply in areas where water has already accumulated; Can apply in any direction or configuration or adjust to outlines of areas; Lower cost than silt fence and more effective in removing sediment and preventing phosphorus and other chemical leaching, thus cleaning up waterways; More effective at removing chemical compounds from runoff; and Compost is an annually renewable resource, all organic, and 100 percent natural. Silt fences, on the other hand, are less effective at containing suspended and settleable solids, are hard to keep up during construction projects and are often left on site after construction, which is unsightly. They also are a nonrecycled material that needs to be disposed.

FILTER BERM AND "COMPOST BLANKET" COMBO

When filter berms are used in combination with slope protection via a layer of compost or composted mulch (compost blankets), minimal erosion can be expected. Filter berms reduce the speed of water flowing on a given slope, which reduces the speed of soil particles tumbling down. Overall displacement of other soil particles is reduced. Many applications have placed a series of filter berms down the slope, which has worked well to slow the water long enough to reduce erosion.

Soil particles are normally round and roll easily once displaced by water. As they gain speed and momentum, they displace other soil particles which channel together in faster moving water, creating small rills. Rills lead to channels and channels lead to gullies. A layer of compost or composted mulch applied to the slope acts like a "wet blanket" or a "wet deck of cards" scattered randomly over the surface that prevents the soil from rolling or gaining this momentum.

A secret of success in the field is making sure that water is not able to get under the blanket at the top of the slope. If water gets under the layer of compost, and if the slope is steep, you can expect erosion and the compost or composted mulch will float away.

Compost filter berms amend native soil, assist in vegetation establishment and can be easily incorporated when the job is done.

At a field trial that tested both a compost filter berm at the top of the slope and compost applied to the slope, a portion of the berm was destroyed during installation of the guardrail (far left). A Band-Aid approach — blowing compost on the slope and repairing the berm (left) — was done with minimal equipment and no damage to other areas of the slope.

Organic materials help water infiltrate into the soil underneath, which is crucial to new seedling germination when vegetation needs to be established on the slope.

However, by having a filter berm at the top of the slope and keeping the compost layer continuous over the "shoulder" of the slope, the water will hit the slope and ride all the way to the bottom on top of the blanket of organic materials.

Because organic materials are more flexible, lighter, and absorb more water than soils in general, they also aid in helping water infiltrate into the soil underneath. For vegetation establishment, this is crucial to new seedling germination.

Depending on the charge for installation and the cost of local compost or composted mulch products, filter berms are competitive and thus cost is not a real barrier to their use. In a study conducted in South Carolina with one of the very largest builders, it was determined that silt fence would cost about $1.50/linear foot installed, versus $1.80/linear foot for compost filter berm installation on flat surfaces.

In many markets, the cost of compost application matches the cost of the product. For instance, compost priced at $20/cubic yard (cy) would cost $20/cy for application. Many blower truck operators simply double the price of materials to arrive at an installed cost for organic materials. This is a good rule of thumb to use. When calculating the amount of compost or composted mulch required, it was determined that one cubic yard provides 20 linear feet of filter berm one foot high and two feet wide. This size is adequate for the majority of silt fence replacements, which are actually demarcations of the work zone itself. Much of the silt fence installation, when performed on flat ground, is simply to show the perimeter of the active work zone.

FIELD REPORTS

Four field projects have been completed recently that focus on the principal objectives outlined earlier: reducing erosion on slopes using compost blankets and installing compost filter berms instead of silt fences.

Richmond, Virginia: A project was coordinated in Richmond with the Virginia Department of Transportation (VDOT) to determine the effectiveness of compost for mulch and as filter berms. The site chosen by VDOT was to be a true challenge for vegetation establishment. "We wanted to use a worst case scenario to try the materials," says Ken Orstaglio of VDOT. "This particular site was a problem for us due to the steep slopes and the sandy, highly erodible soil. We only regret we did not try seeding at the time of application. That is on our wish list of next projects, which we are now planning."

VDOT did not want to use filter berms alone because it had already seen the heavy erosion without protecting the slope and did not want to incur more repair costs. Besides, when slopes are so severe, more than filter berms are needed for best protection.

Four compost materials were used in two

different applications (two-inch and four-inch application depths) for a total of eight treatments. The treatment areas ran the entire length of the slope. A one-by-two-foot compost filter berm ran along the entire treatment area. The yard trimmings-based composts were applied with a Finn blower truck. Four different variations of compost were used: a two-inch minus, a half-inch minus that was heavy on brush and light on grass, a half-inch minus reground leaf compost and one-inch minus recycled and reground screening overs. The overs were rather coarse and a little on the larger side, but seemed to work adequately in the blower trucks.

Results were similar for all four treatment areas, with no noticeable erosion of soil on any of the applications. The one exception was where a road crew installing a guard rail drilled holes in the filter berm to let water that had accumulated drain quickly. In the process, water got under the compost blanket, causing some erosion. The berm was repaired and more compost was applied to the slope. The final determination based on the four materials used on the slopes was that the two-inch application rates provided enough protection to reduce erosion to acceptable levels. From a visual perspective, all composts worked equally well because they allowed the water to travel on top (by creating an interlocking cover) and prevented round soil particles from gathering momentum.

The two-inch application rates are competitive when repair costs experienced on traditionally treated severe slopes are factored into the comparison. The costs of repair involve bringing in more heavy equipment for regrading, hydroseeding and even the application of more straw. Some sites in Virginia have been reworked several times. "Cost comparisons with existing erosion control methods may not be telling the whole story," says Orstaglio. "Vegetation establishment is one budget and maintenance is another. We can substantially impact the maintenance budget if we can keep from reseeding some of these problem areas for many years in a row." He believes that working compost into the slopes prior to seeding will help increase organic matter and result in more permanent vegetative cover.

The VDOT plans to conduct more trials, and they have a project pending in the Tidewater area that will include compost in the bid specifications. "That will give us good feedback to judge what kind of numbers to expect from contractors who will provide this new service," he adds.

Columbus, Ohio: Harry Kalipolitis with the Ohio EPA (OEPA) in Columbus is responsible for field monitoring of controls installed for sediment and runoff at construction sites. Jet Mulch, a company expanding into compost filter berm and compost blanket installation, approached Kalipolitis

"We can substantially impact the maintenance budget if we can keep from reseeding some of these problem areas for many years in a row," says Ken Orstaglio of VDOT.

In the Virginia trial, it was determined that the two-inch compost application rates were enough to reduce erosion to acceptable levels.

about performing a trial on a problem area. They jointly selected a new construction site near a WalMart that served to show how the installation of compost filter berms and compost blankets worked (using a three-quarter-inch minus yard trimmings compost). The project was started September 5, 2000 and ended recently as construction of the final buildings on site were completed.

Kalipolitis was surprised about the berms' ability to retain water on site and then have it seep through slowly. "We still have concerns about concentrated flow areas, like channels," he says, "but for sheet flow, all of the demonstrations seemed to work very well with compost filter berms and compost blankets." Concentrated flows come down the slope perpendicular to the berm and have the most force. Areas of impact are identified by the site engineer prior to installation of a berm or silt fence. To minimize impact from concentrated flows, installers can invert the compost filter berm in a "V" shape going up the slope so that water is channeled off at the point in the V at 45-degree angles. Other installers have used a series of V or horseshoe-shaped berms in the direction of the flow to slow down the water.

Compost also may have an advantage over silt fences and straw in cold weather. "Many people ask about what applications they can use for erosion in the winter," explains Kalipolitis. "They find that tackifier — the gluey substance used to stick the paper fiber and seed to the slopes — does not work as well in cold winter months. And any water-requiring process could be impeded by frozen conditions or equipment. The compost filter berms and compost blankets work even in cold weather. Straw is hard to crimp in when the ground is frozen and the only other alternatives are netting or erosion cells, which raise costs significantly."

Sun City, South Carolina: Del Webb, a large developer, ran several tests in Sun City using compost for erosion control and filter berm replacement. In one project, the company is building up to 500 houses/year, with a total of 6,000 houses. The state requires that silt fence be properly installed around each new construction phase.

One-foot high by two-foot wide berms were installed and seemed to hold up well in most areas. In a few cases, where the berm became damaged from traffic or equipment, Del Webb fixed it by adding a small amount of compost with a Bobcat.

The final analysis of the filter berms at Del Webb is that they work well enough to consider using them in all future construction. The company is analyzing costs and has asked to move to the next stage — using filter berms for construction of a new neighborhood. Installation will be an excellent test to determine how the berms hold up through an entire project rather than just for a couple of months. Another application at Del Webb is the use of compost for seeding in replacement of hydroseeding or sodding.

SWACO Landfill, Columbus, Ohio: A project at the Franklin County Solid Waste Authority (SWACO) landfill in Columbus is testing use of composted screened overs from a yard trimmings composting facility for slope stabilization. "The reprocessed overs used for erosion control on landfill slopes is an ideal application for these materials," says Tom Kurtz, a partner in Kurtz Bros., Inc. in Columbus and Cleveland, Ohio, which supplied the overs. "We have been searching for five years for an application like this because getting plastic out of the overs is just challenging and expensive. There should be no issues with minimal contamination from plastic here on the landfill slopes."

The trial, which took place in early December, was conducted using the installation services provided by Jet Mulch. A filter berm made from overs was installed at the top of the slope and another one at the end of the test area, which measured about 75 feet by 100 feet. A blanket made from composted overs, applied about two to three inches deep, connected the two berms. From the lower elevations, the trial area looks like a black postage stamp. "If this works well, we can use the trucks to install the berms, but we will probably go with a heavier application on the slopes and use our dozers here on site for that," says Rick Dodge, landfill manager.

DEVELOPING SPECIFICATIONS

Silt fence isn't actually specified in many erosion control bids. Instead, the contractor has to submit an erosion control or water discharge plan that calls for some recognized method to reduce erosion. Silt fence, because it is so common, is the leading tool used to respond. When contractors put compost filter berms or compost blankets into their plan, the officials have to determine if this tool is acceptable. Brett Bergefurd, urban conservationist for the Franklin County, Ohio Soil and Water Conservation District (SWCD), first saw filter berm information in the U.S.

EPA documents created in 1997. "At the time, it appeared to be great stuff and we were very interested in it, but nobody around here had any projects to review in the field," says Bergefurd. "We needed more demos and examples to analyze and make sure they worked as depicted."

Bergefurd and Kalipolitis of Ohio EPA are in the process of rewriting the *Rainwater and Land Development Guide — Ohio's Standards for Storm Water Management, Land Development, and Urban Stream Protection*. This guide is used for referenced control measures of sediment, runoff and water movement (e.g. basins, traps, silt fence, drain inlet protection) on any commercial construction in Ohio. They are considering inclusion of compost filter berms in the revision of the guide — which currently includes only one-and-a-half pages on mulching, with no recommendations on using compost. In terms of slope stabilization, the specifications for mulching listed in the handbook are straw, hydroseed, wood cellulose fiber, mulch netting, asphalt emulsion and synthetic binders.

Even though a material such as compost may not be specified, it can be approved as an acceptable alternate if it is proven on a local basis. Alternate specification language has been made available to Ohio for its handbook revision. "We are happy to have this language in specification format, especially during this critical time of rewriting these handbooks for all types of storm water control," says Bergefurd. "The applications we have seen in coordination with Harry Kalipolitis and the Ohio EPA, and recently at the landfill, indicate enough successes on local projects to warrant serious consideration for the applications of these materials in a number of differing erosion settings."

Other states, including Texas, Connecticut, Maine and California, already have compost specifications in their handbooks. Texas has published specifications for its purchase of general use compost, compost manufactured topsoil, and compost filter berms (see www.dot.state.tx.us/insdtdot/orgchart/des/landscape/compost/topsoil.htm).

ISSUES AND ROADBLOCKS

Silt fence and hydroseeding have been the standard erosion control methods over the last ten or 20 years. Lack of awareness about compost filter berms and compost blankets in many local areas is a leading roadblock to rapid future development.

Training and education are critical to moving compost use in this sector forward. A handful of states have active programs, including research and field demonstration projects. In 2000, the U.S. Composting Council received a grant from the U.S. EPA to promote compost use by state departments of transportation in landscaping, turf management, erosion/sediment control and other environmental applications.

In states that have annual printing of specification books for DOT or other agencies, compost use needs to be automatically included with the appropriate drawings. Finally, nothing substitutes for field projects demonstrating the value of what has been discussed above. The field projects we coordinated helped us learn first hand about the issues, roadblocks and politics involved. ■

Rod Tyler is the owner of Green Horizons, a consulting firm outside Cleveland, Ohio and can be reached at rodndon@gte.net. He thanks the people and companies enabling these field demonstrations to be conducted. A portion of this material was presented by Tyler at the Y2K Composting in the Southeast Conference in October, 2000.

A trial is testing use of composted screened overs from a composting facility for slope stabilization at a landfill.

FILTRATION WITH MULCH

USING WOODY MATERIALS FOR EROSION CONTROL

Connecticut researchers conduct a series of field trials and laboratory analyses to determine how particle size and other characteristics affect mulch performance.

Kenneth Demars, Richard Long and Jonathan Ives

WHEREVER a soil slope is exposed to rainfall or running water, methods are needed to prevent erosion. Some sites only need protection during construction – buildings, roadways, development; other sites have a continuing challenge with barren slopes. Wood residuals have been effective at preventing fine silt and clay particles from damaging waterways.

Residuals can consist of a mix of bark, wood shavings, wood chips, wood scraps and mineral grit that are by-products of the lumber, paper and construction industries. In a series of tests at the University of Connecticut, material characteristics were correlated with field performance to get a clearer idea of how effectively erosion could be controlled. The overall objective was to quantify the properties and behavior of mulches made from wood residuals as a medium to control erosion, when applied to slopes at a thickness of three-quarters inch up to three inches.

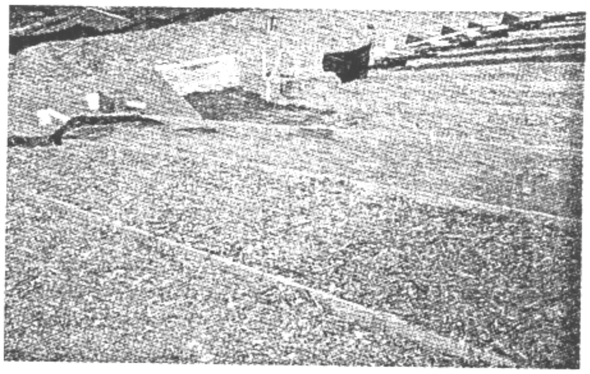
Use of natural materials to reduce erosion has been well established, especially with composted feedstocks. Research trials going back to 1962 show how soil erosion has been controlled with composted materials in the vineyards of Europe, and more recently in general applications as well. State Departments of Transportation have increased their use of compost at highway construction sites to prevent runoff.

PHYSICAL AND CHEMICAL PROPERTIES

When wood particles are used as a mulch at a thickness of three-quarters inch or greater, the amount of soil eroded can be reduced to one-fiftieth or less than the erosion from an untreated surface. For wood residues to be used effectively on large-scale projects, procurement specifications – based on physical properties of materials – are needed to ensure the proper effect is achieved (see sidebar).

Three wood residual products were used for the trials – a paper mill wood waste, a pine bark mulch, and ground stump/wood waste mulch. All samples were subjected to laboratory testing for physical properties; some additional chemical tests for toxicity assessment were completed before these materials were placed at the field test site. Table 1 shows the results of the physical property tests. The organic matter content was highest for the pine bark mulch, followed by the ground stump mulch. The paper mill wood waste had the lowest organic matter content. The friction angle measures the stability (amount of mass movement or sliding) of these products under the gravimetric forces that were imposed during the field tests. Based on the laboratory tests, all three products were expected to be stable on the slope angle of the test site (1 vertical to 2 horizontal or 26.6 degrees versus the lab sites which were all greater than 43 degrees).

The model procurement specifications for source separated compost adopted by the Coalition of Northeast Governors (CONEG) in 1996 specified chemical properties for usable composts and mulches. Chemical properties of the three wood residual products used in this study and the base soil were measured, including stability, pH and conductivity (Table 2). Stability (an indicator of the degree of composting of the raw feedstock) was measured using the Solvita test with a numerical system from one for raw non-composted feedstock to eight for fully composted/biodegraded and cured materials. This test verified that the ground stump mulch was fresh raw material and the other two ma-



Testing was done at a field site with a 1:2 slope. Fourteen test cells were constructed. Three cells were left untreated but contained erosion control structures – silt fence, a hay bale and a mulch berm – at the bottom of the cells.

Table 1. Physical properties of wood waste samples

Material	*Organic Matter Content* (% dry weight)*	*Dry Unit Weight** (lbs. cu. ft.)*	*Friction Angle*** (degrees)*
Ground stump mulch	63.6 (55.9 - 70.5)	11.2, 14.1, 15.0	47.5
Pine bark mulch	94.3 (91.4 - 95.6)	9.6, 11.3, 14.4	48.8
Paper mill wood waste	35.6 (28.9 - 43.0)	36.1, 47.7, 48.6	43.1

**Average of four samples, () - range; **Loose, After vibration, After 100 pound load; ***Average of three tests*

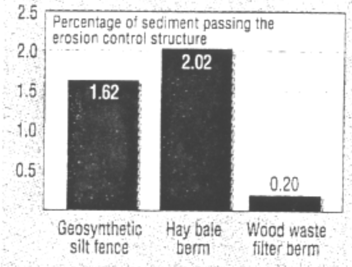
Table 2. Chemical properties for wood waste materials

Material	Stability*	pH**	Conductivity*** (mmhos/cm)
Ground stump mulch	Fresh raw compost (1)	6.99	3.88
Pine bark mulch	Finished mature compost (6-7)	4.86	3.14
Paper mill wood waste	Past active compost, ready to cure (5)	7.51	1.8
Base soil	N.A.	6.60	0.55

*Based on Solvita test number ranging from 1 = raw to 8 = finished; **Based on compost/deionized water ratio = 1/10 by weight; ***Based on compost/deionized water ratio = 1/10 by weight, conductivity = 0.031 mmhos/cm for deionized water

terials are further along in the composting process as evident from their color and appearance. The CONEG specifications recommend that erosion control materials should be very stable to stable, which was not the case for the fresh ground stump material.

Figure 1. Erosion control structure comparison



TRIALS AND RESULTS

Large-scale erosion control testing was done at a field site with a 1:2 slope (the steepest soil slope normally used by the Connecticut Department of Transportation [ConnDOT]). The base soil is an easily eroded silty sand with some gravel. Fourteen test cells (5-feet by 30-feet) were constructed on this slope in May 1999 (Table 3). Two cells were left untreated as reference cells and three other cells were untreated but contained erosion control structures including a wood waste filter berm (made from the paper mill's mulch product), geosynthetic silt fence (silt fence), and hay bale silt barrier near the bottom of the cell. The other nine cells were prepared with different wood waste mulch treatments; each were placed at thicknesses of 0.75, 1.5 and 3.0 inches. None of the cells were seeded or stabilized other than by the wood waste surface treatments. Weed control was performed every month or so and some weeds were pulled or cut to keep roots from developing as an erosion retardant. As a result of this weed control, the late fall storm events were expected to test the erosion resistance of these surface treatments before growth could be established.

Table 3. Surface treatments used in the test cells

Cell No.	Surface Treatment
1	Paper mill wood waste @ 3.0"
2	Paper mill wood waste @ 1.5"
3	Paper mill wood waste @ 0.75"
4	Control (untreated)
5	Pine bark mulch @ 3.0"
6	Pine bark mulch @ 1.5"
7	Pine bark mulch @ 0.75"
8	Geotextile silt fence
9	Hay bale barrier
10	Filter berm of paper mill wood waste
11	Control (untreated)
12	Stump grindings mulch @ 3.0"
13	Stump grindings mulch @ 1.5"
14	Stump grindings mulch @ 0.75"

Note: All wood waste and chip materials were used in this project as a mulch that was placed over the soil and not blended except for the filter berm in cell 10.

The erosion control performance of each cell treatment was evaluated for 11 storm events of varying rainfall magnitude and intensity. Calibrated tipper boxes were used to measure the amount of runoff from each cell and collection buckets were used to sample runoff and determine the mass of sediment eroded from each cell. Evaluating the performance of the various surface treatments when subjected to the expected range of rainfall magnitude and intensity was difficult to achieve because of the random nature of storms. It was accomplished, however, by visiting the field site after each storm for the period of June through mid-October 1999. Rainfall during the storm events varied from 6 mm to a maximum of 110 mm (4.35 inches) for Hurricane Floyd on September 16, 1999.

A day or two after each storm event, each runoff collection bucket was sampled for analysis of suspended solids in the runoff water. These suspended solids measurements indicate average erosion from each cell treatment and storm event, and are combined with the total runoff measured by the tipper boxes to determine the mass of sediment particles eroded from a slope. (The sediment mass eroded had to be corrected for the mass of coarse particles that tended to collect on the apron at the bottom of a slope and not enter the collection system.)

RESULTS AND CONCLUSIONS

The runoff volumes varied among the cells with the amount of total rainfall in the storm. In one case, when a storm event led to a heavy rainfall of 27 mm (1.06 inches) over a long weekend, the suspended solids concentration in the runoff was very high for the two untreated test cells (>10 g/l of solids). These erosion levels are more than an order of magnitude greater than the erosion for any of the treated test cells (<1 g/l).

Cells 8, 9 and 10 are used to compare the performance of the paper mill wood waste filter berm in cell 10 with the effectiveness of a silt fence in cell 8 and hay bales in cell 9. These cell surface areas are untreated like the control cells. Their retention of the flow allows some of the runoff water to percolate into the soil. During all storm events, the wood waste filter berm was more effective in retaining erosion runoff than either the hay bales or the silt fence. Figure 1 shows the ratio of the amount of soil reaching the measuring systems below the retention structures to that measured at the control cells. The results are presented as a percentage. All erosion control structures are effective in significantly reducing the amount of eroded soil that gets past the structure. The silt fence is more effective than a hay bale berm, but the wood waste filter berm reduces the amount passed by nearly an order of magnitude.

The primary conclusions of the study are as follows:

- Wood waste materials are effective in

minimizing erosion when applied to the soil surface as an erosion control mulch with a thickness of 0.75 inches or more. An untreated soil surface produced over 50 times more sediment than a treated surface.

- Wood materials are particularly effective in reducing runoff during storms under 0.5 inches by absorbing rainwater and by promoting percolation.
- The thickness of 0.75 inches allows vegetation to root and grow through wood waste materials.
- The wood waste erosion control filter berm was more effective than either hay bales or silt fence at controlling erosion. While all erosion control structures were effective compared to no treatment, hay bales and silt fence released about an order of magnitude more sediment than the filter berm made from paper mill mulch. ■

The performance of each cell treatment was evaluated for 11 storm events of varying rainfall magnitude and intensity.

Kenneth Demars is Associate Professor and Richard Long is Emeritus Professor at the University of Connecticut in Storrs. Jonathan Ives is a project engineer with URS Greiner in Rocky Hill, Connecticut. This work was sponsored by the New England Transportation Consortium at the University of Connecticut in Storrs.

WOODY RESIDUAL PERFORMANCE SPECIFICATIONS

ALL OF the wood residual materials that have been used in the field to prevent erosion from exposed surfaces have shown good results. The particle size distribution of these materials serves as a basis for writing specifications for mulch to prevent erosion from soil surfaces. Because there has only been limited opportunities to test wood residual materials in the configuration of a filter berm, a research project was designed to determine the hydraulic properties of four wood residual products in an unaltered state and a modified state. The results of this study and earlier phases (see main article) were used to prepare model procurement specifications for wood residual material as erosion control mulch and as erosion control filter berm. The work was sponsored by the New England Transportation Consortium.

Specifications prepared by the Coalition of Northeast Governors (CONEG) in 1996 do not clearly cite particles of wood residuals whose sizes are less than one-inch. It is possible to prepare a wood residual that has 100 percent of particles between one to three inches and meets the CONEG specification but would not filter out erodible soil particles.

Since materials in a berm function primarily as a filter – permitting water movement but retaining particles – it is the filtration behavior that is of greatest interest. To investigate design requirements for wood residuals, we focused on key properties that affect filtration – particle size distribution, organic content, unit weight or density. The accompanying table lists some physical properties for wood residuals tested: ground stump mulch, pine bark mulch, paper mill wood waste and Glastonbury mulch. Modifications made to these products in our test consisted of adding small particles to the grain-size distribution of the wood residuals. The filtration behavior of these materials was evaluated for its erosion control performance (e.g. simulating an erosion control berm). The tests used a series of glass beads of known size and an erodible soil from the field test site.

A filter medium need not retain all the particles in the soil; it must only retain the larger particles reaching it. Filtration is a progressive process in that particles retained will in turn retain smaller particles, etc. If the medium can do this, then these larger particles will help filter the smaller ones. The limitation of this process is that smaller particles reduce the permeability of the system, and reduced permeability will eventually cause the system to be overtopped during severe rain events, allowing some sediment to escape.

Our tests with wood residuals showed the importance of having some finer particles in the filter media. Due to the fact that wood waste particles are rod-like in shape, the relation between particle size and filtration is not as clear as it is for the bulky shape of sand particles or glass beads. The finer particles in wood residuals can be increased in several ways. Woody materials can be composted for a time, so that particles break down or they can be ground finer. In the case of grinding, the process can be adjusted to produce smaller particles.

The following is a summary of our findings: A typical wood residual requires at least 20 to 30 percent by dry weight passing the No. 20 sieve to be an effective filter berm that will retain fine sand to silt sized particles. For coarse wood having between 10 and 30 percent passing a No. 30 sieve, filtration properties and performance of a filter berm can bez improved by adding to the upstream face a thin layer of soil containing particle sizes 80 percent of which are greater than the No. 30 sieve. Moisture content of woody residues is not critical, but material is best placed when slightly damp to help compaction. Finally, paper mill woody residues performed best as a filter berm because they contained a high portion of fine particles and had a lower permeability than other materials tested.

Further field tests on degradation rates would help to determine the useful life of a filter berm using wood particles. Chemical and biological degradation of organics is a continuing process. The additional research would add to our understanding of optimum particle length needed to strengthen a berm, as well as correlate particle size to filtration performance.

Physical properties of wood residual test materials

Test Material	*Water Content,* %*	*Organic Matter Content,* %*	*Dry Unit Weight, pcf*	*Permeability, cm/s*
Ground stump mulch	154.7	55.9 - 93.9	11.2 - 15.0	3.88
Pine bark mulch	187.5	91.4 - 95.6	9.6 - 14.4	4.80
Paper mill wood waste	44.3	22.9 - 43.0	36.1 - 48.6	0.24
Glastonbury mulch	93.7	60.9 - 70.4	15.5 - 16.3	–

** = by dry weight*

This summary was excerpted from "Performance Specifications For Wood Waste Materials As An Erosion Control Mulch And As A Filter Berm" (March 2001) by Kenneth Demars and Richard Long

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Impacts of Compost Application on Highway Construction Sites in Iowa

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Abstract. Runoff, interrill erosion, and growth of erosion control vegetation and weeds were measured on conventionally treated portions (control) of newly constructed roadway embankments, and on areas pretreated with topsoil or one of three different types of composted organics. Runoff rates and interrill erosion rates from the control and topsoil-treated plots were highest. Runoff rates from the three compost media (biosolids, yard waste, bio-industrial waste) used were statistically lower than the control. Runoff from plots treated with yard waste and bio-industrial waste composts were statistically lower from plots treated with topsoil. Interrill erosion rates from topsoil-treated plots were significantly higher than from compost-treated or control plots. The amounts of planted cover crop grown on all treatments were statistically indistinguishable. Mean values for weed growth on the control and topsoil plots are statistically indistinguishable, and all compost treatments except biosolids-10 cm and yard waste-5 cm produced significantly lower weed growth than either the topsoil or control plots.

Keywords. soil erosion, runoff, highways, roads, construction

Introduction

Responding to public concerns expressed in 1989 regarding the groundwater pollution potential and rapidly diminishing capacity of the State's landfills, the Iowa legislature mandated a 50% reduction (by year 2000) in the amount of solid waste buried in landfills, and banned land filling of all yard and garden wastes. The new solid waste policy stimulated rapid growth in the organics composting industry in Iowa during the 1990's. Today, nearly 80 composting facilities divert and process 320,000 metric tons of yard waste, biosolids, and industrial organics from Iowa landfills annually. While successfully reducing pressure on landfills, the rapid increase in composting operations also has created a need for new markets that can utilize large amounts of composted materials.

New road construction and roadway maintenance projects in Iowa offer a potentially large market for composted organics. Iowa's 180,000 km network of city, county, and state roadways require constant repair and expansion, and roadway construction projects also demand significant attention to erosion and runoff control. Rapid establishment of cover crops are one of the most widely used methods of control. During fiscal year 2000 alone, the Iowa Department of Transportation (IDOT) let bids to seed and fertilize more than 2600 acres of land adjacent to 151 miles of state-sponsored road construction projects. Since many city and county road projects do not utilize the IDOT bidding process, statewide demand for roadside seeding and fertilization is even larger than suggested by IDOT project statistics.

While rapid establishment of vegetation is a top priority following completion of new roadway construction projects, the compacted subsoils that form roadway embankments often lack the infiltration capacity and organic matter content needed for rapid and vigorous growth of cover crops. Although it is generally acknowledged that application of composted organics to erosion-prone slopes has potential to improve organic matter content and reduce erosion, few studies have been conducted to quantify these benefits. To support Iowa's solid waste management goals and simultaneously determine if compost applications are sufficiently beneficial to justify their cost to road construction projects, the Iowa Department of Natural Resources and Iowa Department of Transportation funded a two-year study by researchers at Iowa State University.

Summary of Recent Literature

Recognizing that soil loss rates from construction sites are typically 10 – 20 times those from agricultural lands (USEPA, 2000), control of storm water, erosion, and sediment at construction sites was mandated by 1987 amendments to the federal Clean Water Act (CWA). EPA Phase I Rules, promulgated in 1990, require construction permits and pollution prevention plans for construction sites disturbing more than five acres (USEPA, 2000). Phase II rules, which became final in 1999 and will take effect in 2003, extend the requirements of the storm water program to smaller construction sites of one to five acres in size (USEPA, 2001).

Storm water and erosion regulations specific to highway construction sites include the Intermodal Efficiency Act of 1991, which requires the Federal Highway Administration (FHWA) to develop erosion control guidelines to be used by states whenever road construction projects are supported by federal aid (Federal Highway Administration, 1997). The "Transportation Equity Act for the 21st Century", signed into law in June of 1998, continues several water-related provisions of the Intermodal Efficiency Act and adds new programs addressing storm water treatment systems, BMP's, and wetland restoration projects (US Environmental Protection Agency, 1998)

Current literature suggests that many states have experimented informally with using compost to reduce erosion and water quality problems, but there are relatively few reports of quantitative measurements of the impacts of compost on erosion or water quality. A survey of state departments of transportation (DOT's) by Mitchell (1997), indicated that 19 state DOT's had developed specifications for compost use. Thirty-four DOT's reported experimental or routine use of compost on roadsides for purposes such as: improved grass, tree, and wildflower production; erosion control; reduced moisture loss; filter berms; and bioremediation of soils contaminated by petroleum compounds. Highway projects using composted organics specifically to control soil erosion were reported in Maine, California, Washington, Florida, Oregon, and Arizona.

A review of literature on pollution caused by highway runoff and highway construction by Barrett et al. (1995) notes that the most commonly-cited water quality impacts of road building are increased turbidity and suspended solids concentrations in construction site runoff during and immediately following completion of construction. Barrett's review also indicates that most highway erosion research conducted in the U.S. since the 1960's focused on erosion reduction using synthetic slope covers, natural fiber mats, mulches, sediment barriers, check dams, and sedimentation ponds. No specific references to utilization of composted organics for erosion control were noted.

Reports of projects specific to the use of compost (or wood waste) on road construction projects include a project sponsored by the Federal Highway Administration (FHWA) and the US Environmental Protection Agency (EPA) which reported superior vegetative growth on compost amended soils when compared to that produced on plots treated with hydromulch and fertilizer (USEPA, 1997).

The Texas Natural Resources Conservation Commission and the Texas Department of Transportation have cooperated on five road construction demonstration projects using composted dairy or cattle manure. Project coordinators report that three-inch layer of compost substantially improved vegetation growth and reduced soil erosion compared with untreated roadway embankments (Block, 2000, USEPA, 2000).

A seven-month project by the city of Portland, Oregon, applied 7.6 cm layers of three different yard debris composts to a road construction site, mobile home development, and a new home site. Site slopes ranged from 0 to 35 degrees. Erosion was evaluated visually following natural rainfall events and via monthly site photographs. Project staff reported evidence of reduced erosion and improved water quality, with some cracking or rilling of the compost layer on steeper slopes (Portland Solid Waste Department, 1994). Ettlin and Stewart (1993) reported that the use of yard debris compost is an effective alternative to current erosion control measures on slopes up to 42%. A more quantitative follow-up study planned for 2001 by the Oregon Department of Environmental Quality and City of Portland will compare the quantity and quality of natural runoff from an urban construction site amended with compost, to that from a construction site receiving conventional storm water control practices (Kunz, 2001).

Quantitative erosion control studies using compost or organic mulches with textures similar to some composts include work by Demars, Long, and Ives (2000) who applied 2 – 8 cm blankets of wood waste to 14 test cells on a highway embankment with a 26 degree slope. Total rainfall, rainfall intensity, test cell runoff, and suspended solids concentrations, were recorded from 11 natural storm events. Plots treated with wood waste blankets substantially reduced runoff, particularly for storms of 1 cm or less, and bare plots exhibited as much as 50 times more sediment than those treated with the wood mulch.

Alexander (2001) reports that the depth of compost application varies depending on site characteristics such as slope, existing soil conditions, and the type of compost. Stewart and

Pacific (1993) suggested blanket applications of 7.5 cm and Michaud (1995) suggested blanket applications of 10 cm. Michaud (1995) further explained that applications at 10 cm will effectively control erosion on slopes up to 45% for 1 to 3 years.

Storey et al. (1996), compared vegetative growth and erosion on compost-amended plots and plots treated with shredded wood and two types of synthetic chemical tackifiers. Treatments were applied to two general soil types (sand and clay), simulated rainfall was applied at three different intensities, and sediment losses were compared with erosion standards set by the state of Texas. Compost amended plots on clay soils were shown to be as effective as the other treatments. On sandy soils, erosion on compost-treated plots was less than half that recorded for the other treatments.

A two-year study completed in 1998 by the Connecticut Departments of Environmental Protection and Transportation evaluated erosion on experimental plots constructed on a new roadway embankment with 2:1 slopes. Eight plots were treated with 1.5– or 3–inch depths of composted yard waste, wood mulch, and straw. Erosion on the untreated control plot was reported to be more than 10 times that produced on any of the mulched plots. Thickness of the mulch layer did not appear to significantly affect the observed erosion rates (Block, 2000).

Agassi et al. (1998) studied the effects on storm runoff of surface-applied municipal solid waste compost. One- to three-centimeter thick layers of compost were surface applied to identically prepared loess soils placed in small boxes and subjected to six simulated rainfalls totaling 260 mm. Approximately 85% of applied rainfall infiltrated into compost-treated plots while 52% or less was absorbed by control plots.

Project Objectives

Excess erosion on road construction projects results in expensive regrading and reseeding, and during seasons with severe storms this can happen repeatedly before permanent cover is established. While there is considerable qualitative evidence that application of composted organics to roadsides has potential to reduce erosion and improve water quality, the amount of quantitative data currently available are insufficient to determine whether the environmental benefits justify the added cost of compost applications. A better understanding of the relationships between rainfall intensity, compost type and rate of application, erosion, and runoff quality can thus provide transportation officials and other land managers with an important tool for environmental and economic analysis.

To investigate the impacts of compost on roadside erosion control, Iowa State University (ISU) researchers and representatives of the Iowa Department of Natural Resources and the Iowa Department of Transportation established the following project objectives:

- Assess the impacts of compost use on establishment and growth of roadside vegetation intended to reduce runoff and soil erosion;
- Measure and compare runoff and interrill erosion from compost-treated, topsoil-treated, and untreated roadway embankments using rainfall simulation and established erosion measurement techniques;
- Measure and compare rill erosion on compost-treated, topsoil-treated, and untreated roadway embankments using rainfall simulation and established erosion measurement techniques;
- Determine appropriate soil erodibility values for compost-treated slopes that can be used in the USDA Water Erosion Prediction Project (WEPP) computer model to predict potential erosion control benefits of using compost on road construction projects.

- Develop and maintain a project website to inform the citizens of Iowa about the purpose, methods, and results of the project.

This paper presents first-year data and findings (data from 3 additional replications are being collected during the summer of 2001) relevant to the first two objectives (assessment of interrill erosion and vegetative growth) listed above. Analysis of rill erosion data and calculation of soil erodibility factors are under way and will be reported at a later date. Interested readers can view the project website at http://compost.ae.iastate.edu.

Materials and Methods

Compost Selection

Compost is not a homogeneous commodity. A diversity of feedstocks, processing technologies, and product screening techniques generate a wide range of products with varying characteristics. Some characteristics, such as particle size and nutrient availability, may significantly affect the physical processes of erosion and the biological processes of plant growth. Composts selected for inclusion in this study are derived from: sewage biosolids and yard waste processed by the city of Davenport, IA; yard waste processed by the Metro Waste Authority of Des Moines, IA; and a mix of source-separated bio-industrial byproducts (paper mill and grain processing sludge) and yard waste received by the Bluestem Solid Waste Agency in Cedar Rapids, IA. The Iowa Department of Natural Resources selected these composts because they are considered to be representative of three common types of organics that are readily available in large quantity throughout the state.

Site Selection

Iowa Department of Transportation staff and ISU project investigators jointly selected a re-graded interstate highway interchange located approximately 16 km north of Ames, Iowa as the research site. The site includes two south-facing compacted earthen embankments that were reconstructed in late 1999 to permit repositioning of safety railings further from the traffic lanes. The embankment slope is approximately 3 to 1, the maximum typically allowed by state and federal highway construction standards.

Methods

Experimental Plots & Treatments

Prior to establishing the experimental plots, the roadway embankment was prepared by an IDOT site contractor according to IDOT specifications. Site preparation consisted of disking parallel to the slope contour to roughen the compacted soil and destroy unwanted weed growth.

Experimental plots measuring 120 cm by 180 cm were subjected to one of 8 treatments. Six of the treatments consisted of either 5 cm or 10 cm thick blankets of one of the three composts. The remaining two treatments include a 15 cm blanket of imported topsoil, or no treatment (control). Both the topsoil and control treatments are typical practices specified by IDOT and are included in the experimental design to provide a benchmark against which to assess the erosion control and vegetative growth performance of the compost treatments.

Each of the plots was replicated 6 times during the first year of the project. Three of the replications were tested immediately following plot construction to simulate runoff and erosion from an un-vegetated construction site. The remaining three replications were fertilized and planted with a mixture of oats, rye, timothy, and clover according to IDOT specifications, and were subjected to testing approximately 6 weeks after vegetation emerged. During the second year of the project, all treatments will be replicated at a different location on the same highway interchange so that data from six vegetated and six un-vegetated replications will be obtained for each treatment.

Runoff and Erosion Assessment

Runoff and interrill erosion were evaluated by applying simulated rainfall to 50 cm by 75 cm areas located in the center of each of the experimental plots. The erosion and runoff measurement areas are bordered on the up-gradient edge and sides with 20 cm wide galvanized steel strips driven approximately 5 cm into the ground. Runoff originating within the steel borders is captured by a V-shaped galvanized steel tray positioned along the down-gradient edge of each plot, and is diverted into a 1-L plastic sample container positioned outside the rainfall pattern (Fig.1).

Rainfall was applied to experimental plots using an 8-m long single-sweep Norton Rainfall Simulator of the type developed for soil erosion studies and used worldwide by the USDA National Soil Erosion Laboratory located at Purdue University.

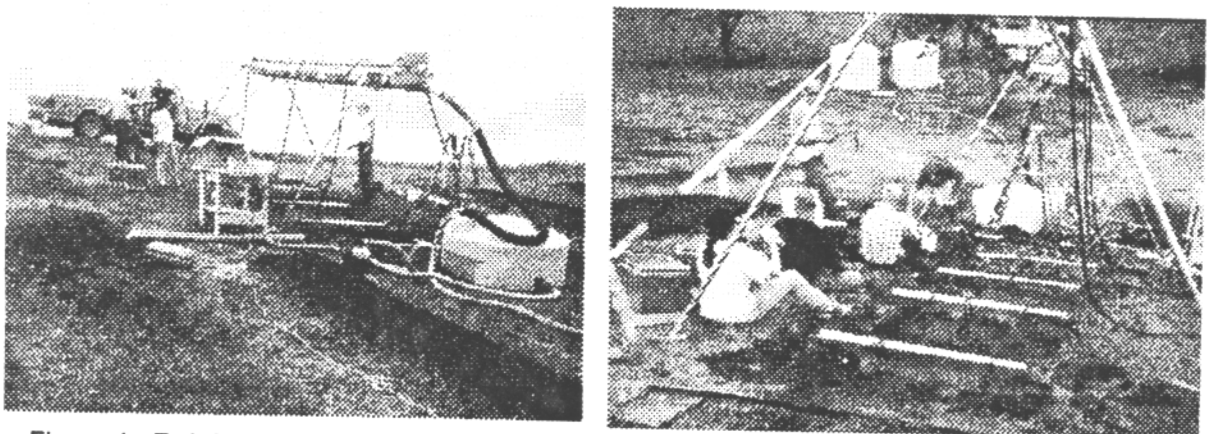

Figure 1. Rainfall simulator and interrill plots (left), and interrill erosion sampling in progress.

Runoff and erosion measurements made during this study followed procedures similar to those used by USDA researchers at the National Soil Erosion Laboratory during development of the Water Erosion Prediction Project (WEPP) and as described in detail by Liebenow et al. (1990) and King et al. (1995). Typically, soil test plots are subjected to simulated rainfall at a fixed rate of 63 mm/hr for approximately one hour or until runoff is initiated. As soon as runoff from a plot is observed, sampling is begun and 10 –12 samples are collected at 5- to 7-minute intervals during the first hour of runoff. Start and finish times for each sample are recorded so that runoff rates can be calculated. Samples are weighed, dried, and reweighed in the laboratory to determine the total mass of sediment and water captured during each runoff-sampling interval. Data from rain gages positioned near each experimental plot are used to determine the total amount and rate of rainfall applied, and plot infiltration is calculated as the difference between the applied rainfall and the amount of runoff collected.

An important difference between the USDA study procedures typically used on natural soils, and those used on the compost treated plots in this particular study, is that the compost produced relatively little runoff at the standard rainfall intensity of 63 mm/hr. In order to initiate runoff from the compost-treated plots within a reasonable length of time, rainfall intensities were increased to 80 –110 mm/hr.

Cover Crop Assessment

First year comparisons of the cover crop produced by the different treatments were accomplished by randomly sampling each of the vegetated plots (outside of the eroded areas subjected to simulated rainfall) at the end of the growing season. A sampling ring of known area was tossed onto the vegetated areas of each plot to randomly select the sample area, and then all vegetation inside the ring was hand clipped at ground level and stored in refrigerated bags until the samples could be dried and weighed. At the time of weighing, each of the samples was visually examined and separated into two sub-samples containing planted species (oats, rye, timothy, and clover) and weeds.

Results

Rainfall Intensity

Since both runoff and erosion are typically affected by rainfall intensity, it is important to determine if all treatments received rainfall of equal intensity during collection of runoff and erosion data. Despite the use of rainfall simulation equipment, shifts in wind velocity and minor day-to-day variations in pump and rainfall simulator control settings can cause differences in the rainfall intensities applied to experimental plots.

Mean rainfall intensities received by each treatment during the first year of the study are summarized in table 1. Analysis of variance (ANOVA) indicates no significant differences ($p=0.7552$) in rainfall intensity received by the various treatments, allowing subsequent analyses of runoff and interrill erosion data to be carried out without making adjustments for rainfall variability.

Table 1. Mean rainfall intensity for 6 compost treatments, control, and topsoil.

Treatment	Replications	Mean Rainfall Intensity (mm/hr)	Standard Deviation
Biosolids – 5 cm	6	90.61[a]	22.28
Biosolids – 10 cm	6	102.44[a]	19.22
Yard waste – 5 cm	6	95.05[a]	16.84
Yard waste – 10 cm	6	89.02[a]	24.94
Bio-industrial waste – 5 cm	6	84.72[a]	23.61
Bio-industrial waste -- 10 cm	6	100.18[a]	24.39
Control	12	91.90[a]	20.97
Topsoil	12	93.53[a]	32.33

Means with different letter designations are significantly different ($p<0.05$).

Runoff Rate

As shown in Figure 2, control and topsoil treatments exhibited the highest mean runoff rates, while mean runoff rates from the bio-industrial and yard waste compost treatments were the lowest. Several statistical tests were conducted to determine whether the treatment differences are statistically significant, and to identify which factors affect runoff the most.

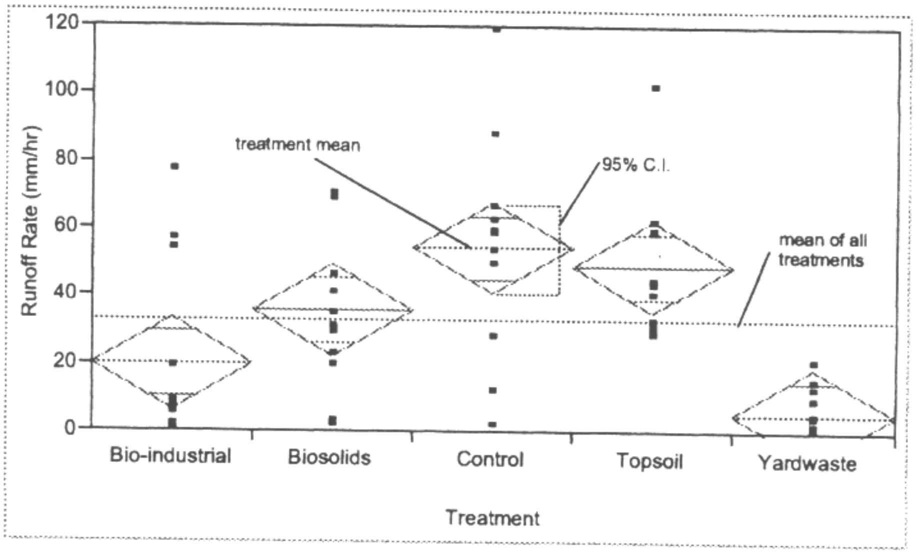

Figure 2. First year mean runoff rates for compost-treated, control, and topsoil-treated plots.

Analysis of variances confirms statistically significant ($p<0.0001$) differences in runoff between some treatments. Although vegetation status is a factor that might reasonably be expected to impact runoff rate, ANOVA results show that the interaction of vegetation with the plot treatments was not significant ($p=0.7650$). This means that vegetation effects are essentially the same for each treatment, and that data from vegetated and un-vegetated plots can be combined for the purposes of subsequent statistical analyses.

Statistical contrasts were performed to answer questions regarding the effects on runoff caused by compost depth and type of compost. The first contrast was performed to determine whether compost application depth (5 cm or 10 cm) is a significant factor in the runoff rate (regardless of compost type). Mean runoff from all 5 cm compost treatments was compared with mean runoff from 10 cm compost treatments and found to be significantly different ($p=0.0494$).

Since compost depth is a significant factor in runoff, it is necessary to test whether depth has similar effect on runoff from each type of compost. If the runoff effects of compost depth are similar for all composts, then depth can be disregarded when comparing different composts to one another or to the control and topsoil treatments. This, in fact, was the case as the interaction between depth and compost type was not statistically significant ($p=0.2629$). Based on this finding, runoff data for the two composts depths were combined for the purpose of subsequent analyses.

Mean runoff rates for all treatment media (aggregating vegetation status and depth, since neither factor is significant), are shown in table 2. Biosolids had the highest rate of runoff of all the composts, and was significantly higher ($p=0.0011$) than yard waste, which had the lowest runoff. Runoff from the bio-industrial compost fell between that from the other two composts and was not significantly different from either.

Mean runoff from the control and topsoil treatments was not significantly different. All compost-treated plots produced significantly lower runoff than the control plots. Both the yard waste and bio-industrial composts produced significantly lower runoff than the topsoil treatment, but mean runoff from the soil-like biosolids compost did not differ significantly ($p=0.1409$) from the topsoil treatments.

Table 2. First year runoff rates for compost, control, and topsoil treatments (aggregated data for 2 vegetation conditions and 2 compost depths).

Media	Replications	Mean Runoff Rate (mm/hr)	Standard Deviation
Biosolids	12	36.00[a,d]	24.00
Yard waste	12	5.50[b]	6.80
Bio-industrial waste	12	19.90[a,b]	26.50
Control	12	54.40[c]	31.30
Topsoil	12	48.90[c,d]	21.00

Means with different letter designations are significantly different ($p<0.05$).

Interrill Erosion Rate

The general trends for mean interrill erosion rates are similar to those for runoff (Figure 3). Again, the control and topsoil treatments exhibited the highest mean values, and the compost treatments are lower.

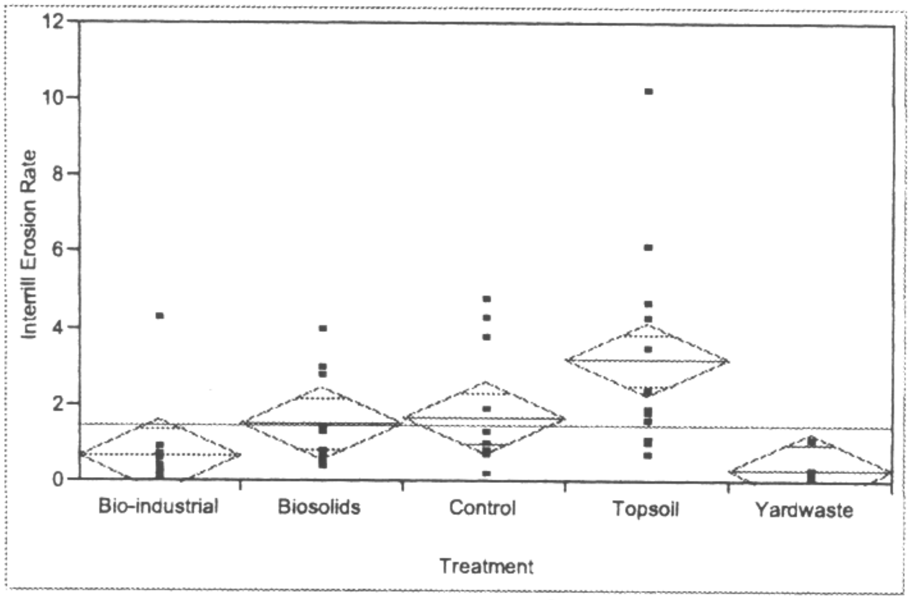

Figure 3. First year mean interrill erosion rates (mg/m²/sec) for compost-treated, control, and topsoil-treated plots.

The ANOVA of mean interrill erosion rates for all treatments indicates highly significant differences among some treatments ($p=0.0002$). As with the runoff data, however, the interaction between vegetation status and treatments was not significant ($p=0.3777$), indicating that the presence or absence of vegetation has equivalent affects on interrill erosion for all treatments. As a result, data from the vegetated and un-vegetated plots were combined for the purposes of subsequent statistical analyses.

As before, statistical contrasts were performed to answer questions regarding the specific effects of depth and type of compost. No significant differences ($p=0.7212$) in mean interrill erosion rate were noted between the 5- and 10-cm compost depths, making it possible to combine the data from both depths for the purposes of subsequent statistical analyses.

Mean interrill erosion rates for all treatment media are presented in table 3.

Similar to the runoff data, biosolids compost had the highest mean interrill erosion of all the composts, and was significantly higher than yard waste, which had the lowest mean interrill erosion. Again, the mean value for the bio-industrial compost fell between those from the other two composts and was not significantly different from either.

Mean interrill erosion for topsoil is significantly higher than for the control or any of the compost treatments. Mean interrill erosion for the control treatment is significantly higher than for the yard waste compost ($p=0.0127$), but is not significantly different from erosion measured on the biosolids or bio-industrial plots.

Table 3. First year interrill erosion rates for compost, control, and topsoil, treatments (aggregated data for 2 vegetation conditions and 2 compost depths).

Media	Replications	Mean Interrill Erosion Rate ($mg/m^2/sec$)	Standard Deviation
Biosolids	12	1.50^{a}	1.25
Yard waste	12	0.27^{b}	0.38
Bio-industrial waste	12	$0.68^{a,b}$	1.14
Control	12	1.65^{a}	1.60
Topsoil	12	3.19^{c}	2.78

Means with different letter designations are significantly different ($p<0.05$).

Vegetative Growth

Planted Species Biomass

Data from 3 end-of-season samples are shown in Figure 4. The mass of planted species (oats, rye, timothy, clover) produced on the biosolids compost was somewhat lower than for the other composts, but there were no statistically distinguishable differences between the dry mass of planted species produced by the various treatments (Table 4).

Table 4. First year mean dry mass of planted species considering media and depth (treatment).

Treatment	Replications	Mean Mass of Planted Species (g)	Standard Deviation
Control	3	49.55^{a}	14.48
Topsoil	3	31.30^{a}	13.53
Biosolids - 5 cm	3	30.56^{a}	18.12
Biosolids - 10 cm	3	33.72^{a}	5.81
Yard waste - 5 cm	3	40.95^{a}	14.68
Yard waste - 10 cm	3	53.93^{a}	4.45
Bio-industrial waste - 5 cm	3	52.70^{a}	7.87
Bio-industrial waste – 10 cm	3	49.89^{a}	23.33

Means with different letter designations are significantly different ($p<0.05$).

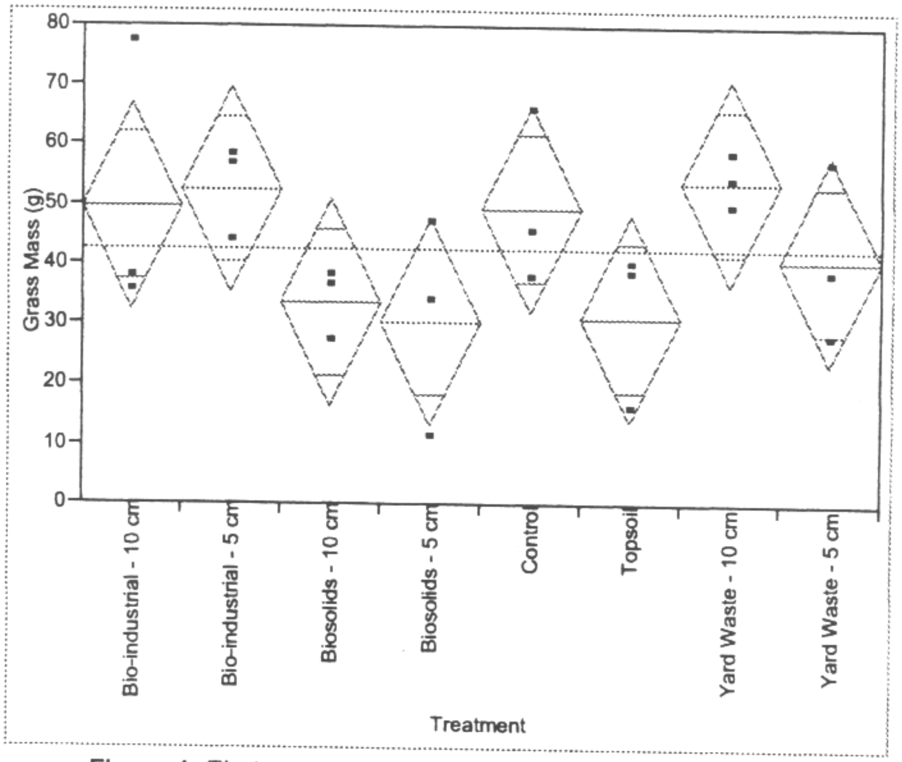

Figure 4. First year mass of planted species by treatment.

Weed Biomass

In general, compost-treated plots produced noticeably less weed mass than the control and topsoil-treated plots as shown in figure 5. Analysis of variance verified significant differences ($p = 0.0323$) in the dry mass of weeds produced by some treatments. Tukey's pair wise comparisons shows that mean values for the control and topsoil plots are statistically indistinguishable, and that all compost treatments except biosolids-10 cm and yard waste-5 cm produced significantly lower weed growth than the topsoil or control plots. As shown in table 5, mean values for these two compost treatments are well below those for the control and topsoil treatments, and it is believed that additional biomass data from the second year of the project will substantiate a significant difference.

Table 5. First year mean dry weed mass considering media and depth (treatment).

Treatment	Replications	Mean Weed Mass (g)	Standard Deviation
Control	3	33.09[a]	27.28
Topsoil	3	29.55[a]	24.10
Biosolids- 5 cm	3	0.00[b]	0.00
Biosolids - 10 cm	3	6.39[a]	11.07
Yard waste - 5 cm	3	5.19[a]	8.18
Yard waste - 10 cm	3	0.10[b]	0.17
Bio-industrial waste - 5 cm	3	0.00[b]	0.00
Bio-industrial waste – 10 cm	3	0.84[b]	1.46

Means with different letter designations are significantly different ($p<0.05$).

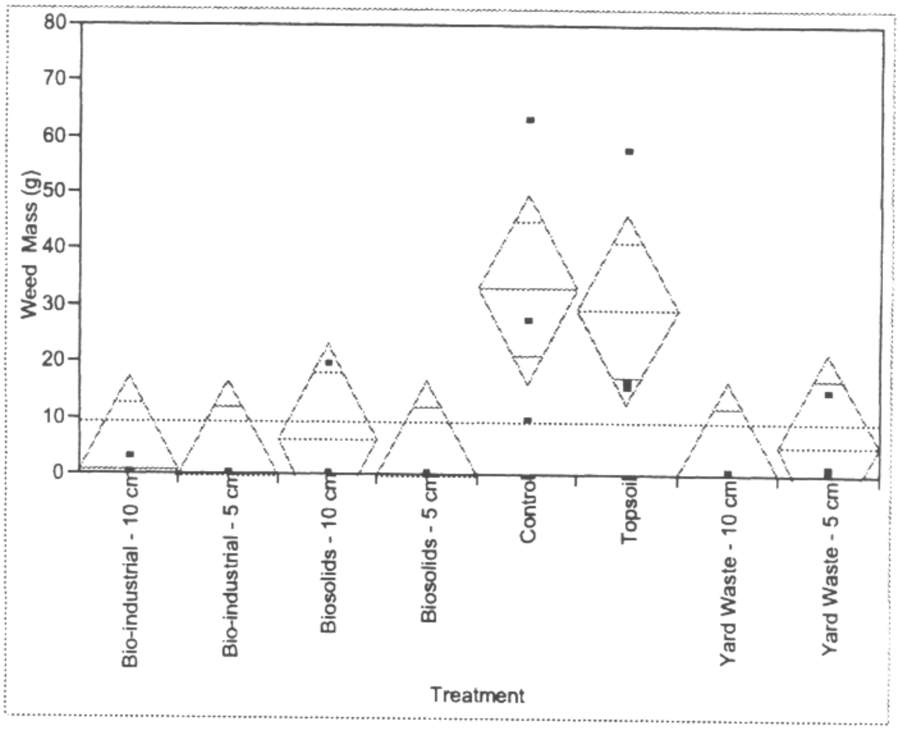

Figure 5. First year weed mass by treatment.

Conclusions

Runoff rates from un-vegetated and vegetated plots did not differ significantly, but runoff rates from plots treated with 5 cm of compost are significantly lower than those treated with 10-cm thick layers of compost. The three compost media runoff rates are all significantly lower than the control. In addition, all three compost media runoff rates are lower than the topsoil, but only the yard waste and bio-industrial waste are significantly lower. Runoff from yard waste was the lowest of the three compost media, and was significantly lower than the biosolids runoff rate.

Mean interrill erosion rates for compost–treated plots are lower than for the control plots, but only the yard waste is significantly lower than the control. All compost-treated plots and the control plots displayed interrill erosion rates significantly lower than topsoil-treated plots. As with the runoff data, yard waste interrill erosion was lowest among the three composts, and is significantly lower than the biosolids interrill erosion rate.

Despite some obvious physical differences in texture, density, and organic matter content, the amounts of planted cover crop grown on all treatments were statistically indistinguishable. Mean values for weed growth on the control and topsoil plots are statistically indistinguishable, and all compost treatments except biosolids-10 cm and yard waste-5 cm produced significantly lower weed growth than either the topsoil or control plots. It is believed that the heat-treated compost materials contained substantially fewer viable weed seeds than the topsoil and control soil. As a result, the cover crop planted into the 5 and 10 cm compost blankets was able to emerge rapidly and establish a canopy before weed seedlings originating in the underlying soil could penetrate through the compost layer.

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TEXAS MAKES INROADS WITH HIGHWAY USE OF COMPOST

Success vegetating a slope that hadn't seen green since the highway was built in 1968 has led to broader use of compost by TxDOT — and a potential solution to how to handle the millions of tons of manure generated annually in the state.

Scott McCoy
and Barrie Cogburn

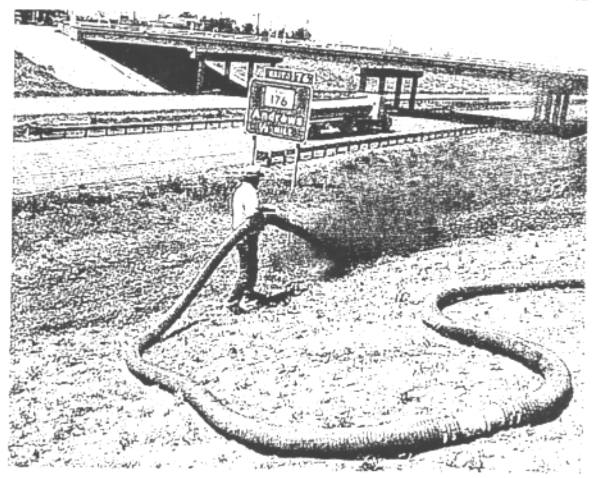
LOCATED 60 miles southwest of the Dallas-Ft.Worth metroplex is the bustling town of Stephenville, Texas, population 14,600 and 67,622 dairy cows. Every dairy cow in Stephenville produces approximately 100 pounds/day of manure, 365 days/year — or 18.25 tons/year/ cow. Multiply that by the total number of dairy cows in the area and you get 1,234,101 tons/year of manure — way more than what the land in the Stephenville area can ever handle in the way of direct land application.

Faced with this manure management challenge, the Texas Natural Resource Conservation Commission (TNRCC) began exploring cost-effective options for handling manure outside of the area where it is generated. One promising solution was to compost the manure and then tap end uses in a broader geographic area. And a promising end use selected is application of the compost to Texas roadways to establish vegetation. The TNRCC approached the Texas Department of Transportation (TxDOT) with a proposal to work jointly to demonstrate the application of compost along roadsides to the public, potential contractors, and other interested parties.

TxDOT responded positively to the idea, especially as the agency was becoming increasingly concerned about depleted soils that had little or no organic material to sustain plant growth, leading to severe erosion on many projects. If erosion occurs while the project is still under contract, the contractor must reapply topsoil, seed, fertilizer, and mulch/and or erosion control blankets and cannot leave the project until sufficient grass growth occurs. If erosion results on existing highway sections, TxDOT maintenance is left to deal with the resulting problem, which is an added expense.

VEGETATING THE FIRST SLOPE

In May, 1999, the two agencies held a demonstration in the West Texas town of Big Spring. TxDOT had tried five times — unsuccessfully — to establish vegetation on a steep, severely eroded overpass. The site was constructed in 1968 in a low rainfall area and had been barren except for the occasional tumbleweed for nearly 30 years. There were six-inch gullies running the entire length of the slope. Compost made from



The Big Spring site had been unsuccessfully revegetated with conventional treatment, and had six-inch gullies running the entire length of the slope (top). A blend of compost and wood chips was applied at a depth of three inches (middle). Within a month, thick grass was growing in the treated area (left side of bottom photo) versus the untreated area (right side of bottom photo).

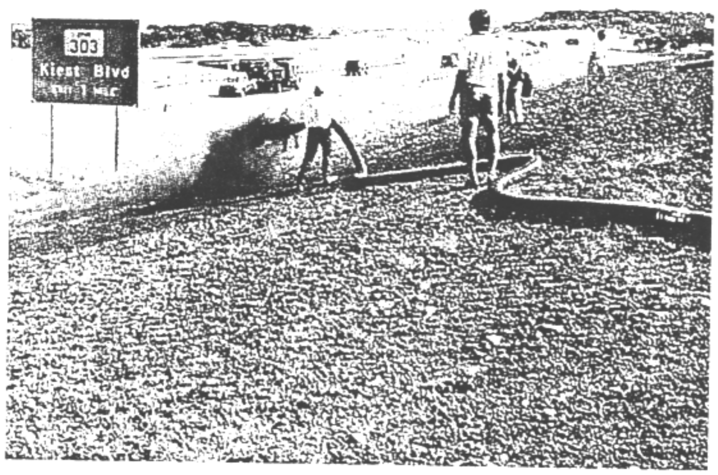
The use of compost along roadways in Texas has been demonstrated in 14 of the 25 TxDOT districts, often with remarkable results.

feedlot manure, cotton burrs and yard trimming wood chips was applied with a Rexius blower truck at a depth of three inches, and was used to fill the gullies. Grass seed was mixed in with the compost prior to application. Because wind erosion was considered a problem at this site, wood chips — generally less than three inches in size — were blended with the compost (at a 3:1 ratio of compost to chips) to keep the lighter compost from blowing away. The wood chip blend held the compost in place.

By mid-June, thick grass was growing on soil that had laid barren since the highway was constructed over 30 years before. Compost was the only application that provided a successful growing media over that time. A filter strip made out of the compost mix was built at the top of the slope for demonstration purposes only. It was about 100 feet in length (it would have been longer, but the supply of compost ran out). The filter berm worked well as it rained within a week of the compost blend application and the water was diverted as designed.

WIDESPREAD DEMONSTRATIONS

After the successful Big Spring project, the TNRCC and TxDOT initiated two more demonstrations using a topsoil manufactured from manure compost. The manure was generated by dairy operations located within the North Bosque watershed around Stephenville and Dublin.



Overall, the use of compost along roadways in Texas has been demonstrated in 14 of the 25 TxDOT districts, often with remarkable results. The latest one is in the Brownwood District, where one side of the highway was done without compost and the other had compost applied. The demonstration led this district office to specify compost for ten miles of roadway.

In another demonstration near Dallas, compost was used side by side with conventional vegetative establishment techniques (application of soil to the slope and a synthetic fiber blanket for erosion control). The application was done during a period of drought in north Texas. The areas established using compost had maintained over 90 percent cover while the areas treated with conventional methods had 25 to 30 percent cover. In addition, the compost areas were green and thriving while in the nontreated areas, the grass had withered and died. TxDOT requires 70 percent coverage of vegetation before a job is considered complete (five percent of the payment for highway projects is withheld until 70 percent is achieved); the composted areas far exceeded these requirements.

The demonstrations also have provided an opportunity to test the three different compost classifications developed for TxDOT's specifications (see below). In addition to manure compost, biosolids and yard trimmings composts have been used. All the applications include a blend of compost and wood chips. Filter berms were used in most of the demonstrations, and with the newly approved filter berm specification, they will be demonstrated in all future programs. Several types of equipment have been used for these applications, including blowers, manure spreaders, side slingers, front-end loaders and graders.

Compost has been applied to the soil surface as a top dressing as well as applied and tilled into the soil. Applications range from one-half inch to two inches deep. We have found that the maximum benefit of compost is limited to one inch in depth, with additional depth adding cost without increasing benefits. Tilling in the compost increases the soil microbe activity with positive benefits to soil tilth.

The demonstration projects also have helped to stimulate an increase in compost production. For example, while composting had been discussed as an alternative to land application of manure in the North Bosque watershed, potential composters who had the capability to build processing capacity were reluctant due to their apprehension about the compost markets. Several compost operations had come and gone in the area, failing because of the lack of reasonably close markets. The large volume markets were 60 miles away in the Dallas/Ft. Worth Metroplex. Dairymen also were reluctant to sign up with a composter because of this market situation. TxDOT's intentions to use compost (and then actual purchases) helped to address the situation, providing a sustainable market for large volumes of compost. The TNRCC has now assisted in the development of seven composting operations within the Bosque/Leon watersheds.

COST COMPARISONS

The demonstration projects have proven that, in addition to conserving water, using composted topsoil alongside highways has an economic benefit. "The Big Spring project showed us that using compost for normal roadside maintenance, erosion control, or repairs saves about 20 percent of the cost of a traditional seed-soil-erosion blanket," says TNRCC Commissioner John Baker. "For new construction, the savings jump to about 60 percent." The amount of savings depends on the location of the project, the costs of transporting compost to that site and the type of application.

While no actual cost comparisons have been done at this time, some general cost discussions between TxDOT and TNRCC, contractors and applicators provide some insights, as follows: Application of erosion control compost — $.75 to $2/sq.yd. (depending on depth); Application of erosion control blanket — $1.25 to $3.50/sq. yd. (depending on slope). Furthermore, in the case of our demonstrations, there has been no additional cost due to the need for maintenance follow-up.

In a demonstration near Dallas, the part of the site treated with compost maintained over 90 percent of its cover (left and above), while an adjacent site treated conventionally had 25 to 30 percent cover.

At the demonstration in the Brownwood District in January, the maintenance engineer expressed a willingness to pay more for the application of compost if it would increase germination rates and reduce the need for revegetation. This would reduce the number of failures that his maintenance staff has to contend with after construction is complete.

Application of mulch/compost material as a filter berm costs in the range of $.80 to $2/linear foot. There are no additional costs for removal and disposal and the compost berm provides more organics to the soil. Application of standard silt fence is $1 to $3.50/linear foot, which does not include the additional cost of maintenance and the removal and disposal of used materials (roughly $1 to $2/linear foot). In the Brownwood District, the same maintenance engineer indicated that he might be interested in using the compost/mulch filter berm to reduce maintenance and removal costs, even if the initial cost is higher.

COMPOST SPECIFICATIONS

Before any demonstration projects were conducted, TxDOT asked TNRCC if it could assist in developing a specification for compost use. The project took almost a year to complete. Information was gathered from all states that had a specification available. A committee was formed with TxDOT and TNRCC staff, and composters from various communities. TxDOT Special Specification Item 1027, "Furnishing and Placing Compost," was developed and submitted to TxDOT's specification committee for approval, which was given in January, 1998. It identifies three grades or classes — compost for manufactured topsoil, erosion control compost, and general use compost. Erosion control compost and general use compost are required to have 40 to 60 percent organic matter; compost for manufactured topsoil has 30 percent organic matter. Particle sizes for the erosion control compost are two to three times that of the other two compost classes. The TxDOT specifications also require that the compost be tested for maturity using the Solvita test. This provides an added layer of product quality control and confirms the results of laboratory analyses that have to be submitted to TxDOT within six months of compost use.

The success of the Texas demonstration projects led to the development of an additional statewide TxDOT specification. The "Mulch/Compost Filter Berm for Erosion and Sedimentation Control" (Item 1034) was approved for statewide use in September, 2000. Item 1034 increases the particle size of the material to allow for water to filtrate through the berm structure. It allows for the use of a variety of materials to be composted and sets minimum requirements for the quality of material and construction methods.

The mulch filter berm is used when an area is not to be reseeded, so shredded brush meeting the specification would be used. When the filter berm is to be reseeded, the compost filter berm would be used. An example would be if a contractor wanted to put a temporary filter berm around a stockpile of topsoil at the site. A mulch filter berm would be utilized because the berm is temporary and seeding is not necessary. If a berm were being used along the top of a slope to reduce erosion, than a compost filter berm would be put in place that could be seeded and left on site after construction.

TxDOT Special Specification Item 1027, "Furnishing and Placing Compost," identifies three grades or classes — compost for manufactured topsoil, erosion control compost and general use compost.

Over the next three years, districts included in a U.S. EPA-funded watershed protection project have committed to utilize 200,000 cubic yards of compost.

COMPOST USE AND WATERSHED PROTECTION

A UNIQUE partnership between the Texas Department of Transportation (TxDOT), Texas Natural Resources Conservation Commission (TNRCC), and the Texas State Soil and Water Conservation Board (TSSWCB) will result in more compost being used on roadsides and in other applications across Texas. The U.S. Environmental Protection Agency's Region 6 office, along with the TNRCC and TSSWCB, have completed a grant in the amount of $5.1 million to assist in further encouraging the use of composted dairy manure through funding of a Clean Water Act Section 319 grant. These are incremental funds to be used by states in areas with threatened waterways.

TxDOT projects using compost made from dairy manure from the Bosque and Leon watersheds will receive $5/cubic yard of compost, which will be applied to the transportation of finished compost for TxDOT construction and maintenance projects within a 150-mile radius of the watersheds. Because transportation is a large factor in the price of compost, eligibility in this program was limited to those districts within a 150 mile radius of the watersheds. Of the 25 TxDOT districts, seven fall within this region and are eligible for this incentive. The grant also will provide an incentive for the transportation of manure from the dairy operations to area composters.

Cities, counties and universities, also can receive the $5/cubic yard transportation refund if they want to utilize compost for construction, grounds work or revegetation projects. A series of workshops have begun to assist these other potential markets/users in the utilization of compost for their particular needs.

Using materials that once were considered a waste also supports TxDOT's emphasis on the use of recycled products. All compost feedstocks used on TxDOT projects must meet the same strict EPA standards for Class A biosolids.

REALIZING THE POTENTIAL

The successes with the use of compost in vegetation establishment along Texas roadways have shown the utility of the product for erosion control and moisture retention as expected. The Texas demonstrations have also shown the benefit of compost for vegetation establishment in the harshest of climatic and soil conditions. Probably it is the latter benefit of compost that makes it most attractive to Texas contractors who need to comply with the requirement of achieving 70 percent revegetation of the disturbed area in order to receive full payment.

The economic impact of using compost-enhanced topsoil becomes clearer when considering that Texas has an estimated 1.3 million acres of highway right-of-way. TxDOT's use of the highway soil enrichment process is a huge market for compost, which in turn has the potential to ignite the composting industry and its ability to remove large volumes of organic material from high-impact watersheds. The TNRCC, working closely with many of TxDOT's district offices as well as public and private stakeholders around the state, has moved beyond the demonstration stage to promoting widespread use of compost in highway revegetation.

While it is difficult to calculate the actual amount of compost being used in TxDOT projects, these examples give some sense of the volume. Over the next three years, TxDOT districts included in a U.S. EPA-funded project (seven districts out of the 25 TxDOT districts) have committed to utilize 200,000 cubic yards of compost (see sidebar). However, one engineer in another district not involved in the EPA project has told us she will utilize 300,000 cubic yards on just one of her projects. The San Antonio district just released its bid for three jobs, which included 10,000 cubic yards in this one letting. At TNRCC, we can only give an educated guess that we will need to find other sources of compost in the state to fill just the needs of TxDOT.

Still, compost use for DOT projects is a very new concept in Texas. Lots of education needs to be done. Contractors who work on DOT projects have been invited to attend workshops with TxDOT staff, which has proved very helpful in lessening apprehension about trying something new. TNRCC and TxDOT staffed a booth at the recent Texas Associated General Contractors annual conference in Austin. Attendees included highway contractors and TxDOT engineers from all over the state. Another booth was staffed by compost suppliers and applicators so that contractors could ask questions about compost. We also electronically distribute a "Navigating the TxDOT Website" fact sheet, which tells composters how to learn more about the TxDOT compost specification, find out what upcoming projects specify compost, and make contact with the low bidder. ■

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ABSTRACT:

District 7 Erosion Control Pilot Study, Caltrans Document #CTSW-RT-00-012

Objective

The objective of the Erosion Control Pilot study was to evaluate alternative soil stabilization methods designed to minimize the transport of sediment from cut and fill slopes. This assessment was performed through a series of field and laboratory tests that were carried out over a two-year period. The field and laboratory testing program was designed to evaluate the soil, rainfall, and vegetation conditions.

Process

Compost was spread evenly on the subplots at a rate of 2,240 kilograms (kg)/hectacre (ha) (2,000 pounds (lb)/acre).

Monitoring

Throughout the 20-month course of the project, from September 1998 through June 2000, weekly inspections were made of all erosion rate test plots. The inspections included observations of the condition of the test plots and the sediment collection systems, and maintenance and repairs as required.

Rainfall was monitored at each of the field sites during the wet seasons (November through April) of the two-year monitoring period.

Rainfall events qualified for sediment/runoff sampling when more than 6 mm (0.25 in.) of rain was recorded within a 24-hour period. A rainfall event was considered to have ended when no subsequent measurable precipitation occurred within a 24-hour period. Within 36 hours after every sampled rain event, sediment discharges were collected from the three replicate test plots at each test site.

Soil samples were collected from all vegetated erosion rate and plant establishment test plots and analyzed for factors relevant to plant growth.

Results

Total Plant Cover:

The results of the evaluation of total plant cover for the final monitoring event (Event 7, April 2000) for all plants (natives and non-natives) were used to rate

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the treatments on a scale of 0 to 10. By Event 7 (for slope types and irrigation treatments considered together), **compost** and bonded fiber matrix performed the best in terms of total plant cover. For this study the compost cost $1,200 installed while the bonded fiber matrix cost $13,600. Compost was the least expensive of any method tested. The cost off all other methods ranged from 175% to 6400% higher than compost for the same coverage.

Erosion Rate:

Treatment	Mean Normalized Erosion Rate ($kg/m^2/mm$)
Bare	0.116
Compost	0.071

The Percent Erosion Reduction almost 40% for the compost treated plot.

Conclusions:

The results from this study took place over two years and were vigorously monitored by faculty and students of San Diego State University as well as Caltrans. The data suggests that dollar for dollar compost is the best means of controlling erosion as well as establishing plant vegetation.

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ABSTRACT:

Environmental Protection Agency: EPA/600/R-00/016

Infiltration Through Disturbed Urban Soils and Compost-Amended Soil Effects on Runoff Quality and Quantity.

Objective

This project examined a common, but poorly understood, problem associated with land development, namely the modifications made to soil structure and the associated reduced rainfall infiltration and increased runoff. The project was divided into two separate major tasks:

1. Testing infiltration rates of impacted soils.
2. Enhancing soils by amending with compost to increase infiltration and prevent runoff.

The first part of this project examined this problem by conducting more than 150 infiltration tests in disturbed urban soils and by comparing these data with site conditions. A complete factorial experiment fully examined the effects, and interactions, of soil texture, soil moisture, and compaction. In addition, age since development was also briefly examined. It was found that compaction had dramatic effects on infiltration rates through sandy soils, while compaction was generally just as important as soil moisture at sites with predominately clay soils. Moisture levels had little effect on infiltration rates at sandy sites. Because of the large amounts of variability in the infiltration rates found, it is important that engineers obtain local data to estimate the infiltration rates associated with local development practices.

The other series of tests examined the benefits of adding large amount of compost to a glacial till soil at the time of development. Compost-amended soils were found to have significantly increased infiltration rates, but increased concentrations of nutrients in the surface runoff. The overall mass of nutrient discharges will most likely decrease when using compost, although the collected data did not always support this hypothesis. The sorption and ion-exchange properties of the compost reduced the concentration of many cations and toxicants in the infiltrating water, but nutrient concentrations significantly increased. In addition, the compost-amended test plots produced superior turf, with little or no need for establishment or maintenance fertilization.

Process

The two composts used at the CUH sites were a sawdust/municipal waste mixture (3:1 ratio, by volume) that is composted in large windrows for at least 1 year and yard waste compost that is also composted in large windrows.

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Monitoring

Tests were recorded on a field observation sheet. Each document contained information such as: relative site information, testing date and time, compaction data, moisture data, and water level drops over time, with the corresponding calculated infiltration rate for the 5-minute intervals.

Results

Compost amendments had the following effects on physical water properties:

1. Water-holding capacity of the soil was doubled with 2:1 compost:soil amendment.
2. Water runoff rates were moderated with the compost amendment, with the compost-amended soil showing greater lag time to peak flow at the initiation of a rainfall event and greater base flow in the interval following a rainfall event.

The compost has significant sorption capacity and ion exchange capacity that is responsible for pollutant reductions in the infiltrating water.

Conclusions:

There was a substantial difference in appearance of amended and unamended plots. There was insufficient grass growth in the unamended plots, even following initial establishment fertilization. The compost-amended plots were very attractive and needed no fertilization. In fact, the initial establishment fertilization may not have been necessary based on studies at the University of Washington of growing turf grass in similar compost-amended soils without inorganic fertilization.

The results of this study clearly show that amending soil with compost alters soil properties known to affect water relations of soils, i.e., the water holding capacity, porosity, bulk density, and structure, as well as increasing soil C and N, and probably other nutrients as well. The mobilization of these constituents probably led to the observed increases in P and N compounds in surface runoff compared to unamended soil plots.

This study found that the infiltration rate increased by 1.5 to 10.5 times after amending the soil with compost, compared to unamended sites

In conclusion, adding large amounts of compost to marginal soils enhanced many desirable soil properties, including improved water infiltration (and

A copy of this abstract is available upon request.

attendant reduced surface runoff), increased fertility, and significantly enhanced aesthetics of the turf. The need for continuous fertilization to establish and maintain the turf is reduced, if not eliminated, at compost-amended sites. Unfortunately, the compost also increased the concentrations of many nutrients in the runoff, especially when the site was newly developed, but with increased infiltration of the soil, the nutrient mass runoff would be significantly decreased.

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ABSTRACT:

Technical Report: CRWR 265
AN EVALUATION OF HIGHWAY RUNOFF FILTRATION SYSTEMS,
University of Texas at Austin and Texas DOT

Objective

This research is concerned with the performance of filtration media used in runoff control systems. The objectives of this research were twofold: 1) evaluation of the performance of the full-scale filtration systems in the field and 2) determination of the pollutant removal efficiencies of several filtration media in bench-scale laboratory experiments.

Process

The compost obtained for testing was a low nitrogen, yard debris compost which has been used successfully elsewhere for the treatment of storm water runoff. The compost was washed and wetted prior to installation in the column. The second media tested was zeolites which are naturally occurring clay minerals. Zeolites have been used in water and wastewater applications as adsorptive and cation exchange media. The zeolites were tested alone and in combination with the Brady sand. The zeolites used in this experiment were a uniform sized granular media with a size range between the Brady sand and the grade 5 gravel.

Highway runoff was collected at the MoPac site in 20L containers. The runoff was stored in a cold room in the laboratory at 5_-10_C for up to one week. The experimental procedure consisted of the following steps:

1. Mix the runoff by pouring into empty container.
2. Collect an initial sample of the mixed runoff.
3. Experiment #1: Fill the column to a predetermined depth, which corresponded to the application of 22 liters of runoff. Experiments #2 and #3: Split the remainder of the runoff into 4.35-L aliquots and dose the columns by pouring one aliquot of runoff into each column.
4. Collect the filtered runoff from each column and reserve a portion of the effluent samples for analyses.
5. Record the time for the water level in the column to drop from H_0 to H.
6. Prepare the influent and effluent samples for analysis.

Monitoring

The field monitoring study focused on the hydraulic behavior of several vertical filters. In addition, the capacity of one system to improve water quality was evaluated. The drainage rate of six runoff control structures was monitored

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between May and October of 1994. The change in water level in the detention basin was measured after runoff events. Water quality samples were collected at one control structure from May 1994 through May 1995. The hydraulic performance of the system was extremely poor (slow drainage rate) prior to modifications in the Fall 1994, so useful water quality data were not collected until the replacement of the media. Therefore, only the data collected from January 1995 through May 1995 are presented in this thesis.

Results

The results of the compost test are:

Consituent	Influent Load, g	Effluent Load, g	Percent Removal
Total Suspended Solids(TSS)	21.13	3.7	82
VSS	3	0.6	80
Chemical Oxygen Demand(COD)	19	13.1	31
Total Carbon	5.7	5	12
Diss. Tot Carbon	2.9	4.2	-47
Nitrate-N	14.2	58.9	-314
Total Phosphorus	15.3	40	-162
Oil and Grease	0.52	0.25	52
Chromium	0.0005	0.0003	53
Copper	0.0032	0.0014	55
Iron	0.32	0.1	69
Lead	0.0018	0.0013	26
Zinc	0.019	0.005	75
Total Metals	0.344	0.108	69

Compost has been used effectively before as a storm water filtration medium and provides removal by adsorption to the organic carbon matrix.

The results of the third experiment indicate that the compost outperformed the Brady sand for the removal of solids, metals, and oil and grease and is a viable alternative.

The compost was a source of nitrate, total phosphorus and dissolved total carbon throughout the experiment. Depending on the type of receiving water and the water quality objectives, the generation of these constituents might be undesirable

Zeolites were tested alone and in combination with the Brady sand. In neither case did the zeolites show promise as a filtration media for highway runoff. Only four dosages were applied to the column containing zeolites alone because the performance was so poor. The zeolites in combination with Brady sand were tested more extensively since some removal occurred. However, sand alone consistently outperformed the combination of sand and zeolites in the removal of

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all constituents. Therefore, it is recommended that zeolites not be used as an alternative filtration medium.

Conclusions:

The data indicate compost is a very effective medium. It out performed the other media for the removal of TSS, oil and grease, and metals. As with any media being used as a filter it is necessary to perform maintenance.

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