CENTER FOR TRANSPORTATION RESEARCH
THE UNIVERSITY OF TEXAS AT AUSTIN

Project Summary Report 0-4403-S
Project 0-4403: Characteristics of Compost Enhanced Topsoils: Moisture Holding and Water Quality Improvement
Authors: Christine J. Kirchhoff, Joseph Malina, Jr., and Michael Barrett
August 2003

PROJECT SUMMARY REPORT

Characteristics of Composts: Moisture Holding and Water Quality Improvement

Introduction

Composted manures, compost-amended soils, and erosion control compost (CMT and ECC) were applied to highway rights-of-way as a means to beneficially dispose of excess manure produced in parts of Texas. These efforts demonstrated that the application of composted manures was successful in establishing vegetation and controlling erosion on highway embankments. TxDOT reports that composted manures have been used beneficially, usually with excellent results in all fourteen TxDOT districts in which compost was applied. However, in spite of the apparent successful application of compost to slopes and other vegetated areas of highway rights-of-way, the effectiveness of various classifications of compost in retaining moisture, in removing constituents of highway runoff, and in overall improvement of water quality in receiving waters has not been defined in detail. The objectives of this research project are to establish the moisture holding capacity of different classes of compost-amended soils and the ability of the compost mixtures to retain pollutants commonly found in highway stormwater runoff.

What We Did…

A comprehensive literature review was conducted to identify:

- Constituents and composition of various types of composted materials;
- Application rates of compost alone as well as compost manufactured topsoil (CMT) to slopes, medians, and other green areas in highway rights-of-way;
- Water-holding capacity and pollutant attenuation characteristics of CMT

The moisture-holding capacity and the physical, chemical and microbiological characteristics of composted manures (dairy cattle, poultry litter, and feedlot) and composted biosolids were determined. Compost manufactured topsoil (CMT) that contained 75% composted manures or composted biosolids mixed with 25% either sandy soil or clay soil, and erosion control compost (ECC) that contained 50% composted manure or composted biosolids and 50% wood chips were evaluated.

The characteristics of the leachate produced during "first-flush" and "extended" column studies were analyzed to assess the degree to which stormwater runoff would leach nutrients, metals and other constituents from the CMT and ECC. The capacity of the CMT and ECC to retain pollutants in highway stormwater runoff also was determined. The onset of runoff

Figure 1: Overall experimental setup

Figure 2: Details of columns with gravel layers and spray nozzles

and peak rate of runoff from CMT and ECC were monitored in channel studies at slopes of 2:1, 3:1, 5:1, and 8:1 (horizontal:vertical).

Leachate Studies

Sixteen columns were fabricated for use in the "first flush" and "extended" leachate studies (Figure 1). The columns consist of 12 in. long, 8 in. diameter acrylic cylinders. Each column contained a 3 in. base layer of washed gravel (0.5 to 1.5 in. diameter) overlaid by a 3 in. layer of washed pea gravel (0.125 to 0.5 in. diameter). A 50 mil filter fabric separated the 3 in. layer of soil, CMT, or ECC, from the pea gravel (Figure 2). A spray nozzle was positioned above each column.

The types of CMT, ECC and soils used in the column studies are presented in Table 1, which also illustrates the experimental matrix. Duplicate columns were operated for each of the CMT and ECC. Two columns, one each for the sandy soil and the clay soil, were used as controls.

The application rate was approximately 3.45 in. of simulated rainfall. The "extended" column studies consisted of applying a volume of deionized water to each column to simulate one year of rainfall in Austin, TX. The collected leachate was analyzed for total suspended solids, total dissolved solids, copper, zinc, total nitrogen, ammonia nitrogen, nitrites, nitrates, total and dissolved phosphorus, fecal coliform, and fecal enterococci.

Channel Studies

The channels were constructed of galvanized sheet metal and are 3 ft wide by 9 ft long and 0.5 ft deep (Figure 3). The soil bed was 3 ft wide by 8 ft long. A layer of gravel was placed to support the CMT or ECC or the soil and to provide drainage of the leachate. A channel that was 3 ft wide and 1 ft long allowed for collection of surface runoff and leachate. The slope of the channel could be varied from 2:1 to 8:1 (horizontal to vertical).

Tap water was applied to the channel that was positioned at the desired slope until the test sample was saturated with water. Leachate was allowed to drain freely from the soil, CMT, or ECC for 24 hours. The erosion control test was begun after waiting 24 hours by applying a volume of water to the sample in the erosion control channel to simulate the 2 year, 3 hour design storm (approximately 2.64 in.)

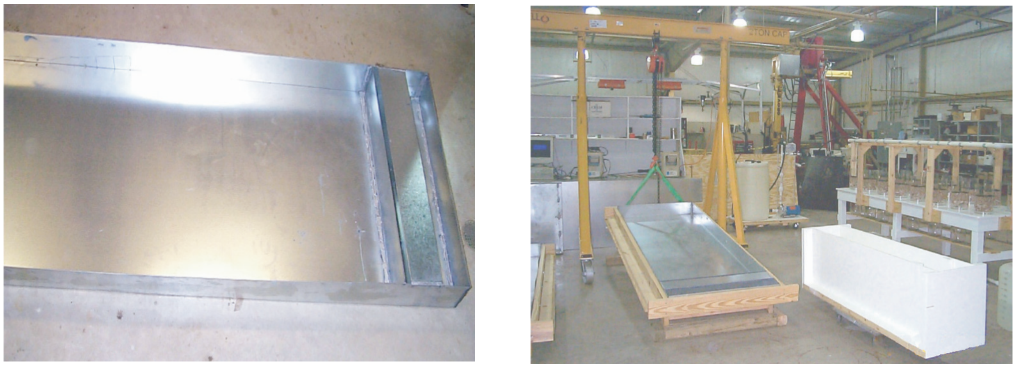
What We Found…

The proposed requirements of TxDOT Specification Item 161 are consistent with compost specifications applied in some 50 states. Composted biosolids met all the limits specified in the TxDOT Specification Item 161. However, the composted dairy cattle manure, composted poultry litter, and the composted feedlot manure failed to meet the specifications in at least one category.

Addition of compost to sandy soil and to sandy clay loam increased the pore size, the range of pore sizes, and

Table 1: Matrix for Evaluating Characteristics of Leachate from Compost-Manufactured Topsoil Using De-Ionized Water and Actual Highway Runoff

	Compost-Manufactured Topsoil (CMT)		Erosion Control	Controls	
Type of Compost	25% compost + 75% sandy soil	25% compost + 75% clay soil	50% compost + 50% wood chips	100% sandy soil	100% clay soil
				X	X
Dairy Manure	X	X	X		
Poultry Litter	X	X	X		
Feedlot Manure	X	X	X		
Biosolids	X	X	X		



(a) (b)

Figure 3: (a) Channel illustrating effluent launder, and (b) Channel in wooden support and frame to adjust slope. Effluent flow measurement device is located in the white box.

the porosity of the CMT. The bulk density of the CMT and ECC decreased compared with the soil controls. The water-holding capacity of the sandy CMT increased but the water-holding capacity of the clay CMT decreased compared to the soil controls.

The water-holding capacity of the compost-amended soils increased compared to the soil controls. The gains in water-holding capacity occurred only with compost amendment of sandy soils. The available water capacity appeared to increase with compost amendment of sandy soils but appeared to decrease with compost amendment of clay soils.

The leachate collected in the "extended" column studies approximate concentrations of constituents in the leachate over time after numerous applications of water. Total nitrogen concentrations decrease in total nitrogen in the leachate over time for all CMT and ECC blends. Phosphorus concentrations decreased over time for all CMT and ECC mixtures. The total phosphorous concentration after 12 months of equivalent rainfall was less than 2 mg/L for clay CMT blends and <10 mg/L for sand CMT blends and ECC blends. Concentrations of copper and zinc also decreased over time. Clay CMT retained more copper than sand CMT, but the reverse was true for zinc. The concentrations of constituents in the leachate observed in the laboratory are more concentrated than the leachate from application of the same compost or CMT or ECC under field conditions where water passing through the compost-amended soils would infiltrate into the underlying soil and be taken up by plants and/or undergo chemical and biological transformations in the soil, resulting in lower concentrations that would reach surface and ground water sources.

The highest peak runoff occurred in the erosion control studies at the steepest slope (2:1) for the clay control and the dairy clay CMT blend. The peak runoff rate generally decreased with decreasing slope for the control, CMT, and ECC. The onset of runoff for CMT and ECC at all slopes was delayed. ECC blends appeared to delay runoff more than CMT blends. The clay CMT blends delayed the onset of runoff compared to clay soil alone at a 3:1 slope. The onset of runoff was delayed 8 to 15 minutes, and the peak runoff flow rate was reduced from 0.5 to 0.4 gpm or less. ECC blends delayed the onset of runoff at a 3:1 slope by 15 minutes or more.

The Researchers Recommend...

Wood chips, yard trimmings, or similar materials should be incorporated as organic bulking agents when composting dairy cattle manure in order to increase the organic matter content of the finished compost to meet the TxDOT Specification 161 organic content of 25% to 65%. The organic bulking material also would provide a source of carbon which upon aerobic decomposition will be converted to carbon dioxide and tend to reduce the pH to less than 8.5.

Increasing the amount of organic bulking material in composting poultry litter would have a similar effect on the pH of the final product.

Composted feedlot manure is not suitable for use in CMT or in ECC because the composted feedlot manure exceeded the specified maximum pH and salt limit, had a low maturity, and exhibited phytotoxicity that would inhibit the establishment of vegetation on rights-of-way of new highways.

Clay or sandy clay are the soils of choice to be blended with composted manures and biosolids in Compost Manufactured Topsoils. The clay CMTs are more efficient in the removal of total nitrogen, phosphorus, total suspended solids, and heavy metals than sand CMTs.

The maximum slope for the application of Compost Manufactured Topsoil or Erosion Control Compost is 3:1 (horizontal:vertical). Runoff delay and reduction in the peak flow rate are enhanced at slopes below 3:1.

For More Details...

Research Supervisor: Joseph Malina, Ph.D., P.E., (512) 471-4614
email: jmalina@mail.utexas.edu
TxDOT Project Director: Barrie Cogburn, P.E., (512) 416-3086
email: bcogburn@dot.state.tx.us

The research is documented in the following reports:

0-4403-1 *A Review and Evaluation of Literature Pertaining to Compost Characteristics and to the Application of Compost Alone and Mixed with Different Soils* July 2002
0-4403-2 *Characteristics of Composts: Moisture Holding and Water Quality Improvement* August 2003

To obtain copies of a report: CTR Library, Center for Transportation Research,
(512) 232-3138, email: ctrlib@uts.cc.utexas.edu

TxDOT Implementation Status
February 2004

The research investigated the moisture holding and water quality characteristics of compost. The research revealed that the application of compost manufactured topsoil and erosion control compost to TxDOT ROW is effective in enhancing the growth of vegetation, controlling erosion, and attenuating the transport of constituents of runoff. The research results will be used to promote, demonstrate, and implement the use of compost in highway projects.

For more information, contact: Sharon Barta, P.E., RTI Research Engineer, at (512) 465-7403 or email: sbarta@dot.state.tx.us.

Your Involvement Is Welcome!

Disclaimer

Center for Transportation Research
The University of Texas at Austin

The University of Texas at Austin
Center for Transportation Research Library
3208 Red River #115
Austin, TX 78705-2650