Evaluation of stormwater from compost and conventional erosion control practices in construction activities

L.B. Faucette, C.F. Jordan, L.M. Risse, M. Cabrera, D.C. Coleman, and L.T. West

ABSTRACT: Soil erosion is considered the biggest contributor to nonpoint source pollution in the United States according to the U.S. Environmental Protection Agency and the federally mandated National Pollution Discharge Elimination System. Soil loss rates from construction sites can be 10 to 20 times that of agricultural lands. The use of surface applied organic amendments has been shown to reduce runoff and erosion, however, with the exception of animal manure, little research has focused on nutrient loss from these amendments. Four types of compost blankets, hydroseed, silt fence, and a bare soil (control) were applied in field test plots. Treatments were seeded with common bermuda grass. A rainfall simulator applied rainfall at an average rate equivalent to a 50 yr hr^{-1} storm event (7.75 cm hr^{-1}). Three simulated rain events were conducted: immediately after treatment application, at three months when vegetation was established, and at one year when the vegetation was mature. After three months, the compost generated five times less runoff than hydroseed with silt fence, and after one year, generated 24 percent less runoff. All treatments proved better than the control at reducing solids loss. Total solid loads were as much as 3.5 times greater from hydroseed and silt fence compared to the composts during the first storm, and as much as 16 times greater during the second storm. Materials high in inorganic nitrogen (N) released greater amounts of nitrogen in storm runoff; however, these materials showed reduced N loss over time. Hydroseeding generated significantly higher total phosphorus (P) and dissolved reactive P loads compared to compost in storm runoff during the first storm event.

The U.S. Environmental Protection Agency (USEPA) has declared that sediment contamination of our surface waters is the greatest threat to our nation's water resources. Soil erosion is considered the largest contributor to nonpoint source pollution in the United States, according to the federally mandated National Pollution Discharge Elimination System (NPDES) (USEPA, 1997). Soil loss rates from construction sites can be 10 to 20 times that of agricultural lands (USEPA, 2000). For example, forestlands lose an average of 0.36 m t ha^{-1} (1 t ac^{-1}) per year, agriculture loses an average of 5.5 metric tons ha^{-1} (15 t ac^{-1}) per year, while construction sites average 73.3 metric t ha^{-1} (200 t ac^{-1}) per year (GASWCC, 2002). In 2003, the federally mandated NPDES Phase II program went into effect extending the stormwater management plan requirement to any land-disturbing activity over 0.4 ha (1 ac). The new regulations label development zones as "point sources" requiring erosion control best management practices (BMPs), stormwater pollution prevention plans, increased monitoring, and more site inspections by state and local officials or certified inspectors.

Areas like construction sites that disturb, excavate or grade soil are particularly prone to soil erosion. In many cases, the existing topsoil has been totally removed reducing soil quality and fertility which reduces future plant establishment. In addition, heavy machinery and traffic compacts the soil which further increase runoff and poor plant growth (Risse and Faucette, 2001).

The most serious impacts of soil erosion occur once the sediment leaves the site and enters surface waters. Ehrhart et al. (2002) reported that suspended sediment concentration discharges from construction activities into streams was as high as 355 mg L^{-1} (355 ppm), with high concentrations persisting 100 m (328 ft) downstream negatively impacting macroinvertebrate populations. When eroded sediment is transported from its site of origin to nearby surface waters it also carries fertilizers, pesticides, fuels, and other contaminants and substances commonly spilled at construction sites that readily attach to soil particles (Risse and Faucette, 2001). For example, total annual loss of nitrogen, phosphorus, and potassium due to soil erosion in the United States is estimated to be over 38 million Mg (42 million t). It is estimated that the annual cost to society for on-site loss of soil, nutrients, water and yield reduction due to soil erosion is over $27 billion per year (Brady and Weil, 1996).

In terrestrial ecosystems, surface layers of organic matter reduce the energy of raindrop impact and allow water to percolate into the soil, reducing surface runoff and erosion (Jordan, 1998). The use of surface applied organic amendments has been shown to reduce runoff and erosion (Adams, 1966; Meyer et al., 1972; Laflen et al., 1978; Vleeschauwer and Boodt, 1978; Foster et al., 1985). Because of better soil contact and reduced susceptibility to movement from wind or water, wood mulches are superior to hay and straw mats (Holmberg, 1983; Lyle, 1987). Shredded bark and straw mulches will intercept and dissipate the energy of raindrops and prevent soil surface crusting. They also break up overland flow of runoff and hold more water at the soil surface allowing more water to infiltrate the soil (Adams, 1966; Gorman et al., 2000).

In the last ten years, compost has been used successfully for slope stabilization, erosion and sediment control, stormwater filtration, and vegetative establishment applications. In

L. Britt Faucette is research director for Filtrexx International in Atlanta, Georgia. **Carl F. Jordan** is senior ecologist at the Institute of Ecology, University of Georgia in Atlanta, Georgia. **L. Mark Risse** is associate professor in the Department of Biological and Agricultural Engineering at the University of Georgia in Atlanta, Georgia. **Miguel Cabrera** is professor in the Department of Crop and Soil Sciences at the University of Georgia in Atlanta, Georgia. **David C. Coleman** is a distinguished research professor in the Institute of Ecology at the University of Georgia in Atlanta, Georgia. **Larry T. West** is a professor in the Department of Crop and Soil Science at the University of Georgia in Atlanta, Georgia.

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Portland, Oregon, yard waste composts used for erosion control in residential construction projects exhibited reduced erosion and improved water quality over conventional erosion and sediment control measures (Portland Metro, 1994). Ettlin and Stewart (1993) found that yard waste compost could be used for slope stabilization and erosion control on slopes up to 42 percent. Four inch compost applications effectively controlled erosion on 45 percent slopes for three years (Michaud, 1995). A study conducted by the Connecticut Department of Transportation found composts and mulches reduced soil erosion ten-fold compared to bare soil surfaces on a 2:1 slope (Demars and Long, 1998). Furthermore, Demars and Long (1998) report that when compared to silt fences, compost is 99 percent more effective in keeping sediment out of nearby surface waters, and 38 percent more effective than hydroseeding. Glanville et al. (2001) reported runoff and interrill erosion rates were significantly lower on newly constructed highway embankments when using compost instead of imported topsoil.

While recent studies have shown the effectiveness of compost and other best management practices to reduce runoff and erosion (Wilson et al., 2001), little attention has been given to the fate of the fertilizer application and nutrients commonly used in erosion control for vegetation establishment. Nutrient management plans and budgets are common in the agricultural industry; however, there is no equivalent for the construction and erosion control industries where soil erosion can be much greater (USEPA, 2000). Eghball and Gilley (1999) reported that unincorporated compost applied to agricultural fields with wheat and sorghum residue released less dissolved phosphorus (P) and bioavailable P, but more particulate P than fertilizer applications during initial rain events. Additionally, they reported that ammonia nitrogen (N) concentrations in runoff were higher from fertilizer applications and nitrate N concentrations where higher from compost applications. However, the inorganic N contents reported for the composts were greater than manure of the same feedstock, which may imply that the compost may not have been fully composted and should not be used for erosion control applications (Alexander, 2003).

Previously, we (Faucette et al., 2004) evaluated a variety of compost and mulch products for runoff and solids loss under a one-time intense rainfall simulation at the University of Georgia. Results showed high quality composts performed better than those of inferior quality; and mulches generally produced less runoff and erosion than composts. We also reported that compost blankets can have relatively high nitrogen and phosphorus concentrations and loads in stormwater runoff, and that some of these inferior compost treatments would be unsuitable for erosion control applications. In addition, no vegetation or subsequent storm simulations were evaluated. Vegetation and temporal changes could have a tremendous affect on short and long-term performance of the treatments and would better reflect real world situations. These conclusions led to the treatment selection and experimental design described in the following section.

The overall objective of this study was to evaluate the surface water quality impacts from compost systems and hydroseed with silt fence (conventional industry best management practices) used for erosion and sediment control applications in construction activities. Specific objectives were to evaluate each treatment as a best management practice for managing stormwater and controlling erosion by: 1) managing stormwater, 2) controlling erosion and soil loss, and 3) minimizing risk related to nutrient application. Effective erosion and sediment control practices should reduce sedimentation while minimizing additional risks, such as nutrient loading, to surface water pollution.

Methods and Materials

Site description. Research test plots were constructed at Spring Valley Farm in Athens and Clarke County, Georgia at 33° 57' N latitude and 83° 19' W longitude. The soil was originally classified as an eroded Pacolet Sandy Clay Loam (USDA, 1968) and has a high soil erodibility factor (K value) of approximately 0.36 (Wischmeier and Smith, 1978). The area receives an average annual rainfall of 1215 mm (48 in), with January through March as the wettest period. The average annual high temperature for the area is 22° C (72° F), the average low is 11° C (52° F), with a mean annual temperature of 17° C (63° F) (Weather Channel, 2004). The week prior to the first simulated storm event, the research site received no natural rainfall. During the three months between the first and second storm event the site only received 90.7 mm (3.57 in) of natural rainfall, with only 16.8 mm (0.66 in) falling in the third month. The week prior to the second storm the research site received no natural rainfall. These extremely dry conditions likely affected vegetation growth. The week before the final storm event the research site received 102.4 mm (4.03 in) of natural rain. This led to saturated field conditions during the final simulated storm event.

The testing area was cleared of vegetation and graded with a grading blade mounted skid steer, exposing a semi-compacted (from the skid steer) subsoil (Bt horizon) to simulate construction site conditions. Test plot borders were installed to prevent cross contamination of plots. Fifteen cm (6 in) wide stainless steel borders were trenched 7.5 cm (3 in) into the soil. The plots were sized to fit the effective rainfall distribution from the rainfall simulator, 1.0 m (3.3 ft) wide by 4.8 m (16 ft) long, for a total plot area of 4.8 m^2 (53 ft^2). A removable flume was installed at the base of each plot prior to each simulated rainfall event. A removable stainless steel border was carefully inserted at the base of each plot, once the flume was removed after each storm event, to maintain the structure and integrity of the soil in the plot. The soil was carefully compacted around the removable flume and the removable border after each one was installed for use. Nine rain gauges were installed in each plot to measure rainfall quantity. Three each were placed 1.2 m (4 ft), 2.4 m (8 ft) and 3.6 m (12 ft) from the top of the plot. Gauges were also spaced evenly across the width of the plot.

Treatments. Seven treatments, each in triplicate, were assigned randomly and applied to twenty-one 1 m by 4.8 m (3.3 ft by 15.7 ft) plots on a cleared field graded to a uniform 10 percent slope on a sandy clay loam surface. The seven treatments were: 1) a biosolids compost blanket with filter berm, 2) a yard-waste compost blanket with filter berm, 3) a municipal solid waste compost and mulch blanket with filter berm (2:1 compost to mulch by volume), 4) a poultry litter compost, mulch, and gypsum blanket with filter berm (2:1 compost to mulch by volume with five percent gypsum addition by volume), 5) hydroseed with silt fence, 6) hydroseed with mulch filter berm; and 7) a bare soil (control) plot. To reduce potential nutrient losses in runoff, the poultry litter compost and municipal solid waste compost treatments

Table 1. Physical, chemical, and biological characterization of treatments.

Treatment	Bulk density (g/cm^3)	Stability - O_2 uptake (mg O_2/g VM hr^{-1})	Germination index (%)	Water (%)	pH	SS (mS/cm)	OM (g kg^{-1})	C:N	C	N	NH_4	NO_3	P	pH
Biosolids comp	0.51	0.02	96	31.3	7	1.62	202	17	100900	5830	2480	1960	4470	7.0
Yard waste comp	0.5	0.09	100	40.66	7.8	0.645	193	19	97500	5010	40	70	3240	7.8
Poultry litter comp	0.59	0.06	100	32.2	7.2	5.93	212	22	131500	5980	70	240	4290	7.2
MSW* comp	0.32	0.1	100	45.7	8.1	4.96	360	20	175200	8660	140	180	1910	8.1
Soil	2.23	Nd	Nd	Nd	4.7	Nd	Nd	18	250	14	0.74	0.053	348	4.7

All nutrients and metals expressed in mg kg^{-1}.

***MSW = municipal solid waste.**

were blended with wood mulch on a volumetric ratio basis (1:1, compost:mulch). This ratio was chosen because it was felt this was the most mulch that could be blended with these materials without adversely affecting plant growth from N immobilization. In addition, the poultry litter compost was blended with approximately five percent (volumetric basis) ground gypsum ($CaSO_4$). This was done to reduce potential P losses in the runoff from the reaction between P and $CaSO_4$ to form the more stable $Ca_3(PO_4)_2$.

Compost blankets were manually applied at 3.75 cm (1.5 in) depths over the entire area of the plot. Filter berms were 60 cm (2 ft) wide by 30 cm (1 ft) high and situated at the base of the slope across the width of the plot. Application depth of the compost blankets and dimensions of the compost filter berms followed American Association of State Highway Transportation Official's specifications for erosion and sediment control (Alexander, 2003). Each treatment, excluding the control plots, were seeded with a 1:1 mix of hulled and unhulled Common Bermuda (*Cynodon dactylon*) grass seed applied at 3.7 kg ha^{-1} (20 lbs ac^{-1}), specified by the Georgia Department of Transportation as an erosion and sediment control vegetative measure for slopes 3:1 or less for the Athens, Georgia region. The compost treatments were physically, biologically, and chemically characterized prior to application in the test plots (Tables 1). Treatments were selected based on availability and results from previous research conducted at The University of Georgia (Faucette et al., 2004).

Rainfall simulator. A Norton Rainfall Simulator with four variable speed V-jet oscillating nozzles was used to simulate rain events. During rain events, nozzle water pressure was maintained at 0.42 kg/cm^2 (6 psi), according to manufacturer's specifications, producing an intensity of 7.75 cm (3.1 in) h^{-1} for one hour. This is equivalent to the one-hour storm event for a 50-year return for the Athens, Georgia region, based on historical rainfall records (USDOC, 1961). It was our intention to evaluate these treatments under a "worst-case" scenario, because most runoff and erosion occurs during these large events. Municipal tap water was used in this study containing NO_3-N of 0.673 mg L^{-1} (0.673 ppm) and $P0_4$-P of 0.093 mg L^{-1} (0.093 ppm).

Three simulated rainstorms were conducted at the beginning of the experiment, at three months, and one year. These time intervals were chosen based on the predicted establishment of the vegetation. The first storm event was intended to provide information on the performance of the treatments prior to vegetation establishment. The second storm event was intended to provide information on how the performance of the treatments changed when vegetation was newly established. The final storm event was to provide information on how the treatments reacted once vegetation was fully established. All of the plots were subjected to natural rainfall between the simulated rainfall events.

Sampling and laboratory analysis. Physical and biological analyses of the treatments were performed at the University of Georgia's Bioconversion Research and Education Center laboratory and followed the procedures outlined in the U.S. Composting Council's Test Methods for the Examination of Composting and Compost (TMECC) (USCC, 1997). Water content (method 07.09-A) was determined by the difference between wet and dry weight. Human made inert analysis (method 07.08) was determined as the non-compost fraction (e.g. glass, plastic, metal) of the total dry weight of the treatment. Germination rate (method 09.05-A) was determined by percent cress seed germination in a water extract of the treatment (USCC, 1997). Bulk density was determined as dry weight per known volume of sample (USDA, 1998), and biological stability was determined as the oxygen uptake rate in a warm water bath for one hour after a 16 hour incubation period using respirometry methods described by Iannotti et. al (1993).

Chemical characterizations were performed at the University of Georgia Agricultural and Soil, Plant and Water Laboratory using EPA or Association of Analytical Communities (AOAC) approved procedures (University of Georgia Soil, Plant and Water Analysis Lab, 2004). Total carbon (C) and total N were analyzed on a Carlo Erba Analyzer and determined by thermal conductivity from combustion to carbon dioxide (CO_2) and nitrous (N_2); organic matter was determined by weight difference after loss on ignition at 550° C (1022° F); nitrate-N and ammonium-N samples were first extracted using a 20 ml (0.68 oz) solution of deionized water and KCl and then filtered with Whatman 42 filter paper before analysis by continuous flow colorimetric assay (see water analysis below for more detail on colorimetric analysis on Alpkem RFA3000); and soluble salts were determined by electrical conductivity. Heavy metals were analyzed and all of the treatments were below the pollutant concentration levels as specified in EPA part 503 Table 4 (USEPA, 1993). Treatment characteristics are reported in Table 1.

Sampling and analyses for stormwater included: rainfall amount, antecedent soil water, time until start of runoff, time until steady state of runoff flow rate, total runoff volume, peak runoff rate, rainfall infiltration, rainfall infiltration to runoff ratio, total solids loads, and total solids loss ratios. Rainfall averages were calculated by averaging the rainfall depths for nine rain gages placed equidistant to each other around the perimeter and within the test plot area. Antecedent soil moisture conditions were measured prior to the first and third rainfall simulation using time domain reflectometry with a Tektronix Cable Tester (Ferre and Topp, 2002). Each plot used three time domain reflectometry probes placed below the soil surface at distance intervals of 0.9 m (3 ft) from the top of the plot. The U.S. Department of Agriculture (USDA) Agricultural Research Service (1980) time domain reflectometry data acquisition (TACQ) computer program was used to process and convert wavelengths to water content.

Runoff sampling procedures and calculation methods followed procedures used for the Water Erosion Prediction Project (WEPP) developed by the USDA National Soil Erosion Lab which have been used in similar studies (Glanville et al., 2001; Faucette et al., 2004). Runoff samples were collected from a flume placed at the base of each plot. The first sample was taken once water began to "trickle" from the flume aperture, the point determined to be the start of runoff. After the first sample was collected, samples were taken every five minutes until the 60-minute storm was finished. Runoff quantity and total solids samples used one 500 ml (2.1 c) Nalgene bottle per five minute interval sample, and "seconds-to-fill" bottle times were recorded to obtain runoff flow rates. The total volume of each runoff sample and the time over which it was collected was recorded.

For nutrient samples the first sample was taken once water began to "trickle" from the flume aperture and every five minutes until the 60-minute storm was finished. Separate nutrient samples were taken using 500 ml (2.1 c) Nalgene bottles and were filled for five second durations. For each test plot, each five-second nutrient sample, taken every five-minutes, was composited in a 3.8 l (1 gal) bottle and kept in a cooler and refrigerated prior to analysis. This created a single volume weighted sample for each test plot and each storm event. Nutrient samples were analyzed for total N, NH_4-N, nitrate N (NO_3-N), total P, and dissolved reactive P.

Each 500 ml (2.1 c) runoff/solids sample was weighed and oven dried at 105° C (221° F) until constant weight was achieved to determine the total solids content. The total solids were measured using methods 2540 B Total Solids Dried at 103 to 105° C (217 to 221° F) (USEPA, 1983). Using these data, the peak runoff rate (once flow reached steady state conditions) was calculated by averaging runoff rates observed during the last three five-minute interval samples, during the simulated storm, or when runoff rates for three time adjacent samples were the same. The runoff rate (known volume per measured time) sampled at five-minute intervals during the simulation were plotted, and the total runoff volume was calculated by summing the area under the runoff curve.

Table 2. Total runoff volume (mm) by treatment at day one, three months, and twelve months, n = 3.

Treatment	Day one Average	Day one Standard deviation	Three months Average	Three months Standard deviation	Twelve months Average	Twelve months Standard deviation
PLC/mulch/gypsum	32.0ab	12.7	5.0c	4.9	15.9c	7.0
Biosolids compost	38.1ab	7.9	9.6c	6.9	21.6bc	17.0
MSW* compost/mulch	22.5b	13.1	1.8c	Nd	21.9bc	2.2
Yardwaste compost	33.0ab	5.6	8.1c	4.1	25.0abc	7.0
Hydroseed/mulch berm	36.7ab	5.8	20.2bc	2.4	34.2ab	9.9
Hydroseed/silt fence	30.0ab	11.6	32.3ab	28.3	27.6abc	5.1
Bare soil (not seeded)	42.3a	5.6	45.9a	20.6	40.8a	8.9

Treatments with same letter are not significantly different at $\alpha = 0.05$ using Duncan's Multiple Range test.

*** MSW = municipal solid waste.**

Total solid loads were calculated by summing the average total solids concentration of two time adjacent concentration samples multiplied by the average of the same two time adjacent samples for runoff volume. Infiltration volumes were calculated by total runoff volume subtracted from total rainfall volume, where total rainfall volume was rainfall total multiplied by the total area of the plot.

Laboratory analysis of the nutrients in runoff water was conducted at the University of Georgia's Institute of Ecology Analytical Chemistry Laboratory (2004) and all standard methods for preparation, analysis, and calculation can be found on their website. All N and P forms determined from water samples were first filtered with a 0.45 micron filter and were processed on an Alpkem RFA300 continuous flow colorimetric analyzer. After 1000 mg L^{-1} (1,000 ppm) of colorimetric reagent was added to each sample, the chemical nutrient concentration in solution was measured as a function of the amount of light absorbance at a particular wavelength. Prior to filtration and colorimetric analysis of total N and total P, a solution using persulfate, boric acid, and sodium hydroxide was added to unfiltered runoff samples at 1:5 for oxidization/digestion pretreatment (Qualls, 1989). Nitrate-N and total N were measured using EPA standard method 353.2 (colorimetric, automated, cadmium reduction), ammonia N using EPA standard method 350.1 (colorimetric, automated phenate), and total P and dissolved reactive P using EPA standard method 365.1 (colorimetric, automated, ascorbic acid) (USEPA, 1983).

Statistical analysis. SAS version 8.2 (SAS, 2001) was used for statistical analysis. Analysis of variance (PROC ANOVA) used Duncan's Multiple Range test for significant differences between cells to determine any significant differences between treatments ($p \leq 0.05$). Correlation analysis (PROC CORR) was used to determine which of the independent variables, including: physical, chemical, and biological treatment characteristics and all vegetation and rainfall characteristics, were correlated to the response variables.

Results and Discussion

Runoff and infiltration. There was significantly less runoff volume for the compost blankets than the control for the simulated rain events at three months and one year, and less runoff from the compost than the hydroseed with silt fence at three months (Table 2). Additionally, compost reduced runoff more over one year than hydroseeding, by 33 percent and eight percent respectively, and reduced total cumulative runoff relative to the control by 55 percent and 30 percent, respectively. These findings are similar to land application of manure in agricultural fields at 62 percent reduction (Gilley and Risse, 2000).

All but one compost treatment had significantly greater infiltration than the control for all storm events, while two were significantly greater than the hydroseed with silt fence. During the first storm event, relative to the control, the municipal solid waste compost and the yard waste compost treatments allowed 51 percent more water to infiltrate the surface, the poultry litter allowed 43 percent more, the biosolids 31 percent, the hydroseed with silt fence 24 percent, and the hydroseed with mulch berm 20 percent more. Similarly, Agassi et al. (1998) found that under rainfall simulation, compost perco-

Table 3. Average time (minutes) until start of runoff and steady state conditions by treatment at day one, three moths, and twelve months, n = 3.

	Day one		Three months		Twelve months	
Treatment	RO start	RO steady state	RO start	RO steady state	RO start	RO steady state
PLC/mulch/gypsum	12.0bc	40.3a	41.0ab	55.3a	21a	44.3ab
Biosolids compost	8.3bcd	26.7ab	32.7b	56.0a	23.7a	40.3a
MSW* compost/mulch	20.0a	40.0a	51.7a	>60.0a	14.3a	37.7ab
Yardwaste compost	13.0b	31.3ab	33.3b	54.0a	14.7a	34.7ab
Hydroseed/mulch berm	7.3cde	25.7ab	14.3b	31.0b	9.0a	27.3ab
Hydroseed/silt fence	6.0de	22.7ab	8.0b	19.7b	10.3a	33.7ab
Bare soil (not seeded)	2.7e	9.3c	6.3b	19.7b	3.7a	18.7b

Treatments with same letter are not significantly different at $\alpha = 0.05$ using Duncan's Multiple Range test.

*** MSW = municipal solid waste.**

lated nearly twice as much rain water as a bare soil. By the final storm event, relative to the control, the composts allowed 61 to 65 percent more water to infiltrate the surface, while the hydroseed treatments allowed 43 to 47 percent. The increased infiltration percentages (compared to the control) that resulted during the final storm event were probably due to the increase in vegetation exhibited by all treatments.

Time to start of runoff and peak runoff rate. The compost systems appeared to absorb more rainfall initially, creating a significantly longer time period for runoff to commence, relative to the control and hydroseed, immediately after treatment application (Table 3). Average cumulative time before runoff commenced was 24 minutes for the compost system and nine minutes for the hydroseed treatments. The delay in runoff (and reduced runoff volumes) is likely from the high water storage capacity characteristic to humus rich materials (Brady and Weil, 1996), as well as the porous nature of the compost blanket created by the heterogeneity of the particle sizes in the material. This may provide evidence that compost can be an effective tool to prevent runoff from occurring during small and medium storm events.

Cumulative peak runoff rates were 60 percent lower for the compost treatments relative to the control and 34 percent lower relative to hydroseed. This is consistent with Glanville et al. (2001), which found compost blankets reduced runoff rates by 62 percent compared to a bare soil and by 58 percent compared to topsoil. This may be further indication that compost blankets allow greater infiltration and reduce soil crusting. Additionally, the heterogeneous particle size distribution and porosity of compost blankets may slow down the surface flow of runoff by physical interruption, and slowing down the runoff *may allow more water to infiltrate,* which was reported in the previous section. Over the one-year study, all four compost treatments showed a reduction in peak runoff rate, while the hydroseed with silt fence runoff rate remained unchanged and the bare soil runoff rate increased. This may be the result of the compost blankets gradually increasing soil structure and water infiltration at the soil interface, while the control and hydroseeded treatments may have experienced soil crusting. Of the compost treatments, the poultry litter and biosolids compost treatments reduced runoff rates the most over the one-year study period, 43 percent and 33 percent respectively. This was likely due to greater vegetation cover and biomass exhibited by these two treatments, which are important factors in reducing runoff and erosion in the revised universal soil loss equation (RUSLE) (Brady and Weil, 1996).

Total solids loss. All treatments significantly reduced total solids loss relative to the control for all storm events (Table 4). The yard waste compost released nearly 3.5 times less total solids load, and 16 times less total solid load than the hydroseed with silt fence during the first and second storm events, respectively. In comparison, Glanville et al. (2001) reported interrill erosion rates from bare soil were six times greater than yard waste compost, while topsoil was nearly 12 times greater. Consistent with this trend, in Faucette et al. (2004) we found the bare soil (control) generated six times more total solids than the yard waste compost blanket. This difference between the compost system relative to the hydroseed with silt fence, is probably a result of the immediate and more stable soil surface cover provided by the compost blankets relative to the hydroseed treatments. In review of 200 studies Doolette and Smyle (1990) reported, mulching reduces soil erosion between 78 and 98 percent; each of the four composts in this study reduced total solids loss between 97 and 99 percent.

The hydroseed with mulch berm treat-

Table 4. Average total solids loads (g/m^2) and total solids loss ratio (treatment to control) by treatment at day one, three months, and twelve months, n = 3.

	Day one			Three months			Twelve months		
Treatment	Average	Standard deviation	Ratio	Average	Standard deviation	Ratio	Average	Standard deviation	Ratio
PLC/mulch/gypsum	158.9b	91.3	0.025	14.6b	8.3	0.003	10.8b	4.5	0.010
Biosolids compost	105.8b	13.0	0.016	18.9b	13.2	0.003	8.8b	6.4	0.008
MSW* compost/mulch	191.9b	107.8	0.030	6.0b	Nd	0.001	17.8b	6.8	0.016
Yardwaste compost	88.5b	45.3	0.014	13.7b	6.6	0.002	17.1b	6.2	0.015
Hydroseed/mulch berm	265.1b	32.3	0.041	78.1b	21.7	0.014	10.9b	6.1	0.010
Hydroseed/silt fence	307.9b	127.8	0.048	219.6b	72.0	0.039	14.5b	6.7	0.013
Bare soil (not seeded)	6428.1a	2182.7		5464.2a	3290.4		1109.7a	987.7	

Treatments with same letter are not significantly different at $\alpha = 0.05$ using Duncan's Multiple Range test.

*** MSW = municipal solid waste.**

Table 5. Results from correlation analysis for runoff during second storm event and solids loss for all storm events. This table lists all variables with significant correlation ($r > 0.70$, $\alpha = 0.05$, $n = 21$).

Response variable	Independent variable (treatment) with correlation coefficient
Time to runoff start	Particle size >25mm (0.71), Particle size >16mm (0.82), Particle size >9.5mm (0.77), Particle size >6.3mm (0.72), pH (0.73), germination rate (0.80)
Time to runoff steady state	Particle size >25mm (0.77), Particle size >16mm (0.89), Particle size >9.5mm (0.82), Particle size >6.3mm (0.74), pH (0.74), germination rate (0.84)
Rain infiltration volume	N (0.74), pH (0.81)
Runoff rate	N (0.86), P (0.81), K (0.76)
Total sediment concentration, Storm #1	Bulk density (0.93)
Total sediment load, Storm #1	Bulk density (0.90), organic matter (0.78)
Total sediment concentration, Storm #2	Bulk density (0.87), organic matter (0.71)
Total sediment load, Storm #2	Bulk density (0.73), organic matter (0.77)
Total sediment concentration, Storm #3	Bulk density (0.76)
Total sediment load, Storm #3	Bulk density (0.75)

ment produced 14 percent and 64 percent less total solid loading than the hydroseed with silt fence treatment during the first and second storms, respectively. This may be the result of the mulch berm to act as a three dimensional sediment filtration device relative to the silt fence, which is a two dimensional filter that appeared to clog easily when exposed to sedimentation. Additionally, the heterogeneous particle size distribution of the filter berm matrix may provide greater surface area and more pore space diversity (micro and macro) for trapping sediment. The decrease in solids loss in the control over time can likely be attributed to the volunteer weed growth within the test plots. Visually, the control and hydroseeded plots had evidence of rilling, indicating erosion from flow stress. The composts had no evidence of rilling but did show some movement of material, indicating stress from sheet flow.

Correlation analysis for runoff and erosion. Based on correlation analysis at three months, particle sizes over 6.3 mm (0.2 in) in the compost seem to have the greatest affect on runoff (Table 5). This is likely due to greater surface porosity, created by a more diverse particle size distribution, which the larger particles served to widen. Buchanan et al. (2000) reported similar findings for soil erosion, where a diverse particle size distribution of wood chips reduced erosion more (by 86 percent) than either small wood chips (22 percent), or large wood chips (78 percent) alone. Additionally, the large particle sizes are more likely to slow down surface runoff; therefore reducing the runoff rate and increasing the potential for water to infiltrate. General characteristics of high quality compost such as high germination rate, a neutral pH, and sufficient N, P, potassium (K) were good indicators that there would be greater infiltration and less runoff. This is likely since these are prerequisites for good vegetation establishment and cover, which can lead to less runoff (Brady and Weil, 1996).

Finally, it appears that the bulk density and organic matter content of compost is correlated to solids loss from the plots. This characteristic is consistent with soil erosion studies where organic matter influences bulk density, soil structure, and infiltration, normally resulting in reduced erosion (Brady and Weil, 1996). This provides compelling evidence that compost may be well suited for a variety of stormwater management applications, particularly where it can eliminate runoff, thus preventing most water erosion from ever occurring.

Total N loss. Nutrient loading was chosen to evaluate the treatments rather than concentrations. If a treatment exhibits comparatively high concentrations of nutrient loss, but is comparatively more effective at reducing runoff, then it may be a more desirable method of erosion control, since it is the *amount* of nutrients entering nearby surface water that are of most concern. The total amount of N applied by each treatment was 132 g/m^2 (5.6 oz/yd^2) from the poultry litter compost, 111 g/m^2 (4.7 oz/yd^2) from the biosolids compost, 104 g/m^2 (4.4 oz/yd^2) from the municipal solid waste compost, 94 g/m^2 (4.0 oz/yd^2) from the yard waste compost, and 10 g/m^2 (0.4 oz/yd^2) from the hydroseeded applications.

The first simulated storm event was conducted immediately after treatment application; therefore the potential for N loss was greatest at this time period due to the absence of vegetation. During the first rainfall simulation total N loads from the biosolids compost (4060 mg/m^2, 0.17 oz/yd^2), municipal solid waste compost (2014 mg/m^2, 0.08 oz/yd^2), and both hydroseeded treatments (1392 and 1008 mg/m^2, 0.06 and 0.05 oz/yd^2) were significantly higher than the control (Table 6). In addition, the biosolids compost was significantly greater than all other treatments. This was likely because 76 percent of the original total N content of the biosolids compost was inorganic N (ammonium-N and nitrate-N), which is more mobile and easily lost in stormwater runoff relative to organic N. Although this percentage of inorganic N is not characteristic to quality compost, it is consistent with previous findings for biosolids compost (Faucette et al., 2004).

Comparatively, the yard waste compost had two percent of its total N as inorganic N, the municipal solid waste compost had four percent, and the poultry litter had five percent (Table 1). Generally, in mature (e.g. sufficiently composted) compost the majority of N is in organic form. Furthermore, total N loading was highly correlated to the ammonium N and nitrate N content of compost (Table 7). The higher N loading from the municipal solid waste compost was likely because this compost had the greatest total N content of the four composts used in the study. Although the hydroseed treatments *had the least amount of N* applied, the relatively high loading was likely because the form of N applied (from fertilizer) was inorganic, and therefore more mobile in runoff. Total N lost in the runoff, combined from all three storms, as a percent of the total N applied by the treatments was 15.3 percent from the hydroseed with mulch, 12.2 percent from the hydroseed with silt fence, 3.9 percent for the biosolids compost, 2 percent for the municipal solid waste compost, and 0.7 percent for both the yard waste compost and poultry litter compost treatments. This gives further evidence that although the compost blankets

Table 6. Average load for total nitrogen (N), nitrate N (NO_3 N), total phosphorus (P), and dissolved reactive P (mg/m^2) in runoff by treatment at day one, three months and twelve months, n = 3.

	Day one				Three months				Twelve months			
Treatment	TN	NO_3 N	TP	DRP	TN	NO_3 N	TP	DRP	TN	NO_3 N	TP	DRP
Poultry	841.9cde	526.8bc	86.7c	75.3c	24.5b	2.9a	16.2a	13.4a	39.9b	4.7c	16.5ab	13.7b
Biosolids	4060.9a	2568.3a	156.7bc	141.2bc	254.3a	126.1a	53.9a	51.4a	41.8b	9.7bc	46.2a	37.8a
MSW*	2014.1b	3.4d	33.2c	2.7c	22.7b	8.5a	7.5a	3.9a	46.5b	5.7c	11.9b	7.4b
Y waste	450.5de	88.2cd	70.1c	56.5c	38.5ab	6.8a	10.3a	7.7a	34.2b	8.4bc	12.5b	9.7b
H/Berm	1391.2cb	796.4b	924.7a	865.6a	89.8ab	64.3a	27.7a	20.3a	43.3b	15.4ab	17.5ab	13.8b
H/fence	1008.3cd	644.3b	483.0b	412.0b	188.2ab	171.6a	41.0a	26.7a	40.1b	13.8abc	20.5ab	12.8b
Bare soil	76.7e	53.4cd	0.6c	0.54c	92.0ab	60.1a	22.0a	0.33a	102.9a	20.1a	26.9ab	19.4ab

Treatments with same letter are not significantly different at $\alpha = 0.05$ using Duncan's Multiple range test.

***MSW = municipal solid waste.**

TN = total nitrogen.

TP = total phosphorus.

DRP = dissolved reactive P.

generally apply more total N, hydroseed (with fertilizer) generally loses more of the N applied during runoff events, likely because inorganic N is more mobile than the organic N in compost.

By the second storm event, total N loads from experimental treatments were not significantly different from the control or between compost and hydroseed treatments. The biosolids compost was still significantly different from two of the composts, likely because the inorganic N content (initially higher than the other composts) had not been fully leached from the biosolids compost or taken up by plants. All treatments exhibited major load reductions between the two storm events, *as ninety percent of the total nitrogen loading occurred during the first storm event* after treatment application, signifying the risk of N loading is greatly diminished for most treatments after the first storm event.

By the final storm event, all total N loads were significantly less than the control. This was probably due to assimilation by vegetation (the control was not seeded) and/or movement into the soil profile, in addition to the losses from previous storm events. The increase in N loading during the final storm event by the control, is likely from higher runoff volumes caused by saturated conditions prior to the rain simulations.

Total N mass loads for the entire study period were 4357 mg L^{-1} (0.18 oz/yd^2) from the biosolids compost, 2083.3 mg L^{-1} (0.08 oz/yd^2) from the municipal solid waste compost, 1524 mg L^{-1} (0.06 oz/yd^2) from the hydroseed with mulch berm, 1236.6 mg L^{-1} (0.05 oz/yd^2) from the hydroseed with silt fence, 906.3 mg L^{-1} (0.04 oz/yd^2) from the poultry litter compost, 523.2 mg L^{-1} (0.02 oz/yd^2) from the yard waste compost, and 271.6 mg L^{-1} (0.01 oz/yd^2) from the bare soil. It should be noted that it is common for hydroseed to be applied multiple times before vegetation is completely established; this could have a major effect on added N loading that was not simulated in this study.

Nitrate N loss. Nitrate nitrogen is a highly mobile form of N and is easily transferred to groundwater. High concentrations of NO_3-N in drinking water have been linked to negative health effects in humans as well as eutrophication in surface waters. Elevated nitrate concentrations have been reported from agricultural fields that apply organic amendments (Eghball and Gilley, 1999). The biosolids compost had the greatest nitrate load during the first storm at 2,568 mg/m^2 (0.1 oz/yd^2), followed by the hydroseed with mulch berm at 797 mg/m^2 (0.03 oz/yd^2), the hydroseed with silt fence at 644 mg/m^2 (0.03 oz/yd^2), the poultry litter compost at 527 mg/m^2 (0.02 oz/yd^2), the yard waste compost at 88 mg/m^2 (0.004 oz/yd^2), the control at 53 mg/m^2 (0.002 oz/yd^2) and the municipal solid waste compost at 3 mg/m^2 (0.0001 oz/yd^2). The biosolids compost and both hydroseed treatments were significantly greater than the control. The amount of nitrate loss by each treatment was reflective of the amount of nitrate in the treatment at the time of application, and was positively correlated. This is likely because nitrate N is a highly mobile form of N (Brady and Weil, 1996). Composts with high nitrate contents and hydroseed using fertilizer with nitrate

Table 7. Results from correlation analysis. This table lists all response variables with significant correlation ($r > 0.70$, $\alpha = 0.05$, n = 21).

Response variable	Independent variable (treatments) with correlation coefficient
Total nitrogen (N) concentration, Storm #1	NH_4(0.92), NO_3(0.92)
Total N load, Storm #1	NH_4(0.93), NO_3(0.92)
Nitrate-N concentration, Storm #1	NH_4(0.94), NO_3(0.94)
Nitrate-N load, Storm #1	NH_4(0.94), NO_3(0.93)
Ammonium-N concentration, Storm #1	NH_4(0.99), NO_3(0.98)
Ammonium-N load, Storm #1	NH_4(0.97), NO_3(0.96)
Total P concentration, Storm #1	C:N ratio (0.88), OM(0.74), C(0.73)
Total P load, Storm #1	C:N ratio (0.89), OM(0.72), C(0.72)
DRP concentration, Storm #1	C:N ratio (0.88), OM(0.70), C(0.69)
DRP load, Storm #1	C:N ratio (0.88), OM(0.71), C(0.769)
Total N concentration, Storm #2	NH_4(0.91), NO_3(0.91)
Nitrate-N concentration, Storm #2	NH_4(0.84), NO_3(0.82)
Ammonium-N concentration, Storm #2	NH_4(0.96), NO_3(0.96)
Ammonium-N load, Storm #2	NH_4(0.71), NO_3(0.70)

DRP = dissolved reactive P.

may not be desirable for use adjacent to, or potentially in, surface water.

During the second storm event, major nitrate load reductions were observed in all treatments excluding the control and the municipal solid waste compost, which had low losses from the first storm. It's likely that substantial amounts of nitrate were either taken up by plants, moved into the soil profile, or was already lost in the runoff from the first storm for most treatments. Additionally, it's possible that minor amounts were lost to denitrification—particularly because the treatments were saturated from the first storm event potentially creating anaerobic conditions favorable to denitrification (Sylvia et al., 1999), and certainly for all treatments after the second storm. Three of the compost treatments had extremely low loads of nitrate, between 3 to 9 mg/m^2 (0.0001 to 0.0002 oz/yd^2), mostly because they generated very little runoff during this storm event, an attribute that may make them attractive for other stormwater management applications.

By the final storm event, the bare soil lost significantly greater nitrate, followed by both hydroseeded treatments. This was due to the higher volume of runoff produced by these treatments relative to the compost treatments. All compost treatments lost less than half the amount of nitrate as the control, ranging between 5 mg/m^2 and 10 mg/m^2 (0.0002 and 0.0004 oz/yd^2). Low nitrate content composts (municipal solid waste compost and yard waste compost in this study) may be desirable in other stormwater management projects and applications near surface water, as the nitrate loads from these treatments were generally lower than the bare soil throughout the study. Ammonium N loads were also determined (data not shown) as trends were consistent with nitrate N results for all treatments.

Total P loss. While phosphorus is not toxic to animals and humans it is one of the main causes of eutrophication in surface water, which can lead to impaired water quality. Total P concentrations generally characteristic to wastewater treatment plant discharges is 5 mg L^{-1} (5 ppm), while the critical concentration of total P (particulate P + dissolved P) in streams at which eutrophication is triggered is 0.10 mg L^{-1} (0.10 ppm), and 0.03 mg L^{-1} (0.03 ppm) for dissolved P (Brady and Weil, 1996). The total amount of phosphorus applied by each treatment was 95 g/m^2 (4 oz/yd^2) from the poultry litter compost, 85 g/m^2 (3.6 oz/yd^2) from the biosolids compost, 23 g/m^2 (1.0 oz/yd^2) from the municipal solid waste compost, 61 g/m^2 (2.6 oz/yd^2) from the yard waste compost, and 10 g/m^2 (0.4 oz/yd^2) from the hydroseeding.

During the first storm event the hydroseed treatments had the highest total P runoff loads, 925 mg/m^2 (0.04 oz/yd^2) from the hydroseed with mulch berm and 483 mg/m^2 (0.02 oz/yd^2) from the hydroseed with silt fence treatment, both were significantly different from the control and the composts (Table 6). This was likely due to the soluble fertilizer P in the hydroseed. Eghball and Gilley (1999) evaluated storm runoff from agricultural fields with sorghum residue and found higher total P *concentrations* from fertilizer applications (2.12 kg ha^{-1}; 11.7 lb ac^{-1}) compared to compost (0.93 kg ha^{-1}; 5.1 lb ac^{-1}) during a second storm event.

During the second storm event, all treatments, with the exception of the control, had major reductions in total P loads in the runoff. This was likely because most P was already lost during the first storm event, *as 85 percent of the total P mass loading occurred during the first storm event,* while the vegetation likely took up lesser amounts and/or it moved into the soil profile. The hydroseed treatments had the greatest reductions between the first and second storm events. This was likely because the P fertilizer in the hydroseed was in soluble form and therefore more likely transported in the initial runoff event.

By the final storm the biosolids compost (46.2 mg/m^2; 0.0002 oz/yd^2) had greater total P loads than the yard waste (12.5 mg/m^2; 0.0006 oz/yd^2) and municipal solid waste (11.9 mg/m^2; 0.0005 oz/yd^2) composts, likely because of the elevated P content of the biosolids compost relative to the other two composts.

Total P mass load for each treatment over the one year study period was 970 mg/m^2 from the hydroseed with mulch, 545 mg/m^2 from the hydroseed with silt fence, 257 mg/m^2 (0.01 oz/yd^2) from the biosolids compost, 119 mg/m^2 (0.005 oz/yd^2) from the poultry litter compost, 93 mg/m^2 (0.004 oz/yd^2) from the yard waste compost, 53 mg/m^2 (0.0022 oz/yd^2) from the municipal solid waste compost, and 50 mg/m^2 (0.002 oz/yd^2) from the bare soil. The higher the total P content in the compost, the greater the P load in the runoff. Additionally, the compost treatments that lost the most P had near neutral pH; while the municipal solid waste compost and yard waste compost pH levels were near 8.0, potentially meaning that the P was not as mobile in high pH composts because it is bound to Ca and/or Mg. The poultry litter compost with gypsum had 54 percent less P loss than the biosolids compost although the P content of the treatments was similar. This may give some evidence that calcium sulfate (gypsum) can reduce P losses from compost blankets; however, more testing is needed to draw any conclusions.

Total P lost in the runoff as a percent of the total P applied from the treatments for all three storms combined was 9.7 percent from the hydroseed with mulch berm, 5.4 percent from the hydroseed with silt fence, 0.4 percent from the biosolids compost, 0.2 percent from the municipal solid waste compost, and 0.1 percent for both the yard waste compost and poultry litter compost. This provides evidence that soluble P fertilizer in hydroseed is more likely to be lost in storm runoff than the organic P supplied from compost, both in percentage of the total amount applied and in total loading if runoff reaches surface water.

Dissolved reactive P loss. Reactive P entering surface water is of particular concern because it is often available to aquatic plants for immediate uptake, leading to increased risk of eutrophication. During the first storm event dissolved reactive P loads were highest among the hydroseeded treatments, 866 mg/m^2 (0.036 oz/yd^2) and 412 mg/m^2 (0.012 oz/yd^2), and both were significantly different from the composts and the control. Eghball and Gilley (1999) also found elevated dissolved and bioavailable P in runoff from fertilizer compared to compost application, in agricultural fields with wheat and sorghum residue, after the first rain event. The low dissolved reactive P loading exhibited from the municipal solid waste compost may be the result of the high pH (8.1) of this compost (in addition to low runoff volumes), which would reduce its solubility because of adsorption to Ca and Mg. These results were interesting for several reasons. First, it is well documented (Brady and Weil, 1996) that highly weathered clay soils (like iron (Fe)/aluminum (Al) oxides represented in this study) have a relatively high capacity to fix dissolved P (as PO_4-), and it is likely that most of the dissolved P in hydroseed comes in contact with the soil which should create a higher propensity for the soluble P from hydroseeding to adsorb to clay colloids and become insoluble and unavailable. Second, organic matter (much higher in the compost treatments) can inhibit the adsorption of dissolved P to soil colloids by physically blocking exchange sites, chelating Fe and Al, thus preventing reaction with P ions, and organic acids can displace P ions by filling up potential exchange sites on clay particle surfaces (Brady and Weil, 1996). These conditions make P loss more favorable from compost than hydroseed; however, the results indicate just the opposite. This is likely because the soluble P (more mobile in runoff than the organic bound P normally characteristic to compost) from the hydroseed saturated the P fixing capacity of the soil quite quickly allowing greater amounts of P to leave the system.

During the second storm event a statistical difference in dissolved reactive P *concentration* (but not loads) was observed between the biosolids (5.9 mg L^{-1}, 5.9 ppm) and the poultry litter composts (1.3 mg L^{-1}, 1.3 ppm). This may be the result of the soluble P in the poultry litter compost reacting with the gypsum (calcium sulfate), but further evaluation would be required to draw conclusions.

During the final storm event, dissolved reactive P loads had decreased relative to the first storm event but were similar to the second storm event, probably due to the increased runoff volumes experienced during the final storm. The biosolids compost was significantly higher than all other treatments except the control—likely due to the *high runoff volumes generated by the control.*

Correlation analysis for nutrient loss. Results from correlation analysis (Table 7) were used to evaluate which of the treatment physical, chemical, and biological characteristics, and rainfall and vegetation growth results (independent variables) were correlated with the parameters from nutrient loss results (response variables).

Total P and dissolved reactive P concentrations and loads from the first storm event were correlated to organic matter content, C content and C:N of the compost treatments ($r > 0.70$). Generally, the higher the organic matter content, C content, and C:N of the compost the lower the P concentration and load in the resulting storm runoff. This may indicate that some dissolved inorganic P in the runoff reacted with humus colloids in the compost treatments or that microorganisms immobilized some dissolved inorganic P because of insufficient P relative to C (Brady and Weil, 1996). It could also indicate a higher percentage of organic P relative to soluble P content (although not directly tested) in compost can lead to less P loss during the first storm event after application, assuming erosion is kept to a minimum.

Summary and Conclusion

Under these experimental conditions compost systems generally performed as well or better than slit fence and hydroseeding in reducing storm runoff. Specifically, compost systems produced significantly less runoff than hydroseed during storms after vegetation establishment and once vegetation was mature, with significantly greater infiltration for all storm events. Compost reduced runoff more over one year than hydroseeding, by 33 percent and 8 percent respectively, and reduced total cumulative runoff relative to the control by 55 percent and 30 percent, respectively. Under intense rainfall, compost systems significantly delayed the onset of runoff by a cumulative average of 15 minutes, compared to hydroseed, and significantly reduced the elapsed time until peak runoff rate after vegetation was established. Cumulative peak runoff rates were 60 percent lower for the compost treatments relative to the control and 34 percent lower relative to hydroseed, thereby reducing erosion potential. Compost systems reduced total solids by 97 to 99 percent relative to a bare soil, and had 3.5 times less solids loss during the first storm after application and 16 times less solids loss during a second storm, relative to hydroseed and silt fence.

Materials high in total N and total P are likely to lose more of each nutrient to storm runoff; however, N and P loading is greatly diminished after the first runoff event. Because hydroseed is applied with inorganic N and soluble P it is more likely that these nutrients will be lost to storm runoff and consequently are in forms more available to aquatic plants. Mass loading of total P from hydroseed was five times greater than compost, and dissolved reactive P was six times greater than compost; even though the total amount of P applied was two to nine times less from hydroseed relative to compost. Composts high in inorganic N generated higher N loads in runoff, therefore compost with a high percentage of organic N of the total N is recommended. Additionally, high concentrations of C, organic matter and Ca (as added gypsum) in compost may reduce P loss in runoff. The high C content (and by relation organic matter content) of composts is likely very important in minimizing P loss. This results either from P immobilization characteristic in high C:P ratio materials or it is an indicator that the chemical constituents in compost are organic in form and therefore less easily transported relative to soluble forms. In light of this, state and federal compost specifications for erosion control should incorporate a nutrient component.

The potential for high losses of P from hydroseeding applications needs to be addressed by the policy and regulatory community, particularly since it is one of the most ubiquitous erosion control best management practices in the United States. Erosion control materials high in nutrients, particularly nutrients in soluble and inorganic forms, increase the risk of nutrients entering water bodies; although, because compost can significantly reduce runoff, nutrient loads are often lower from these materials relative to other best management practices. Future research should focus on testing and improving existing state and federal specifications for compost use in erosion control and stormwater management applications. Specific attention should be given to particle size distribution of compost materials, flow through rates of filter berms, slope steepness, potential to remove other pollutants in runoff such as petroleum hydrocarbons, and the optimum nutrient contents and forms in materials used for stormwater management applications.

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