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DEVELOPMENT AND EVALUATION OF COMPOST MULCH BEST MANAGEMENT PRACTICES FOR EROSION CONTROL

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DEVELOPMENT AND EVALUATION OF COMPOST MULCH BEST MANAGEMENT PRACTICES FOR EROSION CONTROL

1. Purpose.

a) This Public Works Technical Bulletin (PWTB) transmits information on compost mulch best management practices (BMP) for erosion control. Composted byproduct materials such as wood fiber mulch and garden/landscape compost from municipal and military land management activities can provide a cost-effective method for erosion control and vegetation establishment while reducing landfill waste and impacts to water quality. These composted materials can provide a rapid method for erosion control when used as a blanket or as a check dam.[1] This PWTB focuses on using compost wood fiber mulch (shredded and screened) as a BMP, and it also provides results and lessons learned from a side-by-side evaluation of composted mulch treatments. These lessons will provide natural resource and training land managers with a unique capability for cost-effective erosion control.

b) All PWTBs are available electronically as Adobe PDFs at the National Institute of Building Sciences' Whole Building Design Guide (WBDG) webpage, accessible through this link:

http://www.wbdg.org/ccb/browse_cat.php?o=31&c=215

[1] A check dam is a temporary or permanent structure which reduces flow velocity, allowing sediments to settle out behind the structure.

2. Applicability. This PWTB applies to all U.S. Army facilities, both CONUS and OCONUS. The information conveyed thru this PWTB can be applied to any site where erosion is of concern.

3. References.

a) Army Regulation (AR) 200-1, "Environmental Protection and Enhancement," 13 December 2007. http://www.apd.army.mil/pdffiles/r200_1.pdf

b) Executive Order (EO) 13514, Federal Leadership in Environmental, Energy, and Economic Performance. Application to goal related to Pollution Prevention and Waste Elimination. http://www.whitehouse.gov/assets/documents/2009fedleader_eo_rel.pdf

c) The above regulations also reference The Sikes Act (16 U.S.C. 670e-2), EO 13112 ("Invasive Species"), the Clean Air Act (U.S.C, Title 42, Chapter 85), and the Clean Water Act (Federal Water Pollution Control Amendments of 1972, as amended).

4. Discussion.

a) AR 200-1, as revised in December 2007, contains policy for environmental protection and enhancement, implementation of pollution prevention, conservation of natural resources, sustainable practices, compliance with environmental laws, and restoration of previously damaged or contaminated sites. This regulation directs that Army installations be good stewards of land resources by controlling sources of wind-driven and hydrological erosion to prevent management activities from damaging land, water resources, and equipment.

b) Both hydrologic and wind-driven erosion play into multiple laws and regulations such as the Clean Air Act and Clean Water Act, all of which affect how Army training lands are managed for erosion.

c) This PWTB reports the studies and evaluations performed on the effectiveness of three different types of biodegradable erosion control covers composed of: fine municipal compost, mulch (composted wood fiber from soft and hard woods), and a mixture of 50% compost and 50% mulch, for erosion control with field and laboratory-scale experiments.

d) Quantitative analysis was conducted by comparing the sediment load in the runoff collected from sloped plots in the field and in the laboratory with the composted erosion control blankets. The field plots had an average slope of 3.5%, while the laboratory experiments were conducted at three different slopes; 4%, 8%, and 16%. Results for both the laboratory and field data indicated that, in general, a 50/50 mixture of compost and mulch will be optimal for reduction of sediments. There were some exceptions to this trend, however. In the field, the results were tighter between the 50/50 mixture and the 100% mulch; they were not significantly different. Additionally, simulated results from a calibrated Water Erosion Prediction Project (WEPP) model were compared with observations from the laboratory.

e) Appendix A explains the importance of the compost erosion control cover study to the Army's environmental program. Results from this study indicated that all three cover materials significantly reduced the runoff and rate of soil erosion when compared to bare soil conditions, though the compost/mulch mixture and the mulch blankets were more effective than other tested measures for erosion control.

f) Appendix B contains the methods and results from comparison of our laboratory studies with WEPP modeling predictions.

g) Appendix C contains the procedures and results from the field studies.

h) Appendix D lists references cited in the appendices.

i) Appendix E spells out abbreviations used in this PWTB.

5. Points of Contact.

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Appendix A:
Introduction

Authors: Heidi Howard, Daniel Koch, and Niels Svendsen (ERDC-CERL); Rabin Bhattarai and Prasanta Kalita (University of Illinois, Department of Agricultural and Biological Engineering).

Erosion is a constant and immense force of nature. It is responsible for natural wonders like the Grand Canyon, but also responsible for disasters like the Dust Bowl of the 1930s. Both examples identify the power of water, either to carve away the land or, where water was absent, the land could not be held in place. Whether slow or disastrous, erosion works on a scale ranging from microscopic to continental, and therefore, no landscape is immune to it.

Consideration and technique must be employed to minimize any built area’s impact on the environment. This goal has been echoed in legislation and directives for environmental standards that apply to both government and civilian projects. These regulations most notably include the Sikes Act, Army Regulation (AR) 200-1, Executive Order (EO) 13112, the Clean Air Act, and the Clean Water Act.

These regulations encourage and/or require government installations to maintain a healthy, no-net-loss environment. Such an environment is one where there is an effort that strives to balance unavoidable habitat, environmental, and resource losses with replacement of those items on a project-by-project basis so that further losses may be prevented.

Soil erosion is a fundamental concern for a no-net-loss environment; it is vital to minimize erosion’s effects on soil, water, plant, and animal communities. Although erosion is an irrepressible force of nature, human use of the land tends to accelerate the process.

Military training can cause significant alterations to the landscape because foot traffic, off-road vehicles, and exploding ordinance combine to disturb the soil and its vegetative cover (Whitecotton et al. 2000; Wang et al. 2008). An effort to control erosion on just one range is an involved process by itself. In context, the Department of Defense (DoD) controls more than 25 million acres of federally owned land in the United States, with 15 million acres of that land available for a variety of military training activities (Ayers et al. 2000). The disruption of soil and vegetative cover over such a vast expanse of land holds the potential for considerable environmental degradation which, in turn, risks the sustained readiness of military personnel training on those lands.

Thus, controlling soil erosion is critical to safeguarding military lands, both physically and in the broader ecological footprint. Unmitigated erosion can wash out roads and other infrastructure. Soil erosion also is a major source of pollution to waterways. Phosphorus and nitrates that reach surface water encourage mineral and nutrient enrichment of water sources, while heavy metals and organic chemicals harm aquatic organisms. In addition, sediment that enters bodies of water increases turbidity and causes siltation of waterways.

Most of these consequences are either costly to rehabilitate or impossible to reverse. Because the monetary costs to repair this degradation are considerable, erosion control could even be considered a fiscal benefit. Soil management with an effective erosion control infrastructure can contain the otherwise enormous costs of land maintenance.

Controlling soil erosion is direct and deceptively simple—cover bare soil and it will stay where it is. Questions remain, though, regarding methods and processes for optimal, cost-effective erosion control. It is known that an appropriate soil cover can increase infiltration rates and surface storage of moisture because the cover enhances the soil's structure and porosity. The cover also decreases runoff velocity and sediment transportation. An appropriate soil cover, therefore, can restore lost soil nutrients while still mitigating wind and water erosion.

Compost may be a simple solution to establish an effective soil cover. Studies have shown that composted yard waste improves soil moisture and native plant establishment within impacted areas (Singer et al. 2004). Other studies have looked at uses of composted material for increased hydraulic conductivity within decomposed granite road surfaces (Curtis et al. 2007). Similarly, compost treatment generated less than half the sediment compared to the control treatment during a range of storm events. Faucette et al. (2007) evaluated the effect on erosion control of blending wood mulch with compost versus a straw blanket treated with polyacrylamide (PAM). The authors reported that a mixture of compost and mulch reduced runoff volume, peak runoff rate, and soil loss when compared to application of the straw blanket with PAM treatment.

Compost thus has emerged as an inexpensive, renewable, and effective medium for soil cover. It is known to improve soil quality by supplying soil nutrients, moderating soil temperature, and improving soil water retention. Using the compost in a dry land can significantly reduce losses of rainwater (Agassi et al. 2004). Compost is also effective in controlling runoff; peak runoff rates from compost plots are greatly slowed when compared to those from bare soil plots (Zhu and Risse 2009).

Mulch also has been studied closely in recent years as an aid to prevent erosion. Gruda (2008) tested wood fiber mulch (WFM) against bare soil for its effects on water retention, soil temperature, and growth of plants by using a subsurface irrigation system. The research revealed that WFM modified the microenvironment, improved soil moisture retention, and moderated soil temperature gradient to result in better plant growth. Mulching has been found to be effective for erosion control because it increases infiltration rates by minimizing crusting and improving macropores, and it decreases sediment concentration by improving soil structure and protecting the soil from raindrop impact.

Compost and mulch are mediums with great potential. Considering the very large acreage devoted to training lands, regular landscape maintenance waste could be processed on site to become material for erosion control. Compost and mulch could satisfy the need for low-cost, long-range, sustainable management of military training lands.

Studies conducted for this PWTB investigated the erosion-control effectiveness of three compost media in the field and the laboratory (Figure A-1). The results are summarized below:

1. All three blanket materials — compost, mulch (WFM), and 50/50 mixture of compost and mulch — significantly reduced the runoff and rate of soil erosion when compared to bare soil conditions under laboratory conditions. Field versus laboratory results showed that samples collected from the field experiments measured higher in sediment concentration compared to laboratory conditions for all compost erosion-control blankets (Figure A-2 and Table A-1).

2. Of all three materials tested in the field, the compost/mulch mixture blanket performed best on a 3.7% to 3.6% slope when compared to compost or mulch alone.

3. However, in laboratory experiments, the mulch cover blanket was more effective in reducing soil erosion and runoff in higher conditions, compared to the compost or mixed blankets.

4. Overall effectiveness of the compost blankets reduced with slope steepness. By contrast, when using mulch on a 16% slope, an 80% reduction of sediment was observed when compared to bare soil (Table A-1).

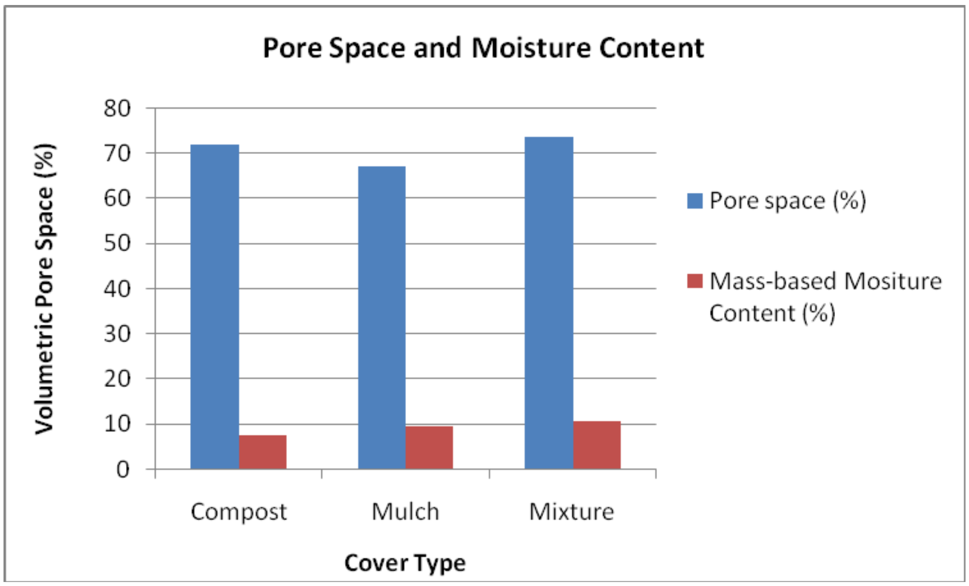

Figure A-1. Average percent of pore space and moisture content of the materials used for both field and laboratory studies.

Table A-1. Effectiveness for erosion control of soil covers at various slopes, in the laboratory and in the field.

Material	Lab Slope (%)	Sediment Reduction (%)	Lab Slope (%)	Sediment Reduction (%)	Lab Slope (%)	Sediment Reduction (%)	Avg. Field Slope (%)	Total runoff (ml)
Compost	4 28		8 33		16	24	3.65	3478.231
50/50 Mix	4 36		8 65		16	75	3.73	2968.242
Mulch	4 55		8 73		16	80	3.60	7021.267
Bare soil	4 0		8 0		16	0	No control	No control

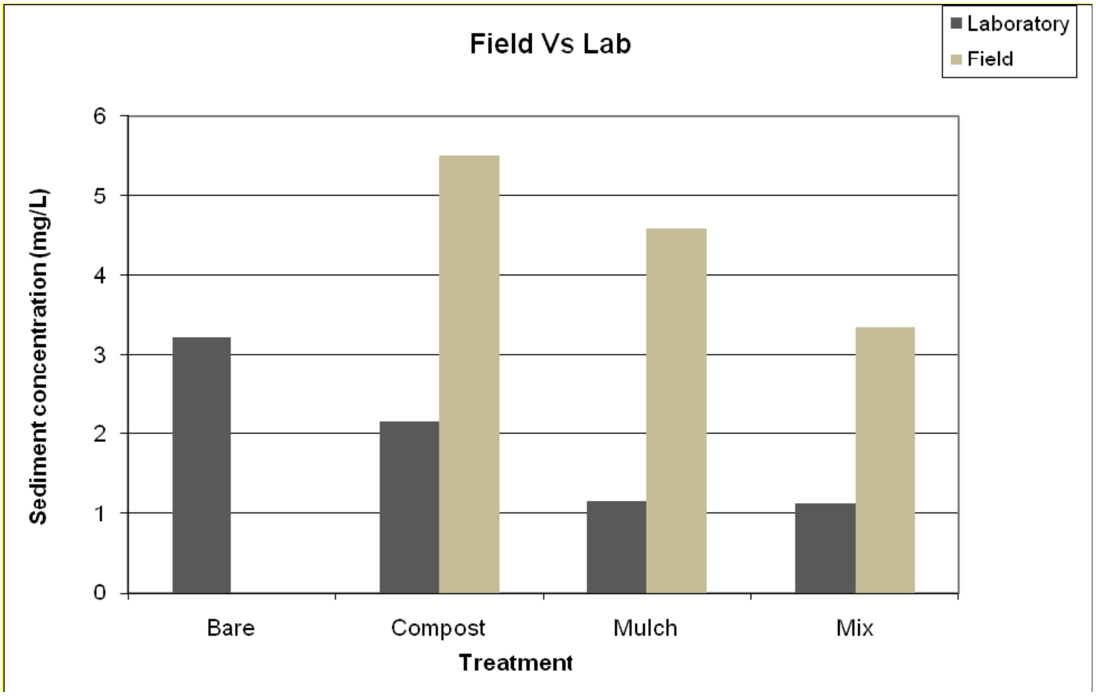

Figure A-2. Sediment concentration comparison of laboratory and field results at 3.6% field and 4% slopes.

While erosion control blankets are not practical for large areas of soil, they are a practical and economical way to manage soil erosion for smaller areas in places such as military ranges, roadside cuts, and other places where you would utilize an erosion control blanket, straw bale, or establish vegetation. Our evaluations have proven the use of inexpensive, readily available materials such as compost and mulch could provide a cost-effective and quick method for erosion control.

Appendix B

LABORATORY STUDIES

Methods

Soil Bed Preparation

A 4% slope was chosen to simulate the field conditions in which the first studies were conducted. The field slopes ranged from 3.2% to 3.8% or an average of 3.6%. Slopes of 8% and 16% were chosen for the soil beds to provide a range of realistic slopes found on military lands.

Two horizontal, tilting soil chambers (3.6-m long, 1.5-m wide, and 0.3-m deep) were used to investigate soil erosion patterns from soil beds covered with biodegradable materials (Figure B-1 and Figure B-2). Each soil chamber was divided into two separate compartments with a steel plate divider placed at the center of the 1.5-m-wide chamber across its 3.6-m length and sealed. Similarly, the bottom and edges of each compartment were sealed completely. The chambers were filled with Dana silt loam series soil which is predominantly found on slopes (from 2%–5%) in Central Illinois. The clay content of this soil series is from 11%–22%. The soil bulk density ranges from 1.40–1.55 g/cc, permeability ranges from 0.6–2.0 in./hr, and contains 4% organic matter.

The top 0.3 m of soil was collected in two separate layers (0–0.15 m and 0.15–0.3 m) and packed in the chamber. The beds were then saturated, re-saturated, and left to settle so that the beds would compact naturally. The edges of each compartment were compacted tightly to eliminate preferential flow of water along the edges of the bed. One compartment of the first bed was left bare, while the second compartment was covered with a 25-mm thick compost layer. Similarly, the second bed was treated with 25-mm thick mulch and mix (50% mulch, 50% compost) cover in its two compartments.

Data Collection

Rainfall was applied to the soil chamber using a computer-controlled laboratory rainfall simulator. The simulator was positioned 10 m from the floor so that the droplet velocity most accurately resembled a natural rainfall event (Hirschi et al. 1990). To resemble a Central Illinois, 10-yr, 30-min rainfall event, the storm scenario applied a rainfall intensity of

43.4 mm/hr (1.71 in./hr) for 30 min. Laboratory experiments were carried out for three different slopes: 4% (replicating field slope), 8%, and 16%, to investigate erosion control effectiveness under advancing slope conditions (Figure B-1 and Figure B-2).

Figure B-1. Bare (left) and compost cover (right) compartments with 16% slope condition, after rainfall simulator experiment.

Figure B-2. Compost and mulch mix (left) and mulch cover (right) compartments with 8% slope condition, after rainfall simulator experiment.

Results

Laboratory Experiments

Figures B-3 and B-4 present the runoff volume collected from the laboratory experiments. Measured surface runoff volume showed a substantial reduction in runoff volume in the presence of soil cover. As expected, the bare ground condition produced the highest runoff volume compared to soil bed covered with mulch, compost, or the 50/50 mixture. Of all conditions, the mulch cover was found to be the most effective to reduce runoff volume. One plausible reason behind this observation could be attributed to the surface roughness of the bed materials. Since the mulch cover had the highest surface roughness among the three bed materials tested, it may contribute to slowing runoff velocity.

On average for all slopes, the compost cover, mix cover, and mulch cover produced 28%, 36%, and 55% less runoff volume, respectively, compared to bare (control) condition. Mulch has a larger surface roughness which reduces water velocity, allowing the rain to percolate through the mulch and soil profile versus running off on the surface. As expected in most cases, higher runoff volume was obtained for high soil moisture conditions and higher slopes.

Since there were two soil beds that were each separated into two compartments, experiments were carried out in two sets: one bed with bare and compost cover conditions, and a second bed with mulch and mix surface conditions. Although data from all four conditions are grouped together in the following figures, the beginning moisture condition for the bare and compost cover experiments may have been slightly different from the mulch and mix set.

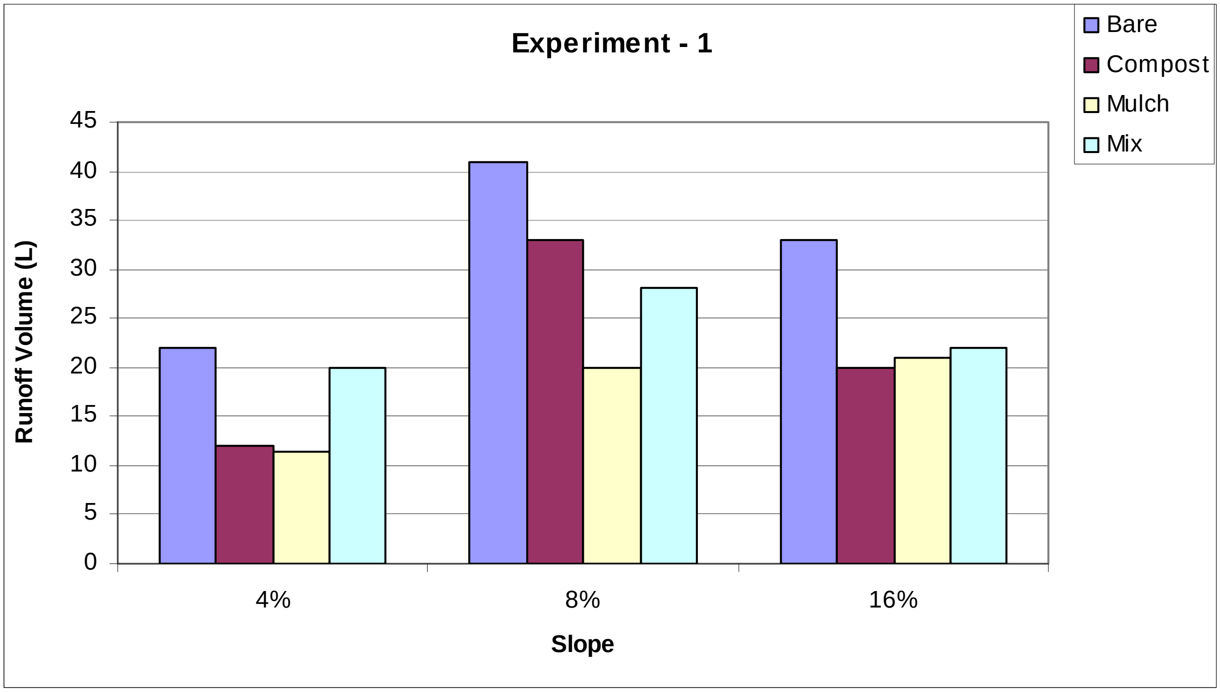

Figure B-3. Runoff volume (L) collected for different cover and slope conditions in Experiment 1.

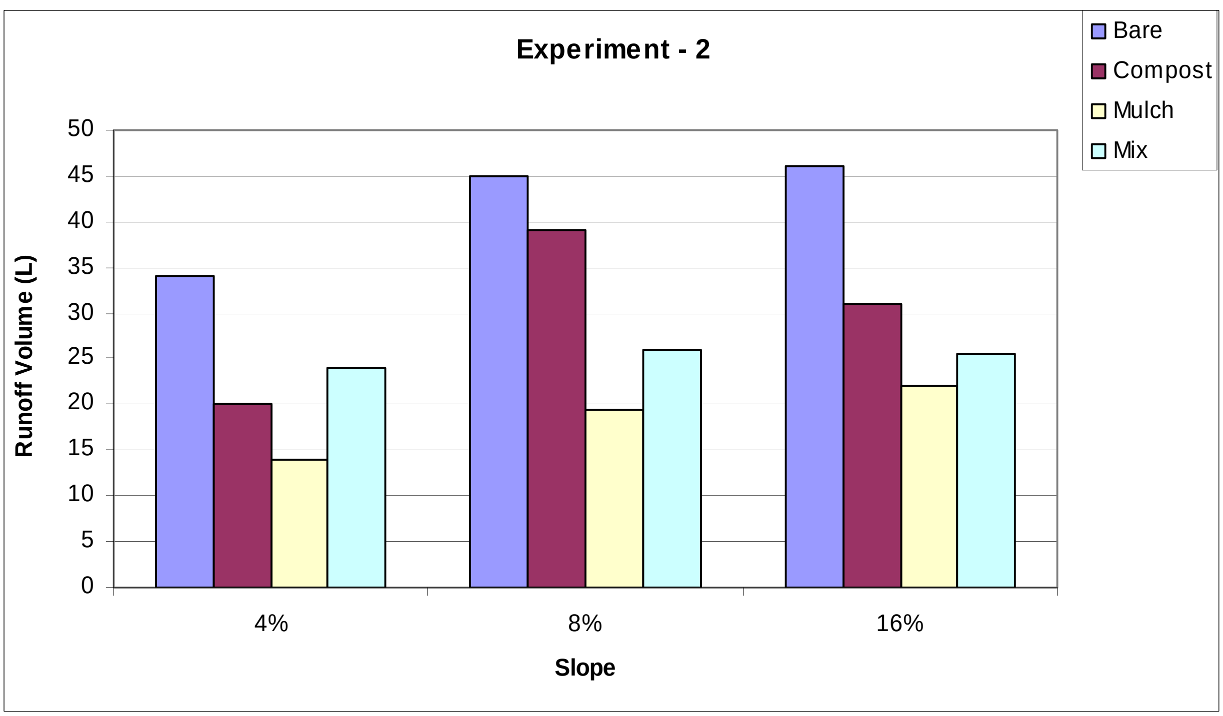

Figure B-4. Runoff volume (L) collected for different cover and slope conditions in Experiment 2.

Sediment concentrations for different cover and slop conditions were measured in two sets of experiments.

As observed in Figure B-5, the mulch and the 50/50 mix cover both were more effective in reducing soil erosion compared to compost for the 4% slope condition. The highest rate of soil erosion was observed from the bare plot. The compost cover was able to reduce the soil erosion by 33% while the mulch and 50/50 mix cover were able to reduce the soil erosion by 64% compared to the bare surface condition.

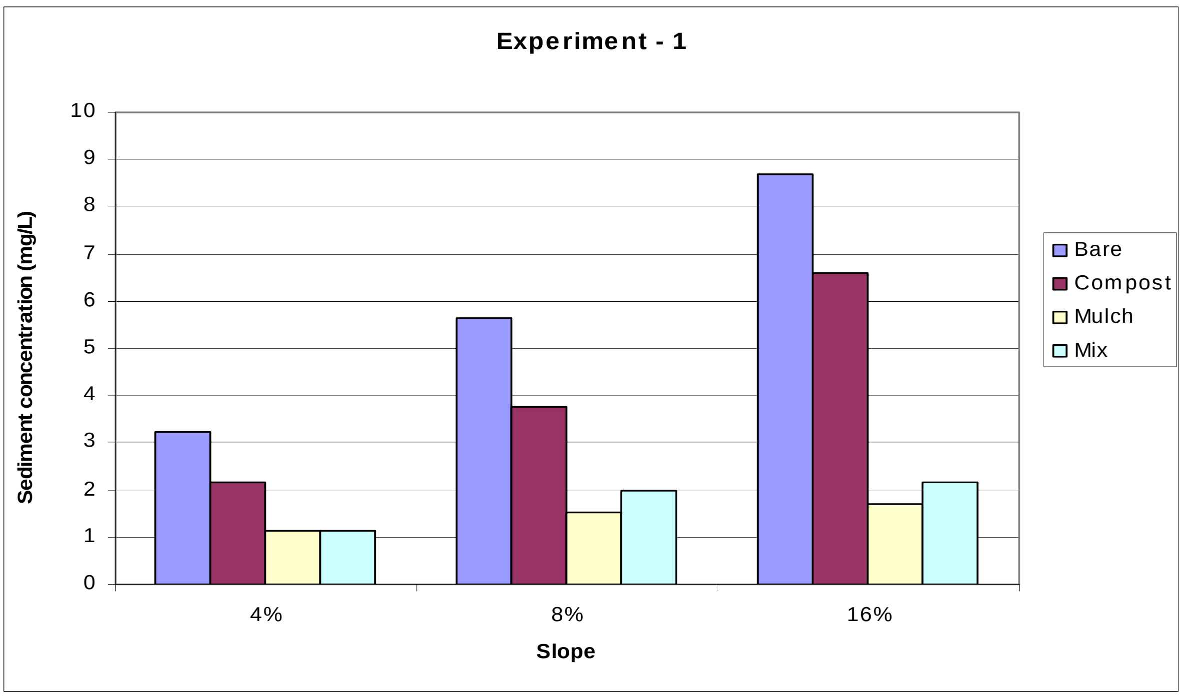

Figure B-5. Sediment concentration (mg/L) measured for different cover and slope conditions in Experiment 1.

For the 8% slope condition, the mulch and mix covers were more effective in reducing soil erosion compared to compost cover. Again, the maximum soil erosion occurred from the bare surface condition. In addition, the erosion rate increased for all cover conditions compared to 4% slope condition. The compost cover was able to reduce the soil erosion by 33% and the 50/50 mix cover reduced it by 65%, while the mulch cover was able to reduce the soil erosion by 73% when compared to the bare condition. This indicates that the mix cover becomes less effective in erosion reduction, compared to mulch cover, as the slope increases.

Similarly, mulch and mixed covers were more effective in reducing soil erosion compared to compost cover for the 16%

slope condition, and the highest erosion rate was observed in the bare surface condition. Again, the erosion rate increased for all 16% slope cover conditions, when compared to 4% and 8% slope conditions. The compost cover was able to reduce the soil erosion by 24%, and the 50/50 mix cover reduced soil erosion by 75%, while the mulch cover was able to reduce the soil erosion by 80% compared to the bare surface condition. This result again suggested that the compost cover becomes a less effective erosion control measure as the slope increases. As slope increases, the mulch cover becomes the better option for erosion control compared to the mix cover.

A second set of experiments was carried out after the first set. Sediment concentration measured for different cover and slope conditions during the second set of experiments is shown in Figure B-6. The results were similar to the results obtained in the previous set of experiments. As expected and observed in the previous set of experiments, the bare condition had the highest rate of soil erosion for all three slope conditions.

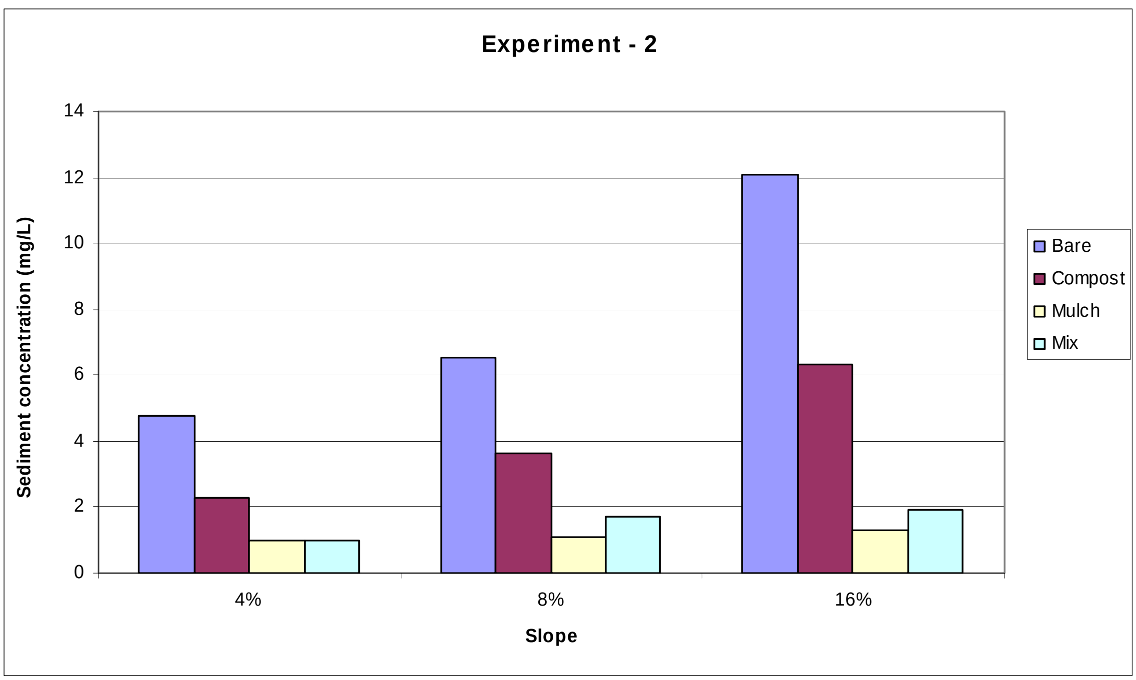

Figure B-6. Sediment concentration (mg/L) measured for different cover and slope conditions in Experiment 2.

Under the 4% slope condition, the compost cover was able to reduce the soil erosion by 77%, the 50/50 mix cover reduced it by 117%, and the mulch cover was able to reduce total erosion by

118%, all compared to the bare condition. Similarly for the 8% slope condition, the compost cover was able to reduce the soil erosion by 51%, the 50/50 mix cover reduced it by 85%, and the mulch cover reduced soil erosion by 95% compared to the bare plot. For the 16% slope condition, the compost cover was able to reduce the soil erosion by 66%, the 50/50 mix cover reduced it by 116%, and the mulch cover reduced erosion by 123% compared to the bare plot.

As observed in the previous set of experiments, mulch and mix covers proved to be better erosion control measures for all slope conditions when compared to compost cover. Even though both mulch and mix covers were equally effective in reducing soil erosion for the 4% slope, the mulch cover was more effective (compared to the mix cover) in preventing soil erosion at higher slopes. Along with the increase in slope, it appeared that the compost material could not hold the soil particles as effectively as it did in gentler slopes. Due to the increased flow velocity as slope increases, the fine compost material in both the mix blanket and compost cover was observed to erode along with the soil particles, which combined to increase the sediment load.

Figure B-7 provides a comparison of runoff percentage by type of cover at three slopes, showing that the mulch provided the best control of runoff at each slope.

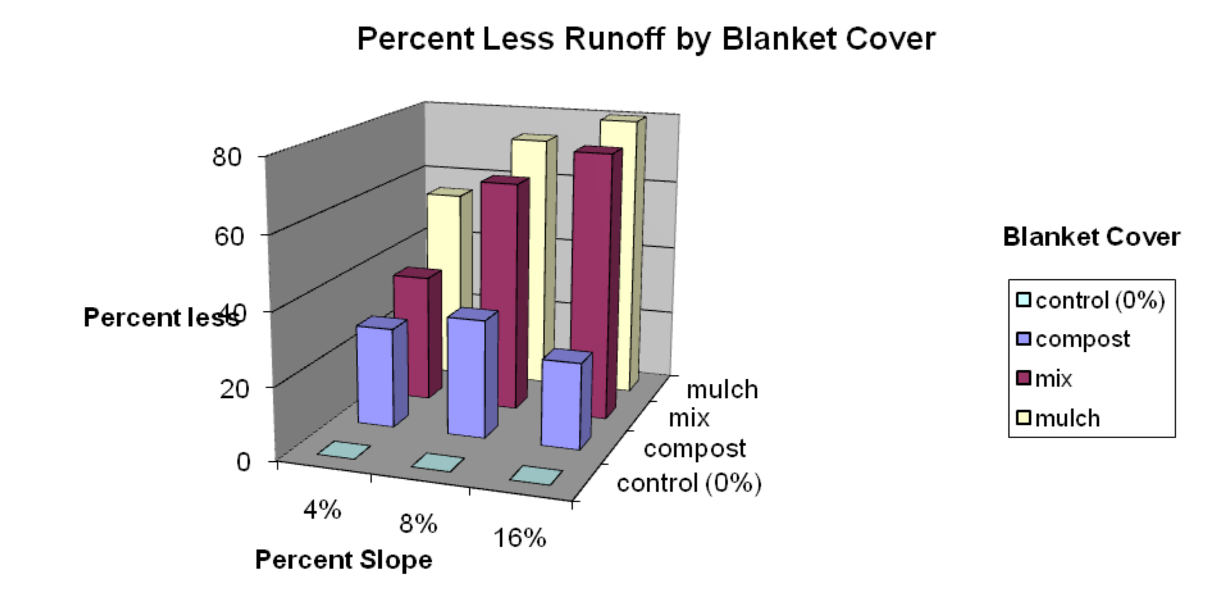

Figure B-7. Comparison of runoff by blanket cover type for each of three slopes and control.

Water Erosion Prediction Project Model Results

The Water Erosion Prediction Project (WEPP) model simulation (USDA 1995) was carried out by replicating the three different slope conditions tested in the laboratory. The model's results were compared with the laboratory scale observations for the bare condition. At first, the WEPP model was calibrated for runoff volume (expressed in millimeters). Most of the parameters for simulations were obtained from actual measurement and literature. The initial soil moisture parameter was used as the calibration parameter during this part of simulation. After comparing the observed runoff volume with simulated runoff, the model was again calibrated for sediment loss prediction. The interrill erodibility parameter for the soil was used as the calibration parameter for predicting sediment loss.

Comparison of observed and simulated results (for runoff volume and sediment loss) is presented in Figure B-8 and Figure B-9. The observed runoff volume shows close agreement with the WEPP model's predicted runoff. The observed runoff volumes for the 4% and 16% slopes were nearly equal to the simulated result, while the model prediction was slightly below the actual runoff volume for the 8% slope condition (Figure B-8). Similarly, the model prediction for sediment loss was slightly below the observed losses for all three slope conditions (Figure B-9).

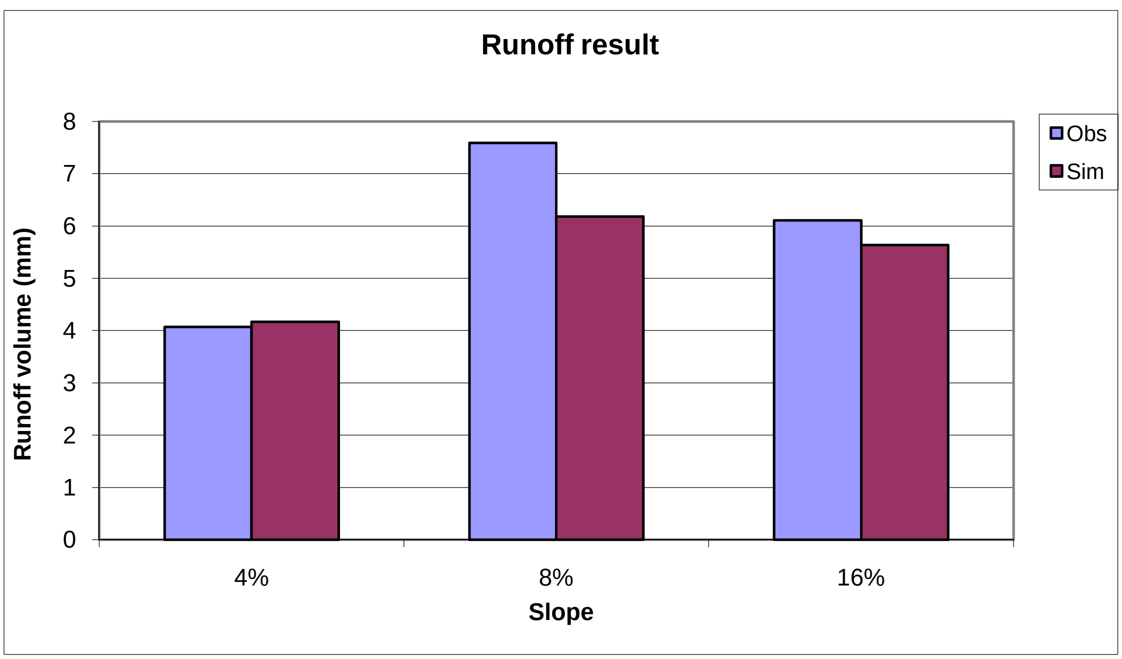

Figure B-8. Observed and simulated runoff depth for different slope conditions in the laboratory experiments.

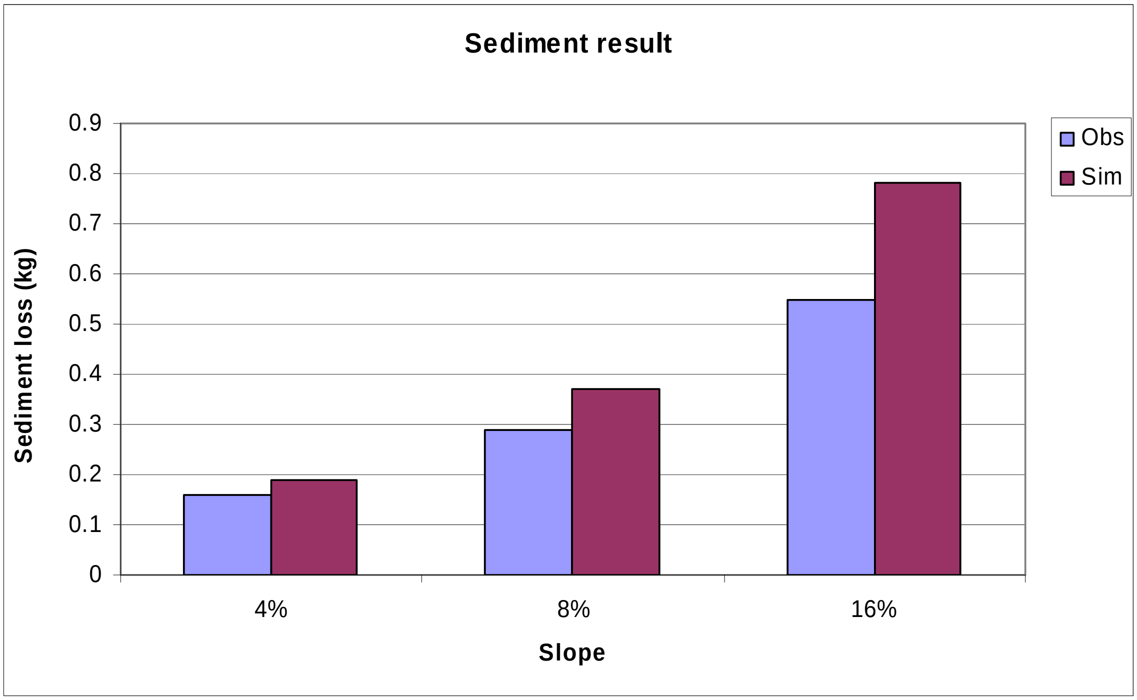

Figure B-9. Observed and simulated sediment loss for different slope conditions in the laboratory experiments.

Appendix C:

FIELD STUDIES

Methods

Site Selection and Plot Construction

The site selected for this study was located south of Urbana, IL. The agricultural field was classified as intermixed Flanagan and Catlin soil types by the online Resource Management Mapping Service developed by the Illinois Department of Natural Resources. The area was divided into nine plots, each comprising a 10 m x 1.5 m rectangle, separated by a 0.3–0.6 m buffer. Slopes were determined by a field survey (Table C-1).

Table C-1. Plot slopes.

Plot #	Mean slope (%)
1	3.43
2	3.76
3	3.57
4	3.81
5	3.96
6	3.57
7	3.71
8	3.47
9	3.67

The plots were grouped into sets of three plots. Each set consisted of one plot blanketed by compost, one plot by mulch, and one plot by mixture of compost and mulch, mixed volumetrically by 50% of each (Table C-2). A randomized block design (RBD) was used to assign a location to each of the three treatments with each having three replications.

Table C-2. Plot treatment.

Number of Plots	Cover Material/Treatment
3	Screened garden compost
3	Shredded hardwood mulch
3	50% compost-50% mulch mixture

Soil cover materials were applied by hand evenly across the plots, 25 mm thick. The upper end of each plot was guarded by a metal sheet to prevent runoff from upstream to enter each plot. The sides of each plot were raised by compost in the form of a berm in order to contain flow over the plot and prevent outside runoff from entering the plots.

Runoff Collection

A pit was dug at the downslope edge of each plot to accommodate several runoff collection buckets. Two pieces of plywood were nailed to a thin sheet of metal forming a funnel for the runoff. This apparatus was installed at the downslope edge of the plot with a bucket placed below the funnel. A sealant was applied as necessary to the funnel to eliminate leakage. Finally, the 2–3 remaining buckets were connected by pipes to the bucket directly under the apparatus. This network of buckets was covered with lids and provided a larger collection volume (Figure C-1 and Figure C-2).

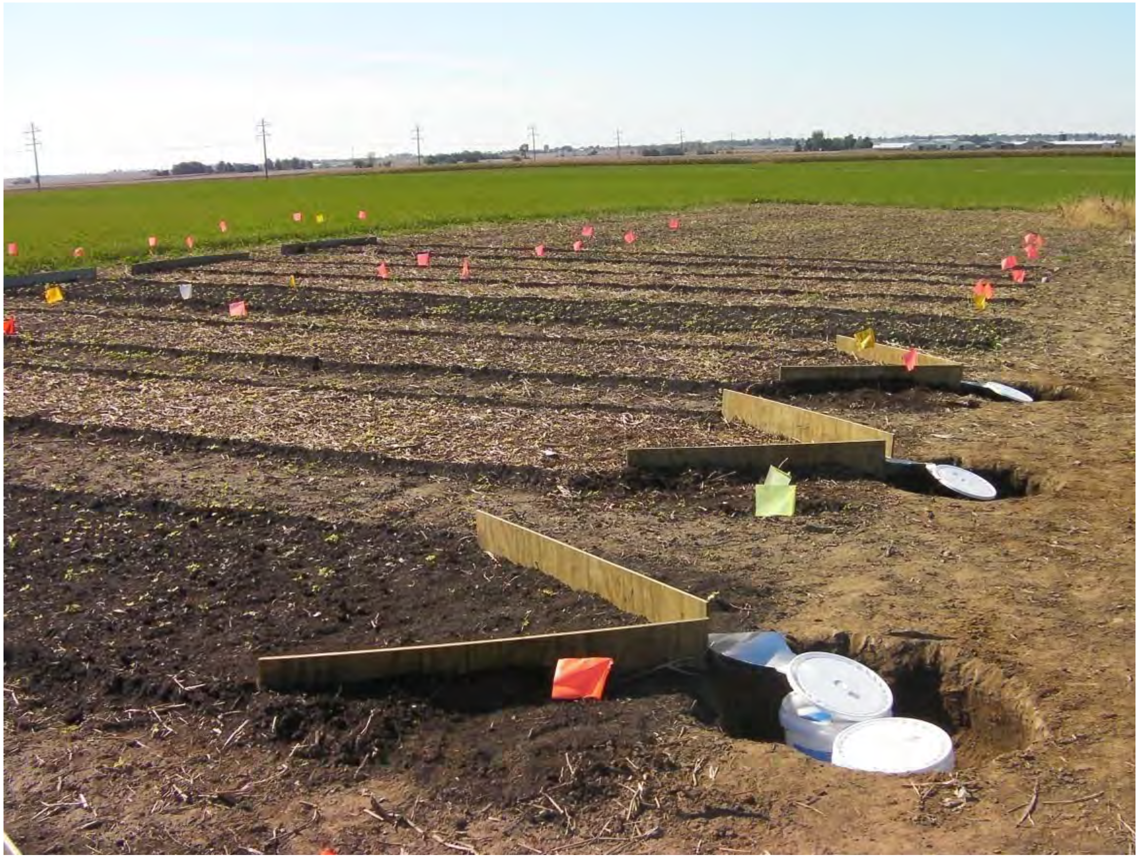

Figure C-1. Layout of the experimental plots at Urbana, IL.

Data Collection

Data was collected immediately following each storm event (or within the next 24 hours following precipitation). The volume of runoff collected from each plot was measured. A representative sample was kept from each plot for analysis. After the mass of the jars with the runoff sample was recorded, the sampling bottles were placed in a laboratory oven for 24 hours or longer at 105 °C. When all the water from sampling bottles evaporated, the remaining mass of sediments was measured allowing for total sediment and sediment concentration calculations.

Figure C-2. Plot with compost treatment.

Results

This section presents erosion data that was generated for three full precipitation events. Additional data were partially collected from three more precipitation events, due to adverse environmental conditions. Both the rainfall amount and the corresponding 5-day rainfall preceding each precipitation event are presented in Table C-3. The rainfall event of 28 December had the highest rainfall amount and the highest 5-day prior total rainfall among the six rainfall events that occurred during the sampling period.

Table C-3. Data from each precipitation event.

Event date	Collection date	Rainfall amount (in)	5-day antecedent rainfall (in)
24-25 Oct 2008	25 Oct 2008	1.12	0.00
7 Nov 2008	7 Nov 2008	0.23	0.00
14-15 Nov 2008	16 Nov 2008	0.46	0.25
28 Dec 2008	29 Dec 2008	1.41	1.42
11-12 Feb 2009	12 Feb 2009	1.11	0.14
8-9 Mar 2009	9 Mar 2009	0.66	0.00

Figure C-3 shows the average runoff volume collected during different storm events. This figure clearly shows that the antecedent moisture condition plays a vital role in runoff production. Although the 25 October event produced more rainfall compared to the 15 November event, the runoff volume collected during both was similar. This is because the antecedent moisture was higher for the 15 November event compared to 25 October.

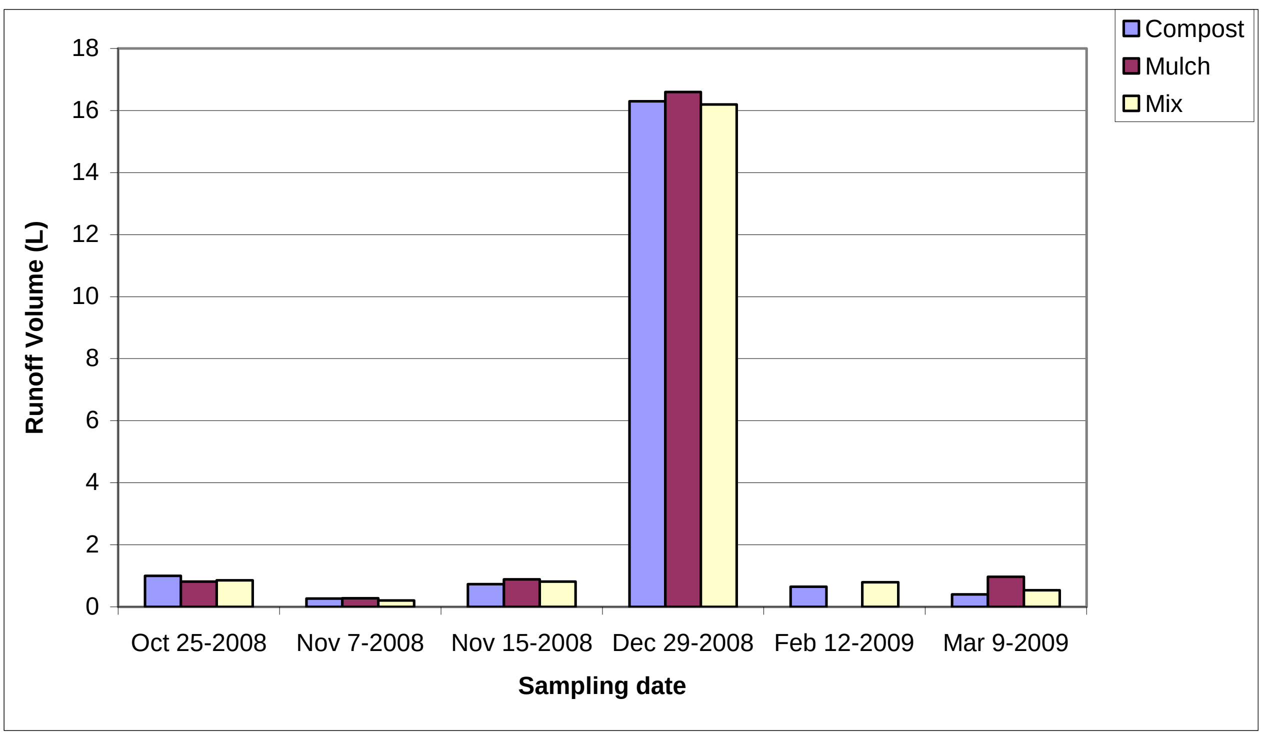

Figure C-3. Runoff volume (L) from experimental plots with different covers.

The measured average sediment concentration from each treatment for every sample collected is displayed in Figure C-4. The error bars indicate the standard deviation in average sediment yield values. Some averaged bars do not show visible error bars because either the error range was very marginal or there was only one data set available for the treatment type. The 50/50 mixture of compost and mulch produced the least concentration of sediments, followed by the mulch and compost covers. There were some exceptions to this trend. For the samples collected from the third set of plots on 7-8 November, the mulch produced the lowest concentration of sediments, followed by the mixture and compost. The sample from third plot set of 16 November was also different from others where the mulch treatment produced slightly higher average sediment concentration by 0.5 mg/L.

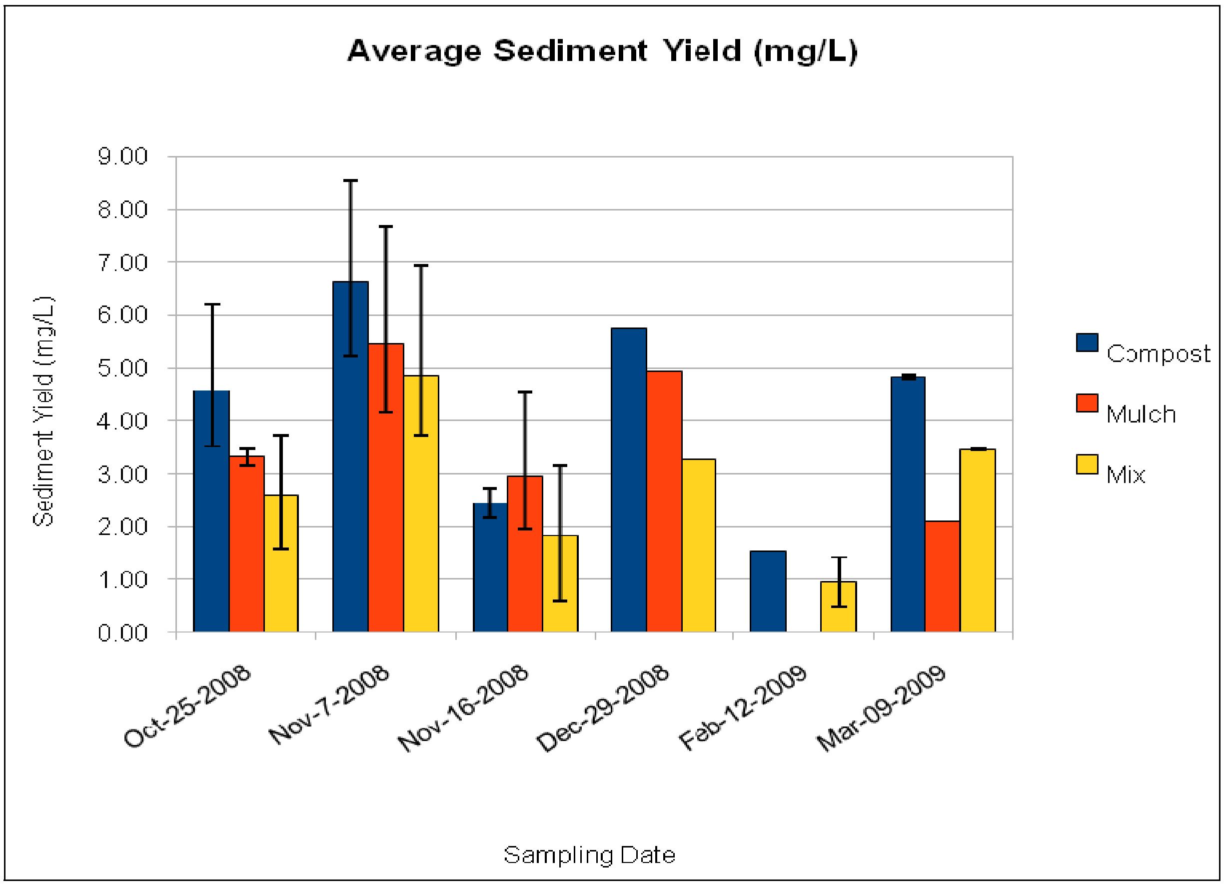

Figure C-4. Average sediment concentration (mg/L).

Analyzing the sediment loss with respect to plot area produced similar results as the analysis based on sediment concentration (Figure C-5). Error bars were added, but some are virtually

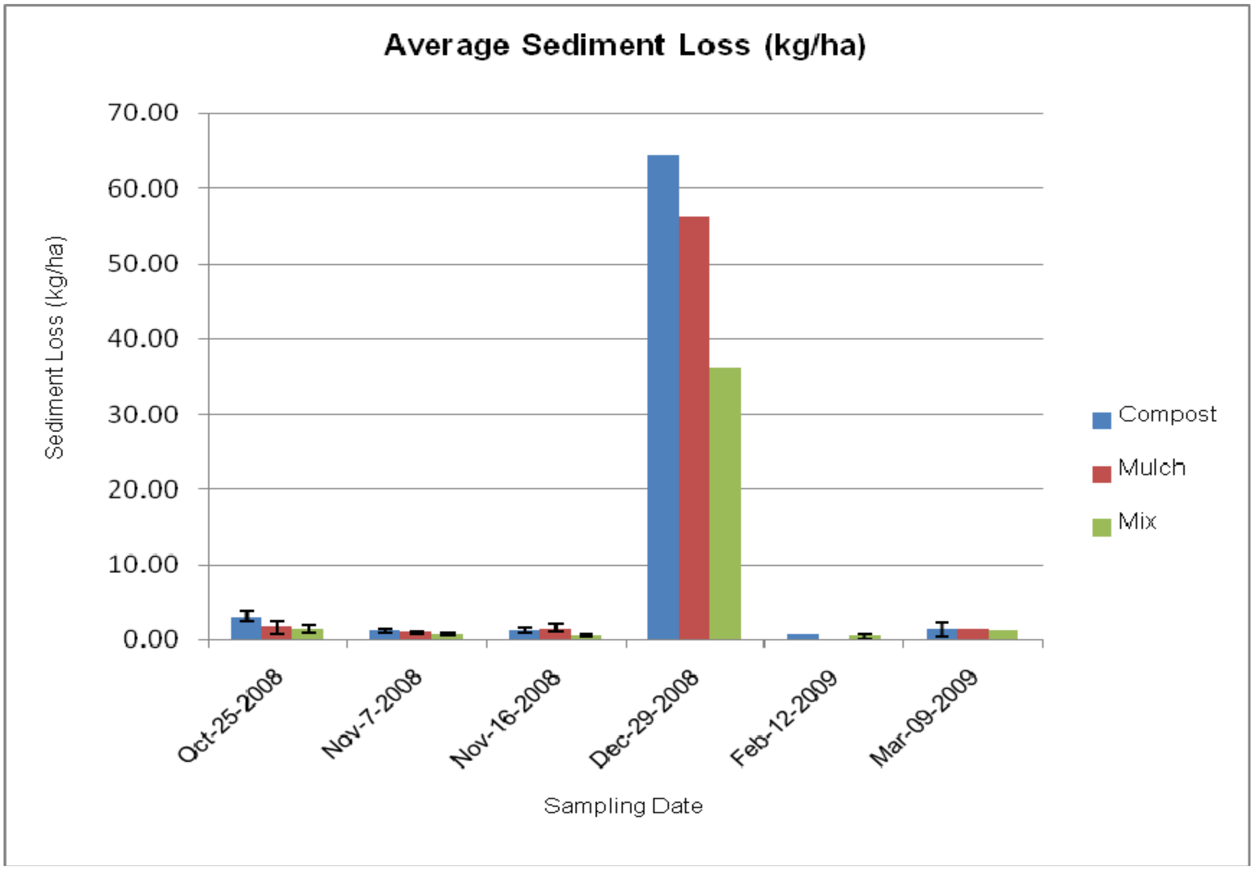

Figure C-5. Average sediment concentration (kg/ha).

nonexistent for the same reasons as occurred for Figure C-4. The results clearly indicate that all three treatments significantly reduce the sediment loss. The compost/mulch mixture yielded the highest sediment reduction compared to the mulch or compost cover alone. On average, the mixture produced the least amount of sediment, often nearly half the amount of sediment lost from the compost plots. On two occasions, the mulch treatment produced more average sediment per unit area than the compost (16 Nov 2008 and 9 Mar 2009), but this was only a marginal difference. Sediment yield from 29 Dec 2008 was significantly more than other events because of a large increase in temperature (from below-freezing to mildly warm weather), followed by a large storm.

At a 4% slope condition, the field experiments showed the compost/mulch mixture treatment was more effective than the compost or mulch treatments for erosion control. Compost is high in organic matter content, which improves its contact with the soil surface, but its fine texture increases its erodibility. This was evident because the plots treated with compost had visible signs of eroded compost treatment. Alternatively, the mulch was made up of less finely shredded materials such as wood chips, twigs, and other biodegradable materials. Such a coarse texture has poor contact with the ground, but it provides more structural stability. By mixing compost and mulch as a soil cover, the treatment was able to provide consistent contact with soil and structural support, thereby increasing its overall effectiveness against soil erosion.

Results from these field experiments promise potential for improved erosion control. Manual application of these soil covers over large areas is highly impractical, but these erosion control methods might be suited for application in discrete and small areas of land. Compost and mulch are relatively inexpensive materials. For example, Landscape Recycling Center in Urbana, IL, sells both compost and mulch for $10 per cubic meter. Furthermore, compost and mulch can be generated onsite by using the refuse from grounds maintenance. Depending on the facility, its soil cover needs could be created in an entirely sustainable process at virtually no cost. It is not clear yet if mulch and compost could be effective on the most actively used sites such as ranges with heavy human and vehicle traffic. The effects of compaction and application of shear force over the soil treatments could render them ineffective. This possibility requires further investigation.

The field experiments faced many difficulties. Often the systematic collection of runoff samples was stymied because of impassable site conditions. Winter 2008–09 in Illinois was one of the coldest in the recorded history. Such harsh weather conditions eventually destroyed some of the funnels. While most were able to be repaired, funnel apparatuses for plots 5, 8, and 9 were severely damaged and were unusable by February. It also was impossible to collect runoff samples from snowmelt because such runoff always froze inside the buckets. There was not an adequate way to keep the runoff samples from freezing due to the limitations of time and resources.

Although it is widely known that a bare soil surface is the most vulnerable condition for soil erosion, the field experiment design would have benefitted from a control plot with no treatment and developed by a similar preparation method. The results from such a plot would have provided an empirical point of comparison for the efficiency of the tested soil cover materials to reduce the sediment concentration in the runoff. Moreover, starting the project earlier in the year would have allowed the collection of more precipitation events.

Appendix D:

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Appendix E

ACRONYMS AND ABBREVIATIONS

Term	Meaning
AR	Army Regulation
BMP	best management practices
CECW	Directorate of Civil Works, US Army Corps of Engineers
CEMP	Directorate of Military Programs, US Army Corps of Engineers
CERL	Construction Engineering Research Laboratory
CONUS	Continental United States
DA	Department of the Army
DoD	Department of Defense
EO	Executive Order
ERDC	Engineer Research and Development Center
HQUSACE	Headquarters, U.S. Army Corps of Engineers
OCONUS	outside Continental United States
PAM	polyacrylamide
PDF	portable document file
PE	professional engineer
POC	point of contact
RBD	randomized block design
URL	universal resource locator
USACE	U.S. Army Corps of Engineers
USC	United States Code
WBDG	Whole Building Design Guide
WEPP	Water Erosion Prediction Project
WFM	wood fiber mulch