Report as of FY2007 for 2006GA118B: "Using compost to control soil erosion and manage stormwater under concentrated flow conditions"

Publications

Project 2006GA118B has resulted in no reported publications as of FY2007.

Report Follows

Report

On

Field investigation of compost blankets for erosion control under concentrated flow conditions

Submitted to

Georgia Water Resource Institute

By
Xianben Zhu and Mark Risse
Department of Biological and Agricultural Engineering
University of Georgia

April 17, 2008

Abstract

Compost is recognized as an effective erosion control practice and has been utilized widely. While previous studies have proven that compost blankets can control erosion as well or better than traditional methods under normal rainfall and sheet flow conditions, little attention has been paid on how compost will respond to concentrated flow conditions. The objectives of this research were to investigate erosion processes on compost blankets under concentrated flow conditions. Erosion control compost (ECC), yard waste compost (YWC) and a bare soil (BS, loam) were studied using four concentrated flow rates on 12.5% slope plots. Time to initiate discharge, flow velocity, solids concentration and total solids loss were measured. The erosion process and rill evolution under these conditions were observed and recorded. Cover scenarios for ECC and bare soil plots with excelsior erosion control were investigated using 20 L/min inflows. Results indicated that the time elapsed to commence discharge from compost plots was significantly longer than that from soil plots. Large amounts of the inflow were able to infiltrate into compost matrix and flow through it, leaving a smaller portion of surface flow on compost plots than on soil plots. Under 16 and 20 L/min inflow, solids loss from compost plots were significantly less than those from soil plots. Under a same inflow conditions, average solids concentrations were significantly lower on compost plots than on soil plots as deposition occurred in compost rills. Deposited solids often formed micro-dams in the compost rills which further promoted flow through the compost matrix and deposition of suspended particles. The formation of micro-dams in compost plots was an important mechanism of preventing soil erosion under concentrated flow conditions. Cover plots of both ECC and bare soil showed increased time required to initiate discharge and reduced total solids loss. Results of this study provide an indication that the erosion process on compost blankets may differ from classical shear induced rill erosion on soil surfaces. Future work will investigate models that may be used to better understand and predict erosion of compost material under concentrated flow conditions.

Keywords. Compost blanket, Concentrated flow, Micro-dams, Rill erosion

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1. Introduction

1.1 Literature Review

Compost materials have been proven beneficial to soil properties by improving soil texture and structure, enhancing organic matter content and PH value, stabilizing soil aggregates, delaying crust formation and seedbed slump, improving revegetation (Shiralipour, 1992; Stewart and Ettlin, 1993; Storey et al., 1996; Bresson et al., 2001, Risse et al., 2004; Harrell and Miller, 2005, Singer et al., 2006). Under simulated or real rainfall conditions, compost blankets have been proven as an effective erosion control practice under sheet erosion and the control mechanisms included absorbing rain water, increase infiltration, postponing runoff commencement, reducing runoff rate and solid content at the discharge (Glanville et al., 2004; Mukhtar et al., 2004; Persyn et al., 2004; Risse et al, 2004; Osorio and Juan, 2006; Ramos and Martinez, 2006). Faucette et al. 2005 reported that compost blankets out performanced traditional erosion control practices in reducing the total sol loss, total N and P concentration. In another study comparing the erosion control effectiveness of compost blankets, straw with PAM and mulch using both simulated or natural rainfall events, Faucette et al. (2007) concluded that soil loss from plots covered by compost blankets was significantly lower than that from plots covered by straw with PAM or mulch.

As discussed above, current research on the use of compost for erosion control and storm water management had been focused on rain fall and sheet flow situation. USEPA approved compost blankets as an erosion and sediment control BMP and used extensively, both on level areas and steep slopes to control erosion and cautiously against using compost blankets on the areas where concentrated flow is likely to occur (US EPA, 1997), however, little guidance or research is available on the amount of concentrated flow a compost blanket would be able to withstand. Persyn et al. (2005) investigated rill erosion on compost blankets and suggested that the mechanisms that cause rill erosion on it might be similar to the mechanisms previously observed for unanchored crop residues (Foster et al., 1982); however, uncertainty was reported due to floatation of compost particles on the water surface, the small size of test plots (0.2 m as plot width) which resulted in preferential flow along the plot boundaries, and movement of compost down the slope in bulk rather than as individual particles. This study suggested that the mechanisms controlling erosion in rills might be different for soils and compost, but additional studies have not been done.

1.2 Study Objectives

The objective of this study was to investigate how compost blankets respond to concentrated flow, determine if the rill erosion processes on compost blankets and soils are similar, and if compost blankets were effective in controlling rill erosion.

2. MATERIALS AND METHODS

2.1 Site Description

This research was conducted at the sediment control facilities in the erosion lab of American

Excelsior Company (Kelsey et al. 2005). The erosion lab is located at Rice Lake/Barron county, Wisconsin, at 45°28'47" N latitude and 91°43'12" W longitude. The field experiment was conducted during the summer of 2007.

Two plots on 12.5% slope, 2.4 m wide and 10.7 m in length were used for this study. The plots were filled with 0.3 m of loam-textured soil (according to USDA classification) above the original sandy loam. Wood and PVC sheets were inserted into the soil to form the plot border. Each original plot was divided into two subplots by trenching 0.1 m and installing wood borders into the soil along the middle of the plot. This created a total of four 1.2 m wide test plots (Figure 1). Prior to each run, the plot was prepared by adding soil to the plot to insure constant starting thickness, tilling up and down the slope using a Troy Bilt Bronco tiller; raking and smoothing the plot along the slope using a garden rake, and carefully compacting the top soil using a Wacker 1550 Plate Compactor run up and down the plot. Compaction was conducted to mimic post-construction conditions. Six numbered flags were then inserted on each side of plot at 1.5 m intervals along the plot border to serve as measuring stations. Water was obtained from a pond near the testing area and stored in a 500-gallon tank, from which it was pumped to the plot. A rotameter and check valves were used to regulate the inflow (Figure 1 and 2). Solid content and density of the inflow water were measured. A flume and receiving tank were installed at the toe of each plot to receive discharge and eroded solids. Compost materials were manually applied on the plots as 7.5 cm blankets over the entire area of the plot. A 2.5 cm deep, 10 cm bottom width and 15 cm top width trapezoidal channel was manually constructed along the plot center. This channel was constructed in an attempt to initially contain the flow. A bunch of packed excelsior was placed on the top of pre-created channel to dissipate the energy of water when the flow was introduced into the plots. The compost blankets and soil in the plots were pre-wet by sprinkling water on the surface using a garden hose to wet the soil or compost surface prior to introducing concentrated flow (Figure 2).

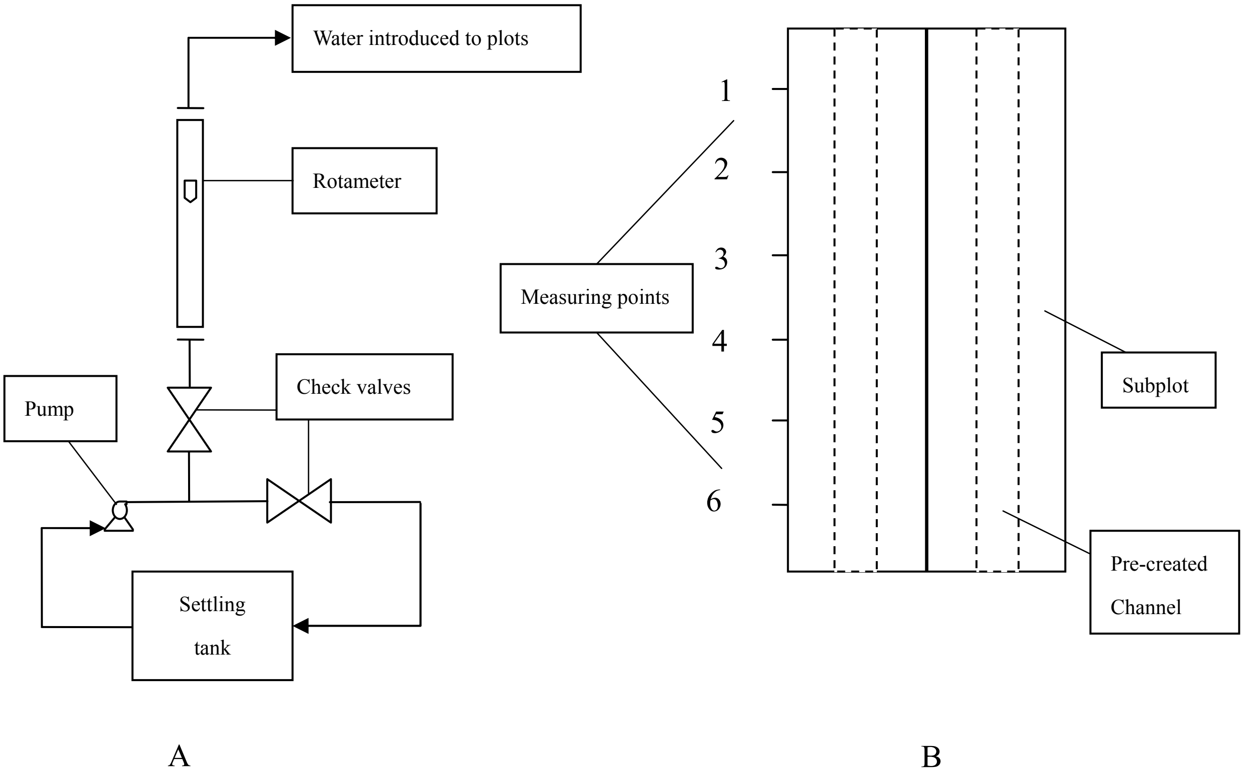

Figure 1. The schematic of A: Inflow station and B: Plot layout

Figure 2. Pictures of A: inflow section and B: testing plots

2.2 Treatments

Materials used in this experiment included yard waste compost (YWC) and erosion control compost (ECC) purchased from White Oak farm in Oconomowoc, Wisconsin, an US Composting Council Testing Assurance sealed company. The feed stock of YWC was 100% yard waste. Feed stock of ECC composed of ground tree branches blended with leaves and grass. Local loamy bare soil (BS) was used as control in this project with particle size distribution shown in table 1. Four designed inflow rates (8.0, 12.0, 16 .0 and 20.0 L/min) were applied randomly on each of the materials. Three repetitions were conducted on each treatment, using a completely randomized design.

Table 1. Particle size distribution by dry weight passing (%) specific sieve size for bare soil

Sieve opening, mm	Percent passing
19.0	100
9.51	97.4
4.76	97.1
2.00	94.2
0.841	92.6
0.420	76.0
0.149	55.1
0.074	52.8

Basic physical and chemical properties of compost materials were measured at Energy Laboratories, INC. at Casper, WY (Table 2). The particle size of compost materials was determined at the erosion lab, using 300 g dried subsamples based on the Test Methods for the Examination of Composting and Compost (USCC, 997). Size of sieve opening included 6.35, 2.38, 1.4, 0.84, 0.6, 0.425, 0.3, 0.25, 0.212 and 0.18 mm.

Table 2. Properties of compost materials, % dry weight basis

Parameters	ECC	YWC
Total Nitrogen	1.57	1.9
Phosphorous (as P_2O_5)	0.52	0.28
Potassium (as K_2O)	1.05	0.49
Calcium (Ca)	5.7	4.7
Magnesium (Mg)	2.14	1.5
Organic Matter Content	39	44.4
pH (standard unit)	8.01	7.71
Sieve opening, mm	**Particle size (percent passing)**	
4.75	98.91	99.89
2.36	86.15	73.75
1.4	63.59	43.05
0.85	46.54	20.87
0.6	31.45	7.84
0.425	21.93	3.80
0.3	13.56	1.84
0.25	6.66	0.79
0.212	1.15	0.15
0.18	1.09	0.11

2.2 Moisture Content Measurement

Compost and soil samples were collected at flags 1, 3 and 6 along the pre-created channel for moisture content measurement before and after each run. The compost samples were collected from the compost blanket surface to the soil interface. Soil samples were collected at the same spots where compost samples were collected to the depth of 5 cm. Compost moisture content was determined gravimetrically, by measuring the sample weight before and after oven drying at 105°C for 1.5 hours, following the method recommended by the USCC (1997). Soil moisture content was determined following ASTM D4643-00 standard test method for determination of water (moisture) content of soil by the microwave oven method (ASTM, 2000).

2.3 Flow Velocity and Rill Width Measurement

The surface flow velocities on plots were measured by tracing the leading edge of a dye plume as described by Elliot et al. (1989) and Persyn et al. (2005). A dye was injected at point one and the time over which the dye traveled to point six was recorded, the dye travel distance was 7.62 m. This measurement was conducted in three-minute intervals. Mean surface flow velocity for each run was obtained by averaging the seven measurements. A factor of 0.7 was used to convert the mean surface flow velocity measured with the dye to a mean flow velocity for each run.

Width of the rill along the channel was measured using a ruler on the seven sections created by the six flags inserted along the plot. Within each section, three critical points were chosen at which flow rill were measured. The critical points were defined as the points which represented major changes of the rill width within a section. The width measurements were conducted at 3-minute intervals. The rill width was measured at the water surface in the rill.

2.4 Discharge and Solids Loss Analysis

Discharge rate from the plot was determined by recording the time required to fill a one gallon bucket. The measurement was conducted at 3-minute intervals throughout each run. The first sample for each run was collected to determine the discharge and solids concentration at first flush. The total amount of discharge for a run was determined by multiplying the average discharge rate by the period of flow which was set as 21 minutes. The run time of 21 minutes was determined based on trial runs that indicated steady conditions were achieved within this time period. Sediment samples were collected by filling 500 mL bottles at 3-minute intervals. Samples were weighed, filtered using Whatman filter paper 410 and oven dried at 105°C until constant weight was achieved. Dry weight of bottles and filter papers were subtracted to determine the solids weight of each sample. Density of discharge for each sample was determined by dividing the sample mass by the volume (500 mL). The average solids concentration for a particular run was determined by averaging the solids content of the samples, excluding the first sample from each run as the first samples often contained a large amount of light surface material and did not represent steady state conditions. However, the solids content of first samples, or first flushes was determined using the similar procedures. The total solids loss for each run was determined by summing the solids loss from the first flush and from the consecutive flows. The total solids loss from the plot was computed by multiplying the mean solids concentration, mean discharge rate, mean discharge density and the period of time over which a run was conducted.

2.5 Cover scenarios

To investigate the effectiveness of covered compost blankets, Curlex II erosion control blankets produced by American Excelsior Company was laid and locked on the erosion control compost blankets and soil surface, following the stable pattern recommended by the producer. 20 L/min inflow was used on cover scenarios for the ECC blankets and bare soil to demonstrated its effect.

2.6 Statistical Analysis

SAS version 9.1 (SAS, 2002) was used for statistical analysis. Separation of means was determined by using ANOVA procedure. Ducan's Multiple Range tests were used to determine any significant differences between treatments at $\alpha = 0.05$.

3. RESULTS

3.1 Moisture Condition

Initial moisture contents were expected to impact the flow and discharge greatly due to the high water absorbing and holding capacity of the compost materials. There were no significant differences in initial moisture content for YWC and BS within the series of inflow events; the variety of initial moisture content on ECC might was due to the compost plots held storm water prior the test of 20 L/min inflow. Each treatment showed significant differences between initial and final moisture content. The final moisture content of both compost materials was significantly greater than the final soil moisture content under the same inflow conditions (Table 3). The differences in the initial and final moisture content between treatments were primarily due to the higher water holding capacity of the compost materials than soil.

Table 3. Average initial and final moisture content of ECC, YWC and BS (3 replications).

Inflow rate, L/min	**ECC**		**YWC**		**BS**	
	[a]Initial MC, %	Final MC, %	Initial MC, %	Final MC, %	Initial MC, %	Final MC, %
8	[b]17.65^{h} ± 5.39	24.20^{fghi} ± 5.66	27.56^{def} ± 1.45	37.70^{ab} ± 2.81	10.13^{k} ± 0.72	18.84^{hij} ± 1.05
12	19.81^{ghij} ± 3.89	25.81^{efg} ± 4.80	28.89^{def} ± 6.10	39.13^{a} ± 3.26	10.46^{k} ± 0.29	18.25^{ij} ± 0.57
16	25.09^{efgh} ± 5.20	30.79^{cde} ± 5.16	30.60^{cde} ± 1.92	40.14^{a} ± 2.82	9.14^{k} ± 0.53	19.18^{hij} ± 2.45
20	29.68^{def} ± 2.25	36.16^{abc} ± 3.67	32.64^{bcd} ± 5.02	40.57^{a} ± 2.60	9.72^{k} ± 0.54	19.19^{hij} ± 1.11

[a] MC. Moisture Content

[b] Results with same letter were not significantly different at α = 0.05 using Dacan's Multiple Range test.

3.2 Time Required to Initiate Discharge at the Plot Outlet

Differences in water holding and infiltration capacity of the materials resulted in differences in the time required to commence discharge at the plot outlet. Both ECC and YWC had significantly longer time periods to commence discharge compared to the bare soil at low inflow conditions (8 and 12 L/min). At high inflow conditions (16 and 20 L/min), ECC showed no significant difference from BS regarding the time to initiate discharge, while YWC significantly delayed the discharge along the whole set of inflow rates compared to the bare soil. Both ECC and YWC had significantly longer times to discharge at 8 L/min compared to the rest of inflow rates (Table 4 and figure 3). Two processes were thought to be responsible for this observation. First, there were lower flow velocities at the plot surface for lower inflow rates, which allowed more time for the compost at the surface to absorb a greater portion of the flowing water. The low flow velocity at the surface also allowed water to infiltrate vertically and laterally into the plot matrix. With a higher percentage of pore space in the compost matrix compared to the soil matrix, a greater amount of water percolated into the compost plot and was absorbed by the compost. Second, there was a greater amount of surface flow under high inflow conditions, and part of it reached the plot outlet before it could percolate and be absorbed by the compost. Large particles in ECC created more pore space allowing more flow through the compost matrix. The higher organic matter content at YWC allowed it to hold more water, resulting in a longer time to initiate discharge in those plots.

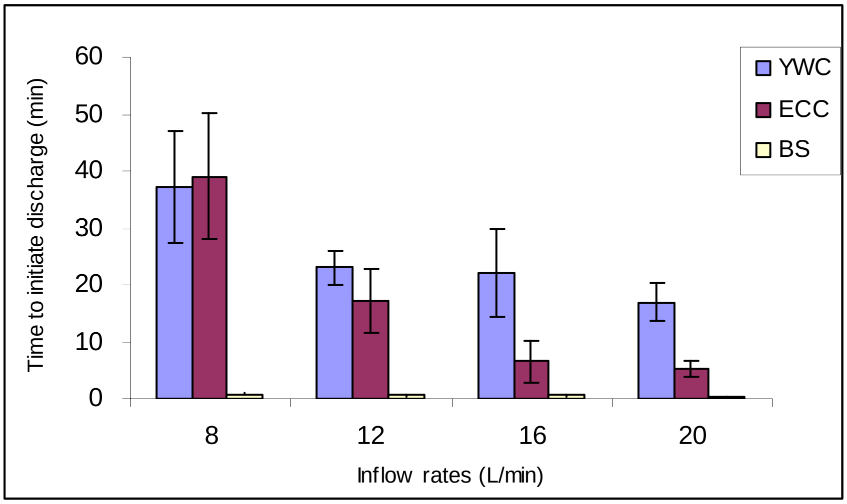

Figure 3. Time to initiate discharge on the three plots under four inflows.

Table 4. Average time for initiating discharge for three materials and four inflow rates, minutes

Inflow,L/min	**BS**	**ECC**	**YWC**
8	0.82 ^{f}	39.09 ^{a}	37.31 $^{a\ b}$
12	0.55 ^{f}	17.06 $^{c\ d\ e}$	23.04 $^{b\ c}$
16	0.54 ^{f}	6.58 $^{d\ e\ f}$	22.11 $^{b\ c\ d}$
20	0.42 ^{f}	5.21 $^{e\ f}$	17.01 $^{c\ d\ e}$

[a] Treatments with same letter were not significantly different at α = 0.05 using Ducan’s multiple range tests.

3.3 Erosion Process and Rill Evolution

Head cut and rill bed scour were the primary erosion mechanisms on both soil and compost plots; however, the temporal and spatial evolution of rills were different on the soil and compost plots (Figure 4 and 5). Under the 8 L/min inflow condition, surface flow was not present on YWC plots during the whole experimental period; whereas on ECC plots, surface flow was only observed at the last three minutes of the run. This absence or delay of surface flow on the compost materials indicated that significant subsurface flow occurred through the compost matrix. The average rill width on both compost plots seemed relatively constant with the time elapsed (Figure 4); however, the actual rill width along those plots was more variable than the rill width on soil plots under the inflows of 12, 16 and 20 L/min (Figure 5). The morphological topography of the rills formed on compost plots under higher inflow rates indicated that complex erosion and deposition process frequently occurred. Head cut at the upstream part of the slope was the major source of the solids carried by the flow. These particles were often deposited in the channel bed as larger macro pores allowed a portion of water to flow through the compost matrix. The deposited particles inter-locked together and trapped the suspended solids flowing downstream; thus the deposition accumulated quickly to form a "micro-dam" across the pre-created channel. This micro-dam blocked flow and ponded water behind it, encouraging additional water to flow through the compost. The transport capacity of the flowing water decreased as the velocity dropped when flow approached a micro-dam, resulting in more solids deposition upstream the micro-dam. As the amount of water ponded behind the micro-dam accumulated, either the flow would scour a new channel through the compost or the micro-dam would eventually blow out under the pressure of the ponded water. Either way, the velocity would suddenly increase and compost particles would be eroded rapidly by local turbulence. Once a micro-dam blew out, the clean water ponded behind the micro-dam had excessive transport capacity and carried many particles downstream. Another micro-dam would quickly form somewhere downstream as the aforementioned process repeated itself. The lower the inflow rates, the greater and more stable the micro-dams would be allowing longer time for water to flow through the compost matrix. Figure 6 illustrates the forming and breaking of a micro-dam on an ECC plot under 12 L/min inflow.

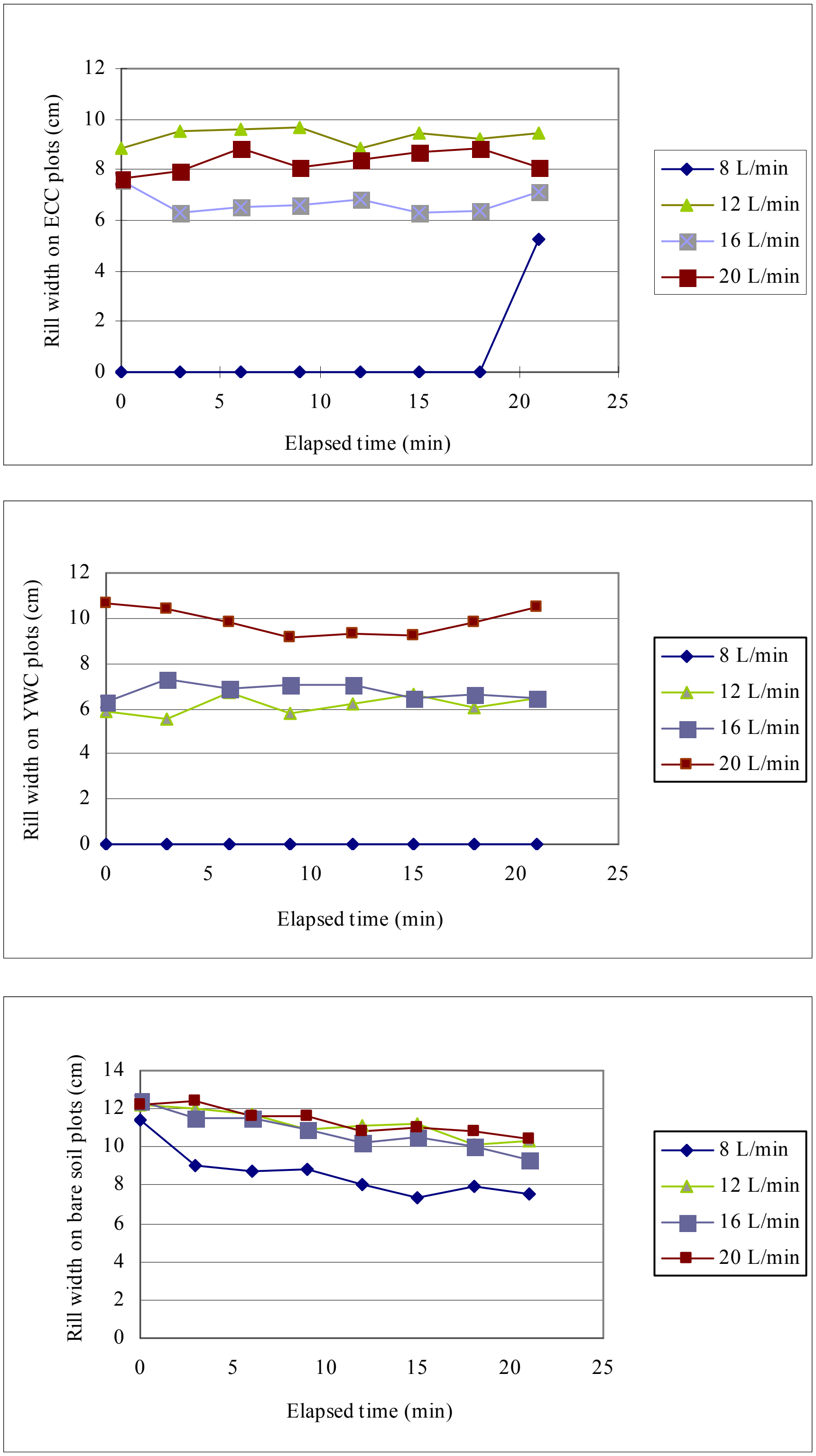

Figure 4. Evolution of the average rill width with time on the three plots with various inflow rates.

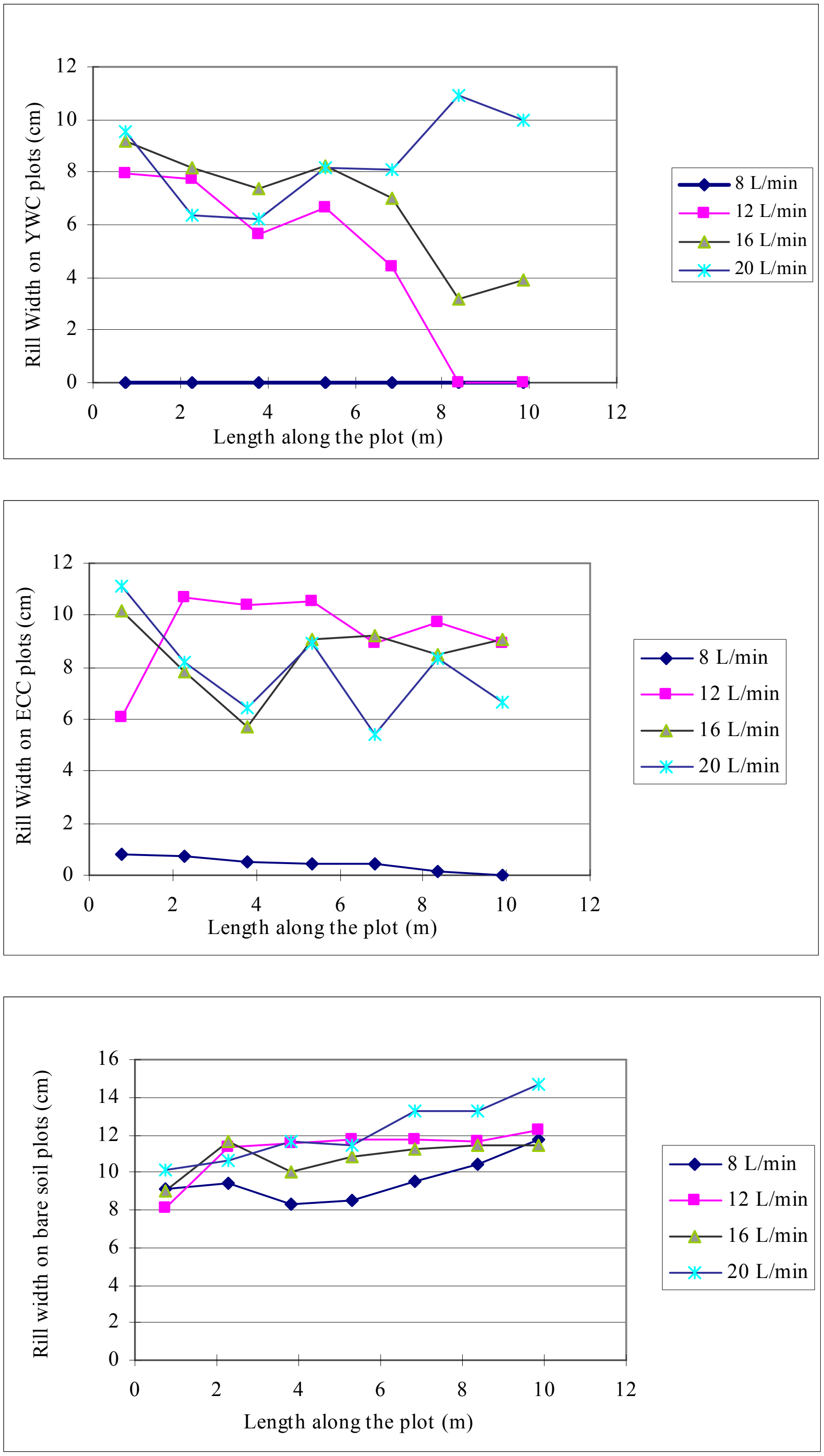

Figure 5. Evolution of the average rill width with plot length for the three plots at various inflow rates.

Figure 6. Pictures showing the micro-dams A: formed across the pre-created channel; B: grew as solids accumulate behind it; C: blew out allowing flow to advance; D: New micro-dam was formed encouraging more infiltration.

While the process of micro-dams forming and breaking occurred on the compost plots, the soil channel did not exhibit this phenomenon along the entire inflow series. Therefore, the erosion process and width of the rill on soil plot was relatively stable (Figure 5). This was probably due to the lower infiltration capacity of the soil plot compared to the compost plots. Most of the soil particles eroded at the upstream of the channel were delivered to the plot outlet with a small portion of them deposited near the plot outlet as the flow velocity slowed down in that area. This explained why the width of flow for soil plots increased as the water approached the plot outlet (Figure 5). On the soil plot, there was a trend toward decreased rill width as time elapsed. This was due to scoring and incision of the rill over time resulting in concentrated flow and deeper, incised rills (Figure 4).

Three reasons potentially explain why the micro-dams often formed on the compost plots but not on soil plot. First, at a given flow transport capacity, a greater volume of compost particles than soil particles were entrained and carried by the flowing water as compost materials had lower bulk density than the soil. Second, the flow through the channel walls was greater in the compost than the soil due to the presence of more macro pores. Third, the greater particle size of the compost material allowed these particles to interlock across the rill and hence trap and filter more particles carried by the flowing water.

Scouring in the rill was significant for both compost and soil plots. The entrained solids from the soil channel bed were delivered downstream to the outlet. Once a rill was formed on a soil plot, the clean water from the upstream continually scoured the channel, resulting severe erosion in the soil channel. Scouring of rills was observed on compost plots and soil layer was occasionally exposed to the flow under the high inflow conditions. Once this occurred, it would also begin eroding; however, three major mechanisms kept most soil particles from leaving the plot with discharge. First, the micro-dams trapped soil particles from the flowing water; second, the reduced velocity encouraged deposition of suspended solids; and third, the macro pores of the compost blanket encouraged lateral flow which diverted the flowing water and reduced shear stress of the flow.

3.4 Flow Velocity

Flow velocity is a key factor affecting soil erosion as it impacts the transport capacity and shear stress of the flowing fluid. A higher flow velocity indicates both higher transport capacity and erosive potential. While the velocity on the soil plot was easily measured using a dye as the water flowed on the surface freely and achieved steady condition quickly; the velocity on the compost plots was often difficult to measure due to the micro-dams which occasionally formed along the artificial channel and thus detoured or disconnected the flow. The velocity on the compost plot was unsteady and varied along the slope. Velocity decreased in the area near micro-dams while rapidly increasing in the areas where micro-dams. Under low inflow conditions, surface flow disappeared as all the water infiltrated into the compost matrix, leading to difficulty in velocity estimation. In this study, the surface flow velocity on the compost plot was measured wherever surface flow was present and then the segmented surface velocities were averaged for mean surface flow velocity.

In the case of 8 L/min inflow, no surface flow was observed on the entire length of the YWC plots as all of the water flowed through the compost matrix (Table 5); the surface velocity for ECC plots could be detected but was significantly less than that for soil plots, indicating that the infiltration capacity and micro-dams forming on the compost plots was major phenomena under low inflow conditions. The flow velocities were not significantly different for YWC and ECC when inflow increased to 12, 16 or 20L/min, suggesting that the process of micro-dams forming and breaking were similar on both of the compost plots. The velocity on the soil plots showed no difference as inflow changed from 8 to 20 L/min. This was probably because the flow was relatively stable in the soil channel, and it reached a terminal velocity (0.27 L/min) for this loamy soil at a 12.5% slope.

Table 5. Average flow velocity, discharge and percent loss of the water from inlet to outlet for YWC, ECC and BS under various inflow rates.

Inflow rate, L/min	**Material**	**Average flow velocity, m/s**	**Discharge, L/min**	**Percent loss of water from inlet to outlet, %**
8	YWC	[a]-	5.07^{e}	36.61^{a}
	ECC	0.14^{b}	4.97^{e}	37.94^{a}
	Soil	0.26^{a}	7.07^{d}	11.62^{bc}
12	YWC	0.21^{ab}	8.64^{cd}	28.02^{abc}
	ECC	0.20^{ab}	9.80^{c}	18.35^{abc}
	Soil	0.27^{a}	10.93^{c}	8.89^{bc}
16	YWC	0.20^{ab}	15.00^{b}	6.23^{c}
	ECC	0.28^{a}	13.73^{b}	14.16^{bc}
	Soil	0.26^{a}	15.04^{b}	6.03^{c}
20	YWC	0.21^{ab}	18.52^{a}	7.38b^{c}
	ECC	0.29^{a}	16.24^{ab}	18.78^{abc}
	Soil	0.27^{a}	18.59^{a}	7.06^{bc}

[a] "-" denoted no data was available.

[b] Treatments with same letter in a column were not significantly different at $\alpha = 0.05$ using Ducan's multiple range tests.

3.5 Discharge at the Plot Outlet

Discharge is a crucial parameter for estimating the surface flow which contributes to shear stress estimation in a rill. The difference between discharge rate and inflow rate is a good indicator of infiltration and water holding capacity of the materials on the plots.

On compost plots, discharge took longer to begin and was lower overall than the soil plots (Figure 3). The discharge was 5.07 L/min from YWC and 4.97 L/min from ECC compared to 7.07

L/min from BS under 8 L/min inflow condition. The loss of water from inlet to outlet was 36.61% for YWC and 37.94% for ECC and 11.62% for bare soil (Table 5). The significant difference of discharge and water loss between compost plots and bare soil plots reflected the function of mircro-dams which ponded the water and allowed greater amount of time for the water to percolate downwardly and flow laterally. Under the higher inflow conditions (12, 16 and 20 L/min), there were no significant differences among the three materials for discharge or water loss, however, there was a trend toward less discharge and more water loss on the compost plots.

3.6 Solids Concentration and Total Solids Loss

The first flush and average total solids concentration for each run were determined. The solids content of first flush indicated the erosion conditions as discharge first commenced from the plot. The average solids concentration was obtained by averaging the solids concentration of the seven successive samples following the first flush sample.

The solids concentration of the first flush from the compost plots were significantly lower than those from soil plots at 8 L/min inflow, confirming the observation that no or little surface flow occurred on the YWC and ECC plots under that low inflow condition. The solids in the first flush were compost particles drawn out by the water when it lifted up from underneath the surface of compost blanket near the plot outlet. This process effectively filtered the soil particles and prevented them from leaving the plot. The solids concentration of first flush from ECC plots increased with inflow from 12 to 20 L/min, but it showed no significant difference with that from soil plots. This was probably due to the greater amount of light compost particles washed away by the greater inflow and the fact that the soil layer was exposed at some points and hence some of soil particles were eroded quickly. The average solids concentration from both of the compost plots were less than from soil plots under the entire series of inflow rates proving the effectiveness of particle trapping and filtering of the micro-dams formed along the compost plots.

The total solids lost for each run was calculated by summing the amount of solids lost from first flush and from the following flow. Under the low inflow conditions (8 and 12 L/min) no statistical differences of solids loss from composts and soil were observed, which was probably due to the lack of significant rill erosion occurred on the soil plots under this inflow condition. There was significantly greater amount of solids lost from soil plots than from compost plots under high inflow conditions (16 and 20 L/min), which indicated the effectiveness of composts in alleviating the severity of channel scouring and incision (Figure 7 and table 6). Under the high inflow conditions, micro-dams were formed on the compost plots and quickly blew out by the inflowing water behind them. At the end of the run, often there were continuous rills going along the plot either within or outside the pre-created channel. The soil layer was often exposed to the flow as the compost materials were eroded away in the rill. Besides scouring downwardly, a portion of water in the rill flowed laterally into the sidewalls as the compost materials had greater amount of micro pore space which allowed water to flow in it easily. Under a same inflow condition, the amount of water flowing in the compost rill was reduced thus the shear stress acting on the soil layer was less than the shear stress exerting by the flow on soil plots, resulting in a smaller amount of solids loss from compost plots compared to soil plots.

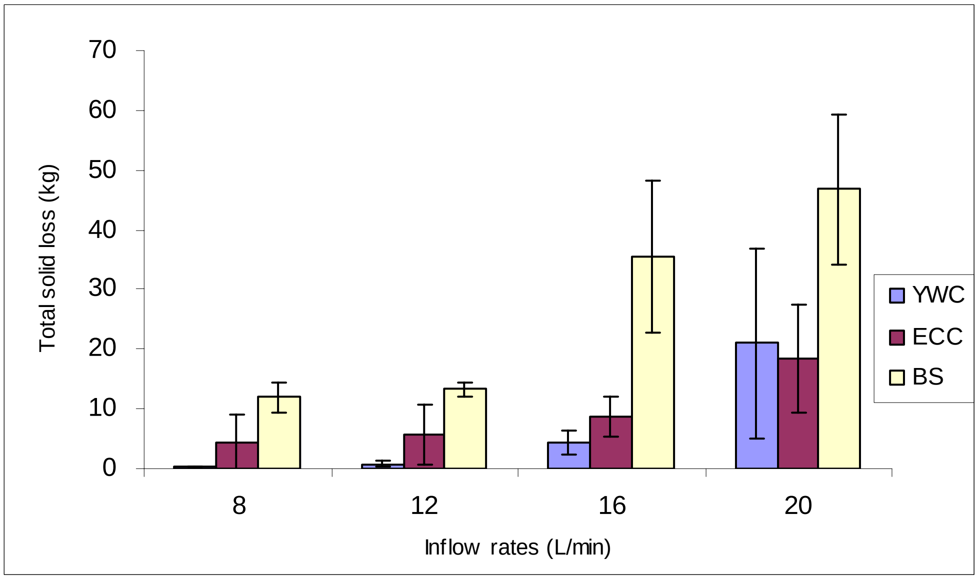

Figure 7. Total solids loss from there plots under the four inflow rates.

Table 6. First flush solids content, average solids content and total solid loss from the three materials under four inflow rates.

Inflow rate, L/min	Material	First flush solids concentration, g/kg	Average solids concentration, g/kg	Total solids loss kg
8	YWC	$3.63^{f} \pm 2.83$	$2.52^{e} \pm 1.73$	$0.24^{c} \pm 0.18$
	ECC	$15.75^{ef} \pm 13.52$	$40.78^{bcde} \pm 42.46$	$5.91^{c} \pm 7.14$
	Soil	$92.82^{de} \pm 32.87$	$72.93^{a} \pm 23.52$	$11.99^{bc} \pm 2.57$
12	YWC	$48.66^{def} \pm 75.83$	$3.66^{de} \pm 2.35$	$0.79^{c} \pm 0.58$
	ECC	$15.75^{ef} \pm 16.95$	$24.44^{cde} \pm 17.44$	$5.76^{c} \pm 5.08$
	Soil	$134.95^{bcd} \pm 31.80$	$54.54^{b} \pm 6.04$	$13.32^{bc} \pm 1.12$
16	YWC	$10.10^{ef} \pm 10.79$	$13.07^{de} \pm 5.92$	$4.35^{c} \pm 2.08$
	ECC	$237.23^{ab} \pm 52.94$	$28.9^{cde} \pm 11.92$	$8.66^{bc} \pm 3.42$
	Soil	$204.28^{abc} \pm 98.56$	$95.75^{a} \pm 26.84$	$35.48^{a} \pm 12.61$
20	YWC	$120.46^{cde} \pm 109.00$	$43.10^{bcd} \pm 26.49$	$20.95^{b} \pm 15.81$
	ECC	$286.34^{a} \pm 14.79$	$30.60^{cde} \pm 12.33$	$11.67^{bc} \pm 4.78$
	Soil	$221.69^{abc} \pm 104.07$	$106.13^{a} \pm 27.40$	$46.79^{a} \pm 12.63$

[a] Treatments with same letter in a column were not significantly different at $\alpha = 0.05$ using Ducan's multiple range tests.

3.7 Cover scenarios

Inflow of 20 L/min was used for cover scenarios investigation. Flow velocity on soil plots covered by excelsior blankets was significantly less than the velocity on bare soil, as figure 8. Flow velocity on covered ECC plots was unable to determine due to water spread out across the whole plot instead of the concentrated on the pre-created channel. Time required to initiate discharge was significantly increased for cover scenarios on both soil and ECC plots (Figure 9). This increase was due to the intersection function of the excelsior to flowing force, encourage water to infiltrated into the materials on the plot. The total solids loss was significantly reduced with covered plot, as showed on figure 10.

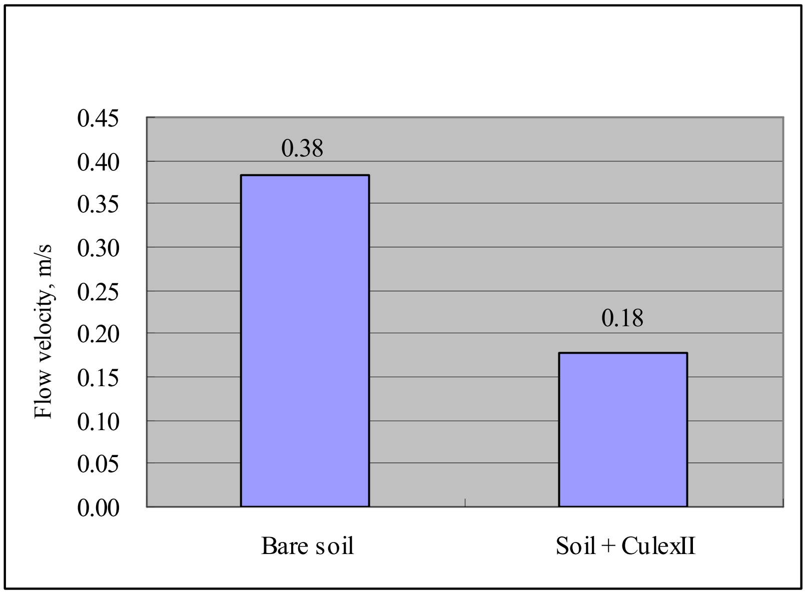

Figure 8. Comparison of flow velocity for cover and uncover scenarios on bare soil plots

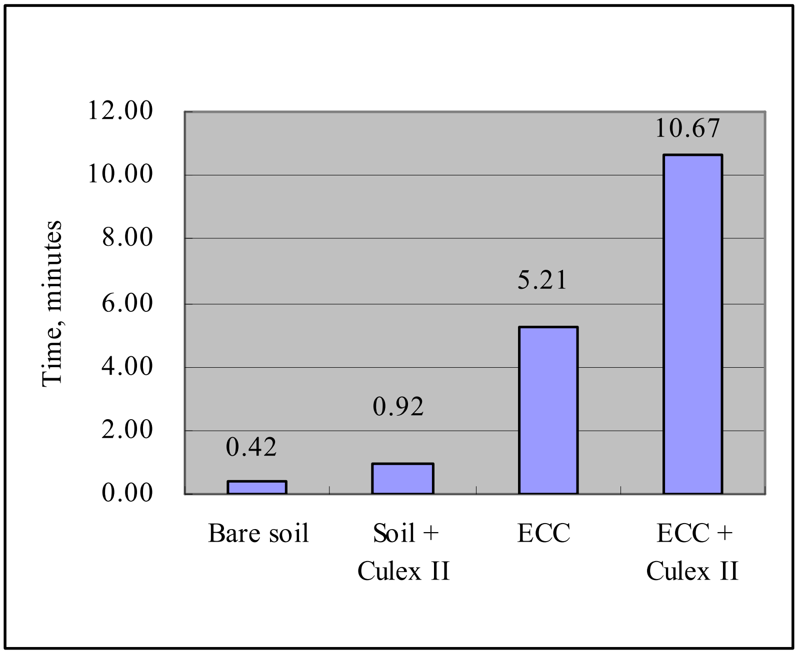

Figure 9. Comparison of time required to initiate discharge for cover and uncover scenarios on bare soil and ECC plots

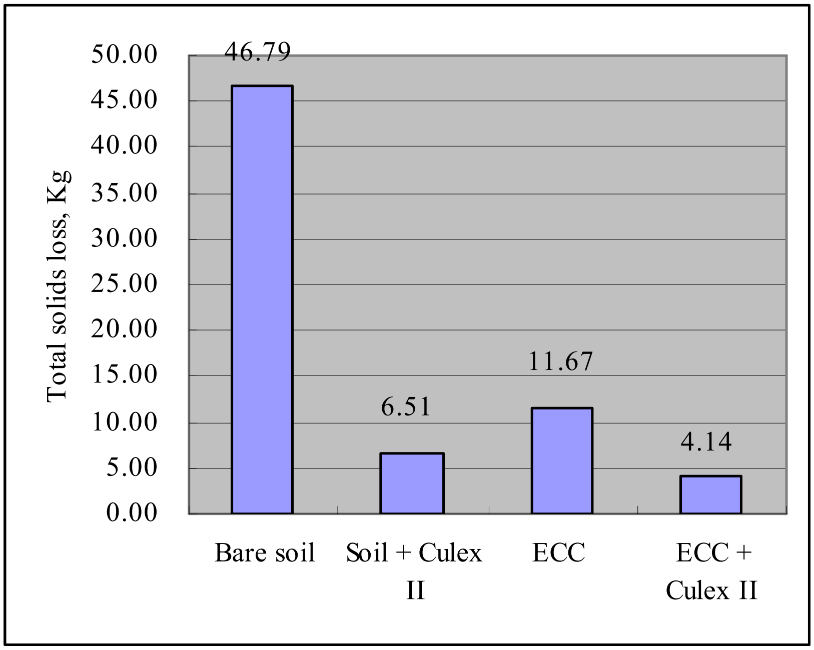

Figure 10. Comparison of total solids loss for cover and uncover scenarios on bare soil and ECC plots

4. CONCLUSIONS

A field experiment was conducted to determine rill erosion processes and solids loss from two composts and a bare soil. There was a significantly greater amount of time required for compost plots to initiate discharge at plot outlet than soil plots indicating an improved ability of compost materials to hold or divert water compared to bare soil. This was verified by water balance that indicated that the compost plots retained more of the inflow. The process of rill evolution on compost plots presented a characteristic of micro-dams forming and encouraging filtering and deposition, which was the primary mechanism of preventing soil erosion. Through the formation and breaking of micro-dams, the entrained soil particles were trapped and deposited along the compost plots, resulting in less delivery of soil particles from upstream to downstream of a slope. Micro-dams formed along the compost plots was divert the flow into the compost matrix which greatly reduced flow velocity and thus decreased shear stress acting on the plot. Both types of compost showed significant reductions in solids loss compared to bare soil under the higher inflow conditions of 16 and 20 L/min. Plots cover by excelsior erosion control blankets seemed effectively reduced the solids loss compared to uncover scenarios. However, the decision of using both compost and excelsior blankets for erosion control on one site should be made under careful consideration of economic issue.

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