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Trap Efficiency of Silt Fences Used in Hillslope Erosion Studies

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Abstract

Renewed interest in land management practices, like conservation tillage techniques on agricultural lands and timber harvesting, prescribed fires and wildfires on forested lands has made it desirable to measure hillslope soil erosion. Measuring soil erosion is generally costly and time consuming requiring expensive equipment, many site visits and laboratory analyses. The objective of the study was to determine the suitability of silt fences for measuring onsite hillslope erosion. Silt fences are low-cost and easy to install. They commonly are used as an erosion control device for construction projects and therefore generally available. For this study a silt fence was installed at the base of an existing long-term hillslope erosion plot at the Agricultural Research Service-Palouse Conservation Field Station, Pullman, WA. Two seasons of erosion data were collected. The silt fence was installed by making a concave cavity facing upslope such that runoff could not go around the silt fence. Also, the silt fence was folded to form a pocket to collect the sediment and eliminate the possibility of undermining the silt fence. Silt fences were installed across the width of the plot. The trap efficiency was determined by measuring the collected runoff and sediment that flowed through the silt fence compared to the sediment trapped by the silt fence. Results indicate that the mean trap efficiency was 93 percent the first year when measured on a storm-by-storm basis and 92 percent efficient the second year when only measured at the end of the runoff season. Thus various time intervals can be used depending of the detail of the erosion rates that are of interest, for example after every storm or seasonally without compromising its trap efficiency.
Keywords. Soil erosion, Geotextiles, Sediment control, Filter fabric.

Introduction

Soil erosion measuring methods are generally costly and time consuming. Recent improvements in the installation of silt fences and less expensive data recording equipment have made it easier for land managers to obtain their own erosion estimates. Silt fences have been used to control erosion in the construction industry for several decades. Silt fences are a synthetic geotextile fabric that is woven to provide structural integrity with small openings (water permeability 0.01 cm sec^{-1}) to pass water and not sediment (Synthetics Industries, 1996). The low permeability rates makes silt fences suitable to form temporary detention storage areas allowing sediment to settle and water to pass. Hydraulic performance of silt fences was measured by Jiang et al. (1996) and in flume studies of silt fence trap efficiency by Britton et al. (2000) and Wishowski et al.(1998).

The objective of this study was to determine the trap efficiency of a silt fence when used for soil erosion research.

Methods

The study site was on existing fallow erosion monitoring plots from the Palouse Conservation Field Station, Pullman WA (McCool et al., 1999; Pannkuk et al., 1998). The soil was a Palouse silt loam (fine-silty, mixed, mesic, *Pachic Ultic Haploxeroll*). The plots were located on a southern aspect, 20 percent slope in a fallow field with the furrows aligned parallel to the flow paths. Furrows were 250 mm apart and 76-152 mm in depth. In the first year the plot was 11 m in length and 1.8 m wide. In the second year the plot was 22 m in length by 3.6 m wide.

The silt fence fabric had a permittivity of 0.2 sec^{-1} and a water permeability of 0.01cm sec^{-1} (Synthetic Industries,

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1996). The silt fences were installed at the base and across the full width of the plot. A trench, with a cross sectional area of 0.04 m^2 was dug along the base of the plot in order to install the silt fence below the ground surface and prevent undermining. The ends of the trench gently curved uphill to prevent runoff from circumventing the silt fence. The excavated material was placed on the downhill side of the trench for latter use in backfilling. The silt fence was laid out along the trench with the bottom edge placed into the trench and laid to the uphill side. The excavated soil was used to backfill the trench. Tamping was necessary to compact the soil against the silt fence. The silt fence was folded downslope over the compacted soil, 0.3 m to form a pocket for sediment to be stored in. Wooden stakes were installed such that 0.4 m of the silt fence lay against the stake to store the sediment. The stakes were spaced 0.5 m apart and were driven at least 0.3 m to be able to support the hydrostatic pressure of the sediment-laden water. The silt fence was attached to the stakes with staples through a strip of asphalt paper (50 mm wide along the length of the exposed stake) to prevent fabric tears.

The remaining loose soil was removed from the uphill side of the silt fence (approximately 0.7 m) and from the pocket that was formed by the silt fence. This insured that the existing soil surface was easily identifiable when cleaning out the trapped sediment. Red construction (plumber) chalk was sprinkled on the compacted soil above the silt fence to aid in defining the boundary between the native ground surface and the deposited sediment.

During the first winter season, sediment was removed from the silt fences after each runoff event. Careful scrapping using a trowel or a hand hoe in the silt fence pocket prevented puncturing the fabric or removing any red-tinted native soil. The total volume of the sediment collected by the silt fence was returned to the laboratory for analysis. Sediment and runoff that passed through the silt fence was collected on a metal tray and funneled into a 75 mm diam. pipe to a covered storage tank. When the silt fences were cleaned, the runoff volume was measured in the tanks. Subsamples were taken after the sediment in the tanks was agitated for sediment concentration. After settling the subsamples, the clear water was siphoned off and the remaining sediment was processed in the laboratory to determine the total sediment weight that passed thru the silt fence. Sediment in the silt fences was not removed during the second winter season in order to evaluate the cumulative trap efficiency of the silt fence. Sediment and runoff that passed through the fence were measured as described above.

Results

During the first winter season, 7 runoff events occurred. The first 3 events produced little erosion due to snow cover even though the runoff was high (19.3 mm) (Table 1). The largest events occurred on the 18th and 19th of February causing 6.9 and 7.1 kg of sediment to be collected in the silt fence and 0.66 and 0.16 kg in the collection tanks. These events cause most of the first year's erosion. The calculated silt fence trap efficiencies were 91 and 98 percent. By the end of the first season, the silt fence trapped 20.1 kg and the storage tanks 1.4 kg for a seasonal trap efficiency of 93 percent with 43 mm of runoff.

Table 1. First year winter runoff and sediment data from a fallow plot with a silt fence. The silt fence was cleaned after each runoff event

	---- Sediment Collected ----				---- Sediment Yield ----		
	---- Flow thru to collection tank ----						
Storm Date	Runoff (mm)	Sediment Conc. (mg L^{-1})	Collection Tank (kg)	Silt Fence (kg)	Collection Tank (Mg ha^{-1})	Silt Fence (Mg ha^{-1})	Silt Fence Trap Efficiency (%)
9 Dec	11.4	346	0.08	0.5	0.040	0.25	87
12 Dec	0.9	825	0.02	2.6	0.008	1.29	99
2 Jan	19.3	210	0.08	NA*	0.041		
18 Feb	4.5	7230	0.66	6.9	0.326	3.43	91
19 Feb	1.2	6251	0.16	7.1	0.077	3.52	98
10 Mar	2.3	0	0	1.9	0.0	0.95	100
17 Mar	3.7	5312	0.39	1.1	0.196	0.53	73
Season	43.3	NA	1.39	20.1	0.687	9.97	93

* No sediment was observed trapped in the silt fence due to snow cover.

Eight runoff events occurred the second season with little snow cover (Table 2). The largest events occurred in January producing 12 and 15 mm of runoff. Since the silt fences were only cleaned at the end of the season, only a season trap efficiency of 92 percent was determined with 62 mm of runoff. The trap efficiencies were consistent with work by Wyant (1980) and greater than flume studies trap efficiencies (50 to 75 percent trap efficiency) by Britton et al. (2000), probably due to lower flow rates and non-uniform particle sizes.

Table 2. Second year winter runoff and sediment data from a fallow plot with a silt fence. The silt fence was only cleaned at the end of the runoff season

	---------------- Sediment Collected ------------------				--- Sediment Yield ---		
	---- Flow thru to collection tank---						
Storm Date	Runoff (mm)	Sed. Conc. (mg L^{-1})	Tank (kg)	Silt Fence (kg)	Tank (Mg ha^{-1})	Silt Fence (Mg ha^{-1})	Silt Fence Trap Efficiency (%)
10 Nov	1.8	0	0	not collected	0		
21 Nov	7.6	14,225	8.7	not collected	1.1		
26 Nov	5.1	11,930	4.8	not collected	0.6		
17 Dec	6.1	11,434	5.6	not collected	0.7		
8 Jan	6.4	17,224	8.9	not collected	1.1		
15 Jan	12.3	3,798	3.7	not collected	0,5		
20 Jan	15.5	13,305	16.5	not collected	2.1		
30 Jan	7.4	19,403	11.4	not collected	1.4		
Season	62.2	NA	59.6	664	7.5	83.1	92

Summary

High trap efficiency (greater than 90 percent) was observed both on a storm-by-storm basis and a seasonal basis on a field erosion study site. Thus, clean-out intervals can vary with acceptable results. Properly installed silt fences, such that runoff can not undermine or go around the silt fence, provide a low cost method for measuring hillslope erosion.

References

Britton, S.L., K.M. Robinson, B.J. Barfield, and K.C. Kadavy. 2000. Silt fence performance testing. Presented at the July 2000 ASAE Annual International Meeting, Paper 00-2162. ASAE, 2950 Niles Road, St. Joseph, MI 49085.

Jiang, N., M.C. Hirschi, R.A.C. Cooke, and J. K. Mitchell. 1996. Equation for flow through filter fabric. Presented at the July 1996 ASAE Annual International Meeting, Paper 96-2098. ASAE, 2950 Niles Road, St. Joseph, MI 49085.

McCool, D.K., C.D. Pannkuk, K.E. Saxton, and P.K. Kalita. 1999. Winter runoff and erosion on Northwestern, USA cropland. *International Journal of Sediment Resources*. Accepted March 1999.

Pannkuk, C.D., D.K. McCool, and P.W. Mutch. 1998. Effects of canopy cover on soil loss. Presented at the July 1998 ASAE Annual International Meeting, Paper 98-202. ASAE, 2950 Niles Road, St. Joseph, MI 49085.

Synthetic Industries. 1996. Geotex silt fence geotextile. Chattanooga, TN 37416.

Wishowskie, J.M., M. Mamo, and G.D. Bubenzer. 1998. Trap efficiencies of filter fabric fence. Presented at the July 1998 ASAE Annual International Meeting, Paper 98-2158. ASAE, 2950 Niles Road, St. Joseph, MI 49085.

Wyant, D.C. 1980. *Evaluation of Filter Fabrics For Use as Silt Fences*. Charlottesville, VA: Virginia Highway and Transportation Research Council.