Research article

Evaluation of Sediment Trapping Capacity by Geotextile for Erosion Control

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Abstract Heavy precipitation events induce sediment transport resulting in soil loss, aggravating erosion. Geotextile for erosion control, offers environmentally friendly benefits and have lower costs than other physical structures. Recently, there has been interest in high performance and multifunctional geotextiles. In this study, evaluation was made to investigate the capacity of geotextile in sediment trapping. A runoff experiment was conducted, using a runoff plot using two types of geotextiles, having dimensions of 100 and 10 cm length and breadth respectively. Slope for the runoff plot was created at 0.859 degrees. Four treatments, for each geotextile were made. The treatments were, 1) no folds, 2) folds for 25 cm of the runoff plot, 3) folds for 50 cm of runoff plot, 4) folds for 100 cm of the runoff plot. Muddy water suspension having Suspended Solid (SS) of 25000 mg/L was discharged on the treatments. SS of runoff and infiltered suspension were analyzed. According to the results, both geotextiles were effective in sediment trapping. For Sample A, SS decreased by 88.1%, 97.16%, 99.14% and 99.15% in no folds, 25 cm fold, 50 cm fold and 100 cm fold treatment respectively from the initial SS of the muddy water suspension. Whereas, for Sample B, SS decreased by 87.3%, 91.87%, 98.74% and 98.34% in no folds, 25 cm fold, 50 cm fold and 100 cm fold treatments respectively. Additionally, SS significantly decreased in folded treatments for both geotextiles. Accordingly, it was established that geotextile can function for erosion controlling with increase in folds. However, further research is required to understand the intensity of discharge on geotextiles for sediment trapping capacity for future applications.

Keywords geotextile, sediment trap, erosion control, suspended solid

INTRODUCTION

Precipitation and heavy precipitation events are amongst the most significant weather parameters inducing sediment transport aggravating soil erosion. Soil erosion is one of the biggest concerns of land`s surface as it has many impacts in agriculture, engineering, and construction industries. Various physical measures have been developed and used for controlling soil erosion. Geotextiles are permeable fabrics which functions in separation, filtration, drainage, reinforcement, stabilization, barrier, and erosion protection (Agrawal, 2011). Geotextiles helps in reducing soil erosion by reducing runoff velocity (Balasubramanian, 2017). Physical erosion measures such as gabions, riprap, drop structures, chutes, check dams etc., which works on principal of reducing runoff velocity (Balasubramanian, 2017) are expensive to construct and maintain, also it takes considerable time for construction. However, geotextiles are environmentally friendly, cost-effective measure and are easy to install. Geotextiles, like mulches control soil erosion by imitating the salient properties of vegetation (Rickson, 1990). Geotextiles can improve the surface microclimate, retains soil moisture which promotes seed germination and vegetation growth (Bergado and Soralump, 1999). Additionally, geotextiles can control soil erosion by affecting the quantity and volume of runoff that detaches and transports the sediments. The erosion control geotextiles are directly applied on the exposed surface which provides an immediate protection against soil erosion by reducing flow velocity and detaching forces by impact of raindrops (GEO, 2011). In recent years, there has been interest in high performance and multifunction geotextiles. Therefore, in this study, two geotextiles which functions in inhibiting weed growth were subjected to determine its sediment trapping capacity potential for erosion control.

MATERIALS AND METHOD

Characteristics of Geotextile Used

The geotextiles used in this study are made up of polyester fibers having high tensile strength, elongation capacity, water and air permeability and maintains the natural conditions of the soil. As can be observed from the Table 1, Sample A has lower mass, thickness, tensile strength, and horizontal elongation compared to Sample B. Whereas, water permeability and light resistance for both the geotextiles are similar.

Table 1 Characteristics of geotextile tested

Parameters	Sample A	Sample B
Mass (g/m^2)	130	300
Thickness (mm)	0.5	1.0
Tensile strength (N/5 cm)		
Vertically	343	882
Horizontally	196	686
Elongation (%)		
Vertically	32.0	35.0
Horizontally	28.0	40.0
Water permeability (cm/sec)	1.0×10^{-2} above	1.0×10^{-2} above
Light resistance (%)	9.0	9.0

Note: Data obtained from Toyobo Corp., Japan

Experiment Settings and Conditions

In this research, sediment trapping capacity of two geotextiles Sample A and Sample B were evaluated. For this, runoff experiment was conducted using a runoff plot of 100 cm and 10 cm length and breadth respectively having a slope gradient of 0.859 degrees (Fig. 1).

Three different treatments for each geotextile were made as shown in Table 2: 1) Control, 2) Folds for 25 cm of the plot, 3) Folds for 50 cm of the plot, 4) Folds for 100 cm of the plot. This was done to see the effectiveness of having folds on reducing the sediment flow. Runoff experiment on the geotextile was conducted using 500 ml of muddy water suspension having Suspended Solid (SS) value of 25000 mg/L. The muddy suspension water was poured at inlet in 10 seconds. The runoff and percolated suspension were collected, and SS was analyzed between geotextiles and their groups.

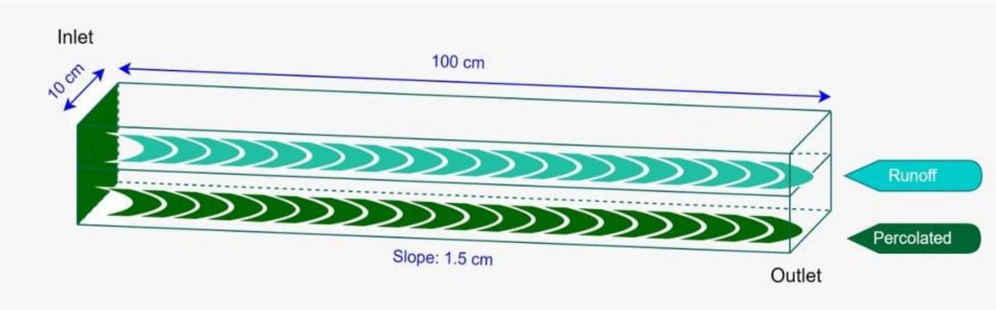
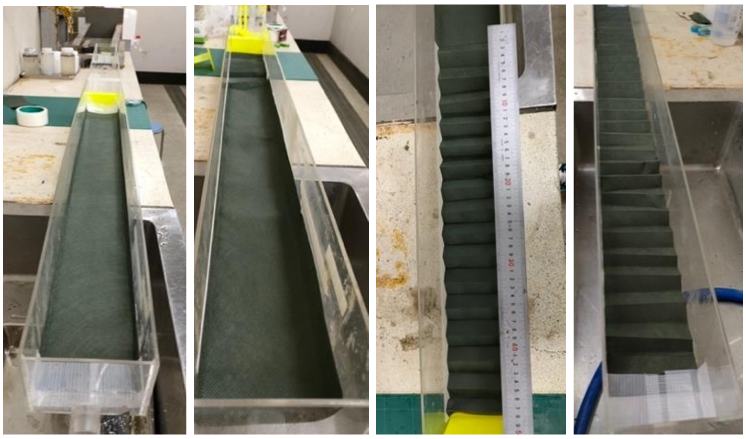


Fig. 1 Schematic diagram of runoff plot

Table 2 Treatments for the geotextiles used for this research

	Sample A	Sample B
1.	Control (plain surface)	Control (plain surface)
2.	Folds for 25 cm of the plot	Folds for 25 cm of the plot
3.	Folds for 50 cm of the plot	Folds for 50 cm of the plot
4.	Folds for 100 cm of the plot	Folds for 100 cm of the plot

Note: Each fold was made of 2cm length



1 2 3 4

Fig. 2 Treatments made for runoff experiment

Determination of Suspended Solid and Soil Loss Reduction Effectiveness

Suspended Solid of the runoff was analyzed using glass fiber filter method. In this method a measured volume of sample (less than 1L) is passed through pre-weighted filter paper which is dried at 104°C ± 1. After drying, the filter paper is weighed, and SS was calculated using Equation 1.

$$SS\ \ mg/L = \frac{Weight\ \ (final) - Weight\ \ (initial) \times 1000}{Volume\ \ of\ \ sample\ \ (mL)} \quad \text{Eq. 1}$$

To see the difference of soil loss created by runoff in each treatment with those of the control plots, ratios between treatments and control (Ogbobe et al., 1998) and effectiveness indexes (Sutherland, 1998) was used. For this, in this experiment, soil loss reduction effectiveness (SLRE, %) was used (Sutherland, 1998), which was calculated using Equation 2.

$$SLREt = \frac{SLc - SLt}{SLc} \times 100 \qquad \text{Eq. 2}$$

Where, *t*, *c*, *SL* are treatment, control, and soil loss respectively. A positive effectiveness indicates geotextile reduces soil loss, whereas a negative effectiveness indicates geotextiles produces more soil loss. In this experiment the value of SS is used for soil loss.

RESULTS AND DISCUSSION

Comparison of Runoff SS between Geotextiles and Sediment Trapping Capacity

The sediment trapping capacity of the geotextiles were evaluated by the difference in initial SS of muddy water suspension with the SS of runoff for each geotextile. Fig. 3 shows the comparisons between the treatments**.** As can be observed from Fig. 3, all the treatments were effective in reducing runoff SS. Additionally, it was observed that treatments with folds could reduce SS significantly compared to control. However, no significant difference was seen between the geotextiles for each treatment. Rickson, 1992, states that the random roughness of fibers contributes to decrease in runoff velocities, thereby reducing the transport capacity and leading to deposition of particles within the geotextile fibers. It can be argued that both geotextiles may have changed the hydraulic flow properties, trapping the sediments.

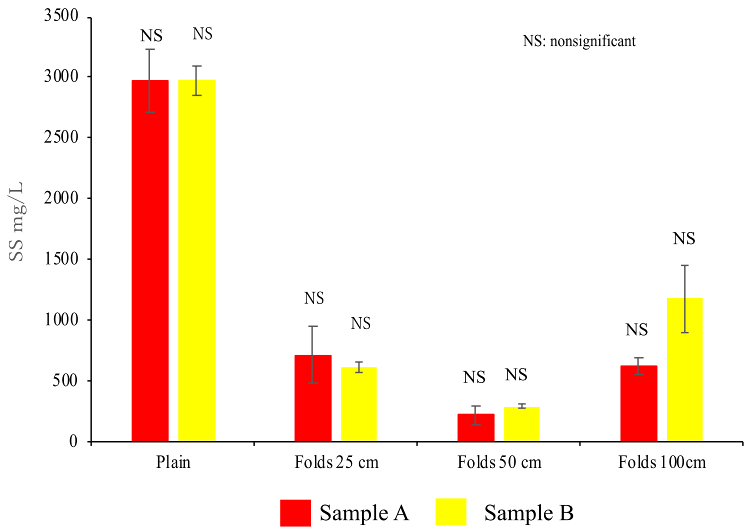


Fig. 3 Comparison of SS of runoff suspension between geotextile treatments

Comparison of Runoff and Percolated SS between in Sample A

The result for runoff SS and percolated SS is shown in Figs. 4 and 5 respectively for Sample A. As can be observed from the results, SS for all the treatments including control decreased significantly. In addition, it was clarified that having folds in the treatment reduced SS. This can be explained as with increase in folds, the kinetic energy of the runoff decreases due to obstacles and friction. Further, it was observed during the experiment that, muddy suspensions got trapped in the folds. This deposited the sediments in the folds, significantly reducing the runoff SS. In given condition of the experiment, folds 50 and folds 100 were more effective compared to 25 cm fold. It was also clarified that Sample A had filtration function. The SS of percolated suspension had very low SS for all the treatments.

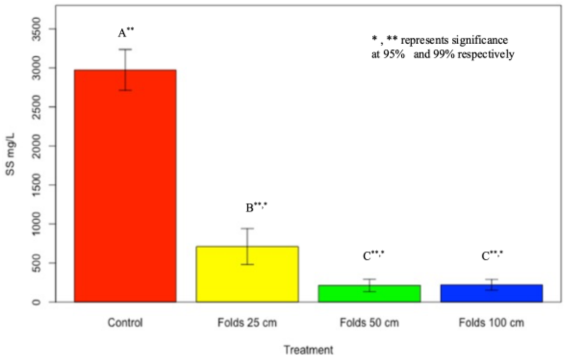


Fig. 4 Difference SS of runoff suspension for Sample A geotextile treatments

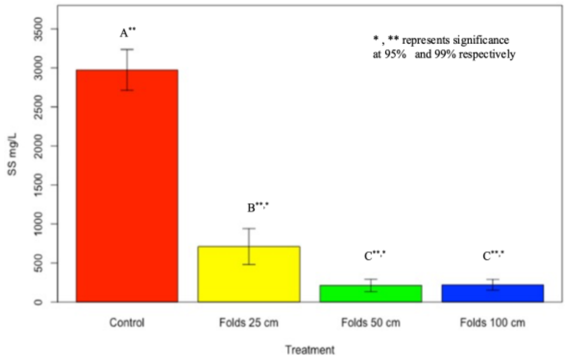


Fig. 5 Difference in SS percolated suspension for Sample B geotextile treatments

Comparison of Runoff and Percolated SS between in Sample B

The results for runoff and percolated SS in geotextile Sample B showed similar results to that of Sample A. The surface runoff SS decreased significantly compared to initial muddy water suspension in all the treatments. As can be observed from Fig. 6, having folds in the textile increased sediment trapping capacity decreasing runoff SS. Similar arguments can be made for the sediment trapping capacity as made for geotextile Sample A. Figure 7 shows the result of percolated SS for geotextile Sample B. Unlike Sample A, percolated SS was not observed in this geotextile. Geotextile Sample B is 0.5 mm thicker than geotextile Sample A (Table 1), which made the runoff faster, resulting in less time for saturation of geotextile and percolation. On the other hand, in folds the suspension was trapped, resulting in percolation. The percolated SS for this geotextile was also very low showing filtration function.

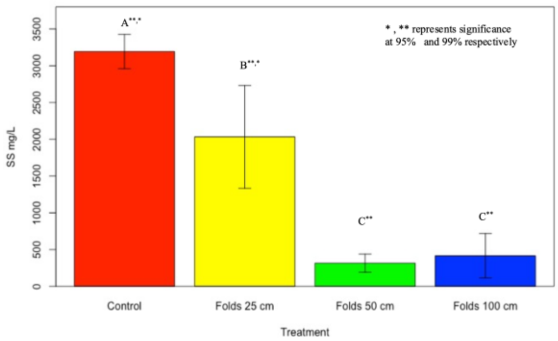


Fig. 6 Difference SS of runoff suspension Sample B geotextile treatments

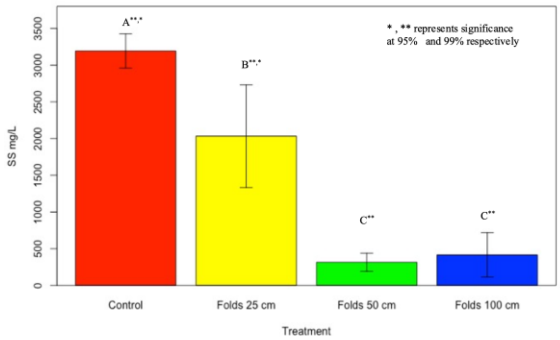


Fig. 7 Difference in SS percolated suspension for Sample B geotextile treatments

Suspended Solid Reduction (%) and Soil Loss Reduction Effectiveness (SLRE, %)

Table 3 shows the SS runoff decrease percent compared to SS of initial muddy water suspension. For Sample A, SS decreased by 88.1%, 97.16%, 99.14% and 99.15% in no folds, 25 cm fold, 50 cm fold and 100 cm fold treatment respectively from the initial SS of the muddy water suspension. Whereas, for geotextile Sample B, SS decreased by 87.3%, 91.87%, 98.74% and 98.34% in no folds, 25 cm fold, 50 cm fold and 100 cm fold treatments respectively. SLRE (%) had positive effectiveness, showing folds in geotextiles was effective in reducing soil loss for both the geotextiles.

Table 3 Suspended solid reduction (%) and SLRE (%)

	Sample A			Sample B		
Treatment	SS (mg/L)	% Decrease	SLRE (%)	SS (mg/L)	% Decrease	SLRE (%)
Initial sample	25000			25000		
Control	2974	88.1		3193	87.23	
25 cm folds	711	97.16	76.09	2032	91.87	36.36
50 cm folds	213	99.14	97.31	315	98.74	90.13
100 cm folds	221	99.15	97.67	416	98.34	86.97

CONCLUSION

A runoff experiment was conducted to examine sediment trapping capacity of two geotextiles. The results showed that both geotextiles significantly decreased the runoff and percolated SS. It was also observed that having folds in the geotextile increased sediment trapping capacity. In addition, soil loss reduction efficiency had high positive values for indicating soil loss reduction. Soil loss reduction efficiency increased with increase in folds in the geotextile. With outcomes of this study, it can be concluded that geotextiles A and B had sediment trapping capacity and can function in reducing soil erosion. However, for future application, further studies are required with varying runoff intensity and slope for sediment trapping capacity.

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