Mitigation of Soil Erosion with Jute Geotextile Aided by Vegetation Cover: Optimization of an Integrated Tactic for Sustainable Soil Conservation System (SSCS)

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Abstract
Degradation of soil considered as one of the foremost vulnerability and global threats nowadays not only for agricultural production and food security, but also for the environmental challenges related to watershed protection, disaster management, bio-diversity conservation, sustainable management of natural resources and climate change, furthermore, complication in Civil engineering. In Bangladesh where arable lands are less than necessary, certainly susceptible to severe erosion due to rainfall and flood, particularly when poor agricultural methods are used or preventive measures are not taken. Implementation of Jute Geotextiles (JGT) aided by native vegetation cover was investigated intended to design a sustainable and low cost tactic at Beel Dakatia through the entire year of 2009. Prime consequences were that erosion, moisture content and runoff are likely to be considerably impacted by rainfall intensity, soil surface slope; additionally, combined presence of JGT and vegetation cover reduced rate of erosion about 95

***Index terms*—** Soil Protection, Jute Geotextiles (JGT), Watershed Management, Renewable Natural Resource, Disaster Management, Soil Strength.

1 INTRODUCTION

oil, one of the most fundamental and essential resources of our earth, providing the medium for plant growth and water retention; hence make certain conservation of life in the earth. Prime soil resources of the worlds are finite over the human time frame, and prone to degradation. Natural balances amid pivotal natural resources like soil, water, and plant deteriorated due to disproportionate and Unplanned use of these resources for centuries in Bangladesh. Consequently, a substantial amount of soil loss becomes a very common phenomena and one of the Engineering & Technology (KUET), Bangladesh. Email : nazmul.shuvo32@gmail.com, manjurkuet@gmail.com, cehasan06@yahoo.com, kamrul.hasan2k7@gmail.co most vital tribulations as it has enormous effects on the soil feature, aquatic being, soil productivity in natural and managed ecosystems, and on the entire environment of the country. **??**Chowdhury. E. H et. al., 1988) Scientists and professionals are sentient about apposite utilization of soil, and considered soil erosion as one of the most severe environmental problems in the earth and ecosystem (Govers, G. et. al 1990). Around one-third of the world's coastal regions are at soaring jeopardy of soil erosion (Caffyn et al., 2002) for the most part, from land-based sources of contamination and infrastructure development. Erosion is one of the most significant forms of land degradation (soil truncation, loss of fertility, slope instability), greatly influenced by land use and management (Rey, 2003;Bini et al., 2006). Soil erosion would remain an imperative global issue for the 21st century because of its adverse impact on agronomic productivity, the environment, and its effect on food security and the quality of life **??**Esrawan et al., 2001).

Detrimental impact of accelerated soil erosion on entire surrounding had been recognized since agricultural societies of ancient date back to Plato and Aristotle **??**Marsh, 1864;Lowdermilk, 1953;Dale, 1955). Formerly, a handful investigation of the changes and comprehensive inventories of components of natural resources took place to illustrate the cause, effect, and remedy; which leads to modern research. At present, the focal causes of land use alteration around the world is pervasive use of land for agricultural purposes plus substantial expansion of urban areas and changes in the land cover. This directly affects ecological landscape functions and processes with all-embracing consequences for biodiversity as well as natural resources (Hansen et al., 2004;State et al., 2001). The potential for surface runoff and soil erosion has consistently affected by land use, crop growing and vegetation cover reduction in an enormous quantity (Van Ropey et al., 2001).

Evaluation of soil loss along with runoff associated sediment yield is obligatory for the resolution of several applied environmental troubles. For instance, this is important to assess contaminant mobility (Johansen et al., 2003), efficacy of land management treatments (Hastings et al., 2003), post-fire hydrology (Johansen et al., 2003) indices of ecosystem health (Davenport et al., 1998) and archeological site stability (Sydoriak et al., 2000). In favor of the rationale that soil quality has influence over to whole ecosystem, this is essential to take urgent actions for appropriate conservation of this pivotal resource. Although extensive attempt has gone into studying and controlling soil erosion (Pimentel et al., 1987;Renard et al., 1997;Fullen and Booth, 2006) optimization of integrated strategy for sustainable system for watershed management is yet to commence. Sustainable Soil Conservation System (SSCS) implies the prudent use land, water and vegetation to obtain optimum production along with enhancing the productivity of resources in ways that are ecologically protective, socially acceptable, efficiently productive, economically viable and institutionally sustainable with least disturbance to the environment (Hurni, 1997).To achieve sustainable development, sustainable technologies needed to be developed, transferred and adopted (Guerin, 2001).

The intention of the study was to amplify our understanding of the effect of different initial soil surface roughness and rainfall intensity on runoff and sediment yield in a variety of stages of runoff generation for the period of comparing the data found from field experiment and from the analysis, and optimize JGT as stabilizer for land as well technical feasibility study of JGT designed for soil erosion reduction, slope stabilization and bio-mass augment; hence providing a sustainable conservation method for land and watershed management in Bangladesh. Moreover, in this study, we investigated the rainfall intensity, runoff, soil moisture contents and rate of erosion on several model beds with the variation of slope.

The use of JGT for soil surface management has not received significant consideration despite their potential (Ogbobe et al., 1998). Jute produced in Bangladesh was once known as the 'Golden fiber' accounting for 80% of total world export. In course of time with the advent of synthetic material jute lost that primary position and had to go for diversification (such as JGT) ; nonetheless, strength properties of JGT are often superior to synthetic fibers (Mandal, 1987).

Initially it gets the high strength and non-hazardous properties; likewise it is a renewable source of energy as Influence of vegetation cover on water infiltration, runoff and erosion has been reported by numerous investigators including Rauzi (1963), Orr (1970), Busby and Gifford (1981).Vegetation cover provides incredibly imperative function in reduction of erosion rate in quite a lot of mode such as interception, restraint, retardation, infiltration, transpiration etc (Gray and Leiser, 1982). Greenway (1987) notes that roots reinforce the soil, increase soil shear strength, reduce susceptibility to erosion and extract moisture from soil.

2 II. Study Area

The study area was Beel Dakatia, situated at the district of Khulna, southwestern part in Bangladesh and falls within the Ganges tidal deltaic plain. Lies between administrative boundaries of Dumuria and Phultala Upazilas of Khulna district (longitudes 89°20'E and 89°35'E and latitudes 22°45'N and 23°00'N). The climate of the area is characterized by sultry summers, moderate winters, tropical cyclones, tidal inundation, heavy rainfall and salinity. The average annual rainfall during is about 1,750 mm. (Rahman 1995;Chowdhury 2006)III.

3 Treatment of JGT

Generally jute fiber is swelled and degraded within six months in water and less durable in acidic, alkaline and other solutions. Therefore some chemical treatment is necessary to convert jute into design biodegradable (5-20 years) and hydrophobic in nature without changing its environmental friendly properties. Designed for the treatment purpose firstly, we collected JGT from local jute mill, after that we prepared a mixer of Copper Sulphate (0.01 kg/m 2), Sodium Carbonate (0.1 kg/m 2) and sprayed manually over JGT mat and then dried in sun light. As soon as treated JGT were fully dried, we laminated the JGT mat by an emulsion made from Bitumen (0.5 kg/m 2) and Kerosine (0.4 L/m 2). Finally, we added Sodium Silicate (0.005 kg/m 2) solution on the bitumen treated surface and a layer of Rice mill by product (0.075 kg/m 2) and kept it under sun light until fully dried. **??**reated natural bio-mass and it protects soil and can endow with instant rain splash and runoff control, creating a stable non-eroding environment (Mitchell et al., 2003). It also protects seeds in the preliminary stages of vegetative growth and helps vegetation establishment (Langford and Coleman, 1996).

Table **??** :

IV.

4 Research Methodology

We established study plots within the Beel Dakatia in such a way that reflects a variety in the slope and vegetation cover. The studies were conducted during the year of 2009 on eight 5.0 X 8.0 m runoff plots. Runoff plots numbered (P1-P8) consisted of a set of eight sheet metal sediment traps with aperture parallel to the slope contour.

We used a profile probe to measure moisture contents of soil and implemented a self reading rain gauge to measure the rainfall intensity; in addition at each site, we also evaluated bulk density and surface shear strength. Every plot was different from each other in such a manner that at least one of the three parameters (Geotextile, vegetation cover, and slope) is dissimilar as follows: We prepared bare plots by removing the grass turfs and rotavating the surface and did maintain in a bare condition by regular herbicide treatments. To maintain perfect slope we used level. After implementing JGT mat on four plots, a layer of soil of average thickness 100mm was laid over the mat, later the surface was finished uniformly.

We planted native grass in four plots and nourished them. We used traps and water stage recorder for measurement of soil sediment yield, soil splash height, and runoff volume. Total runoff during a rain was channeled through traps fabricated from a 2000 L reservoir and 3 mm mesh hardware cloth in each plot. Each trap consisted of a 30 cm diameter circular tube inserted into the soil, containing a similar-sized funnel on top of the reservoir; however, analogous splash traps have been used by Poesen and Torri (1988). After collecting the jar we dried the sedimentation by oven and weighted them.

Our study was distinctive in several respects, as we physically captured soil and sediment in collector traps, more to the point we were able to measure slope erosion directly, rather than relying on ocular estimates or indirect techniques such as erosion pins (Haigh 1977) or erosion bridges (Ranger and Frank 1978). Four technicians were employed during the study to monitor and evaluate overall criteria.

V.

5 Results and Discussion

Variation in erosion rate, runoff and moisture content illustrate the competence of each plot to sustain against the susceptibility of soil degradation. Results showed that during the experimental period total runoff from plots aided with both JGT and vegetation cover was ~70% and ~35% less than those of bare plots and plots with either JGT or vegetation cover respectively (Table -3). Sediment yield from the plots with both JGT and vegetation cover were about 95% and 65% less than those of bare plots and singly treated plots respectively. Although, mere implementation of JGT or vegetation cover can shrink considerable amount of erosion, consequence of combined outcome was tremendous. Mean total soil loss equates to 18, 7.5, 5.5 and 1 t/ha from the bare plots, vegetated plots, JGT plots and combined JGT and Vegetated plots respectively (Table -3). However, amount of slope is a crucial factor for soil degradation, its affect can be alleviated by JGT and vegetation cover.

A broad observation confirms that the JGT plays the essential role of catalyst to burgeon native grasses. Whereas in the plots with JGT and grasses contain at least 40% more grasses than those of the plots without JGT implemented. JGT slows down and catches runoff so that sediment settles and moisture retains in the root zone and encourages vegetation growth by creating a congenial climate conductive to augmentation on the soil surface. Moreover, the density of the grass roots within the soil mass and the root tensile strength contribute to the ability of the soils to resist shear stress; hence increase the shear strength of soil.

When JGT turn out to be drenched they swell to the soil surface, enhancing the tendency to support surface micro-topography and hence runoff and erosion control. Results put forward JGT aided by vegetation cover are very functional in dipping soil erosion and runoff. This is for the reason that JGT serve as a defensive barrier that dissipates raindrop kinetic energy impact. Following severe rainfall (Graph-1), fine sediment was visible, trapped by the JGT resulting in decreased surface erosion. Besides offering defense, JGT might have improved soil organic matter that bind soil particles and aid the retention of topsoil structure and aggregate stability, thereby reducing surface erosion by encouraging infiltration. Both of the remedial processes increase the quantity of moisture content (Graph-2). This is due to the intermingle opening of JGT, which provides a porous soil condition and water passes into the underlying soil, in contrast grasses absorb moisture in the root zone. Outcome of the treatment in the plots corroborate the significance of l retaining protective vegetative covers on sloping land. In view of the fact that vegetation cover serve as a shielding hurdle that squanders the impact of raindrop kinetic energy. Every part of these aspects may perhaps have contributed to the increased effectiveness of JGT in attenuation of soil erosion and total runoff.

6 VI.

7 Conclusion

The results subsequent to one year of research signify the combined implementation of JGT aided by native vegetation cover drastically trimmed down soil erosion rate and runoff. Intended for sustainable soil conservation by means of eco friendly, low cost technology combined application of JGT and vegetation cover can be the factual competent as JGT has distinct advantages in respect of each variable determinant. JGT is excellent design biodegradable, anionic, pricecompetitive and environment friendly material; besides its flexibility and distinctive physical characteristics coupled with its high spin ability make it an ideal material for new technical applications. Even though we have been able to formulate several preliminary comparisons and note general trends, further adaptive relentless research with technology development and participatory dissemination addressed along with existing functioning relations between the government, multilateral development partners and the local people will be necessary prior to obtain optimum outcome. [1] [2]

Figure 1:

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Weight (g/m 2)	Properties of Treated JGT 800
Thickness (mm) Spiral angle (degree)	5 9
Water holding capacity %	275
Tensile strength (kN/m) (MDXCD)	18 X 18
Porometry (micron)	200
Elongation on break %	6

Figure 2:

[2] Mitigation of Soil Erosion with Jute Geotextile Aided By Vegetation Cover: Optimization of an Integrated Tactic for Sustainable Soil Conservation System (SSCS)

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Figure 3: Table 2 :

Graph-2 :

Plot	Erosion Value Measured in the site (g/m 2)	Erosion Rate Equivalent t/ha/yr	Moisture content (%) at 20 cm depth in August (2009) Runoff (L/m 2)
P 1	21050	21	79.5
P 2	17308	17.3	71.9
P 3	8255	8.2	49.5
P 4	7005	7.1	43.3
P 5	6140	6.1	43.6
P 6	4920	4.9	35.5
P 7	1150	1.1	20.8
P 8	809	0.8	17

Figure 4:

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Figure 5: Table - 3

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[Graph-1 : Monthly Rainfall Measured at Site] *Graph-1 : Monthly Rainfall Measured at Site*,

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