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# Interactive comment on "Experimental study using coir geotextiles in watershed management" by S. Vishnudas et al.

**S. Vishnudas et al.**

Explanation for the comments from HESSD

1. Detention ponds are traditional water conservation structures used for drinking, domestic and irrigation purposes in Kerala. These ponds will also act as an infiltration basin or recharge basin, which will enhance groundwater recharge. In almost all micro-watersheds there is one village pond which is under the control of the local government called the Panchayat. But due to shortage of funds and high labour cost, these ponds are not maintained periodically. Hence, water storage capacity of the ponds is reduced due to erosion of side banks. This leads to water shortage in summer seasons and even in dry spells. These ponds are the major water source for the village community.

2. Coir has been used in this experiment as a temporary erosion control measure to establish vegetation and to stabilise steep slopes such as embankments of ponds. In

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this study 'Coir + grass is considered as a sustainable agronomic control measure. A composite of geotextiles and vegetation is required to keep erosion down to a tolerable level. In this case the aim is to achieve a synergic relationship between geotextiles and vegetation. Tests carried out on a combination of vegetation and geotextiles, requiring less time for establishment, demonstrated to yield immediate benefits for erosion control and slope stability (Rickson, 1995).

In Kerala there are two monsoon seasons: Northeast (June-August) and Southwest (October-December). The rainfall pattern is a intensity of short duration. The experiment was started just before the onset of the monsoon. Hence when 'grass alone' is planted, before roots get established, it gets eroded or uprooted.

3. Experiment was conducted and monitored from the view point of the user community. In this study the user community developed indicators for monitoring and evaluation. They evaluated, monitored and gave the results and triangulation was carried out by scientists. Through experimentation jointly with the people, beneficiaries receive training and experience in the design, implementation and evaluation of experiments; their capacity for innovation can be substantially increased (Johnson et al. (2003). Bunch & Lopez, (1999), through their study reveal that, for farmers to accept soil conservation technologies, which are to be sustained, it must be combined with a technology that enhances yields. It is the increase in yield that convinces the farmers of the value of soil conservation. This will enable them to get involved in a development process for and by themselves. If the yields have increased or costs have decreased, artificial incentives are not required. On the other hand if yields have not increased, no artificial incentive will make the technology's adoption sustainable. 4. As coir is a biodegradable natural fibre, the major positive impact of the application of coir is on the environment. Due to time constraints, the impact on the environment could not be studied. Regarding the cost of construction, the conventional method of slope protection is by stone pitching, which costs 2.50 euro/ m2. However, by using coir geotextiles, the costs are less than 1. euro/m2. Moreover, unlike conventional structures, this structure

itself provides a means for cultivation of fodder or other crops for the rural poor.

7 & 14. Introduction (rewrite as)

Soil erosion is increasingly recognized as a problem which needs an effective and economic solution. Several slope protection methods are currently used to stabilize slopes. Among these methods biotechnical methods are emerging because environmental and ecological restoration is considered to be more important from the view point of sustainable development. Natural vegetation on slopes are able to self-maintain, brake and dilute the kinetic energy of the rain and also provide surface roughness which slows the runoff velocity. The root system reinforces the soil and also aids infiltration of water by improving the porosity of soils (Ranganathan, 1994; Ahn et al., 2002). However there are certain limitations which can hamper the establishment of vegetation: it is susceptible to drought, it is difficult to get establish on slopes, it is unable to resist severe scour or high runoff and it is slow to establish (Abramson et al., 1995). The effect of vegetation is only fully realised once it has reached maturity. During the critical stage of plant establishment the beneficial engineering properties of the vegetation may not be apparent and a site is still highly susceptible to soil erosion. Without immediate, appropriate and adequate protection, slopes can suffer severe soil erosion and instability, which in turn make vegetation establishment extremely difficult. Seeds and seedlings from unprotected sites by surface runoff and high winds incurs costs in time and money as all previous attempts to establish vegetation on the slope have to be repeated (Rickson, 1995). Hence a protective covering on soil is required which resists soil erosion, retains runoff water for a long time and establishes vegetation on the surface. By protecting the surface, these covering materials dissipate raindrop impact energy, increase infiltration by reducing surface sealing and reduce the velocity of overland flow. In addition they help to reduce intense solar radiation, suppress extreme fluctuations of soil temperature, reduce water loss through evaporation and increase soil moisture, which can assist in creating ideal conditions for plant growth (Sutherland et al., 1998a; Ziegler et al., 1997). Over the past decade, geosynthetics have played a

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significant role in geo-environmental engineering applications. Woven and nonwoven geosynthetics have been used in various applications such as soil stabilization, turf reinforcement, erosion control, separation, filtration and drainage. Depending on the application, they are available under various trade names such as rolled erosion control systems (RECSs), geosynthetic matting, geotextiles, erosion control blankets (ECBs), erosion control re-vegetation mats (ECRMs) and turf reinforcement mats. Despite the technological advances made in this relatively new discipline, the majority of research has focused on geosynthetics made from synthetic materials. The use of naturally occurring fibre products for similar applications has not received significant consideration despite their potential (Ogbobe et al., 1998). However, strength properties of natural fibres are often superior to the synthetic fibres (Mandal, 1987). Recently, pilot projects have been launched as field trials using natural geotextiles in various applications, but not much published research is available on how geotextiles can be used to control erosion (Rickson, 1995). In the rural areas of Kerala, India, small streams and village ponds are the main source of water for irrigation and domestic use. However, during monsoon, the side banks of these ponds erode and the ponds get silted up. The same silt from the pond is subsequently used to restore the side banks but it is often eroded before vegetation can establish. Hence continuous maintenance is required for deepening and desilting of ponds to maintain their water holding capacity. Neither the local government nor the community may have enough funds for these labour intensive works. Ultimately the ponds get filled up and deteriorate and the area becomes subject to water shortage during the summer season. Most watershed projects meant to support communities propose conventional stone bunds for soil and water conservation. However, the majority of the people cannot afford these structures without support from the government. Hence it is interesting to look for an alternative material which is effective in reducing soil erosion, enhancing soil moisture and vegetation growth, and which at the same time is economically attractive and can be manufactured locally.

The aim of the experiment was to study the effectiveness of coir geotextiles for slope protection and to provide an alternative, cost effective option to reduce soil erosion,

increase vegetation growth and increase soil moisture availability.

8. Title: The stability and attractiveness of a vegetated embankment using Coir geo-textiles

2328, 24-27 To test the effectiveness of coir geotextiles as an ecofriendly affordable material for slope protection thereby reducing soil erosion and increasing vegetation and soil moisture availability.

9. Abstract: This paper presents the results of a field experiment conducted in Kerala, South India, to test the effectiveness of coir geotextiles for embankment protection. The results reveal that treatment with geotextile in combination with grass is an ef-fective eco-hydrological measure to protect steep slopes from erosion. In the context of sustainable watershed management, coir is a cheap and locally available material that can be used to strengthen traditional earthen bunds or protect the banks of vil-lage ponds from erosion. Particularly in developing countries, where coir is abundantly available and textiles can be produced by small-scale industry, this is an attractive al-ternative for conventional methods. The paper analyses the performance of different treatments with regard to soil moisture content, protection against erosion and biomass production.

Explanation to general comments 4 & 6

The perception of the people has been statistically analysed by 3 factor ANOVA.

The average length of the sampled leaves, at any period, is assumed to be indicative of the vegetation growth at that period. The ANOVA table for the perceived length of the grass is shown in Table -1 (qualitative data).

Table 1 ANNOVA table; Response of participants on length of grass: whole treatment B1 B2 B3 B4 B5 B6 B7 B8 B9 C1A1 31.50 34.50 42.33 44.83 47.00 45.66 43.83 41.83 35.66 C1A2 20.50 25.00 30.16 30.16 32.66 35.00 35.83 28.83 31.00 C1A3 13.16 20.16 21.83 20.00 22.66 18.83 16.50 18.00 28.00 C2A1 43.66 44.50 44.33 47.00 47.66 48.16

44.83 42.66 41.66 C2A2 38.50 41.33 32.00 34.16 34.83 29.83 20.66 24.66 27.66 C2A3 19.33 27.66 22.50 19.33 18.50 15.16 14.83 13.50 19.00 C3A1 45.50 46.83 48.83 48.50 48.16 49.00 48.00 45.83 43.33 C3A2 41.50 31.66 34.33 33.83 30.83 27.00 23.83 21.16 27.66 C3A3 30.33 30.00 21.00 18.33 19.00 17.83 15.16 16.33 18.50 C4A1 45.33 45.50 46.16 44.33 49.50 46.50 47.16 46.16 43.66 C4A2 31.16 29.33 25.50 21.16 23.50 19.16 17.50 22.83 24.16 C4A3 23.33 21.83 20.83 20.00 19.50 18.16 17.50 16.33 18.83

Critical difference CD = 2.29 F Value = 10.82* * C- Sides of the pond, C1= North B- Month, (1= June) A- Treatment, A1= CGG, A2 = CG, A3 = CP respectively

In the experiment CGG (A1), the length of the grass generally increased over the first four-five months. Minimum response on length of grass was noted in the initial months, and gradually it increased until the month of November. The monitoring was carried out for 9 months from June, with three treatments on 4 areas. Hence the degree of freedom (df) = 48 (2 x 3 x 8). For 5% significance (*), the F value is 1.41 and for 1% significance (* *), the F value is 1.55. In this study the F value = 10.82**, which shows that there is high significant difference between treatments. Among the three different treatments significant increase in length of grass was observed in geotextile with grass plots compared to control plots.

Considering individual treatments, with df = 2, the F value for 5% significance (*) is 3.01 and for 1% significance, the F value is 4.64. In this study the F value is 1321.17**, which shows that the treatments are very effective and differences between treatments are highly significant. Mean value for treatment A1 (CGG) is 44.72, for A2 (CG) is 28.86 and A3 (CP) is 19.77. CD between A1 (CGG) and A2 (CG) is 15.86 and between A2 (CG) and A3 (CP) is 9.09, whereas between A1 (CGG) and A3 (CP) is 24.95. This shows that treatment A1 (CGG) is highly significant different from A3 (CP), and A1 (CGG) and A2 (CG) are significantly different from A3 (CP). Table 2 shows the ANOVA table for individual treatments.

Table -2, Response of participants; ANOVA table for individual treatment

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A1 44.72 A2 28.86 A3 19.77 CD 0.963 F value 1321.17**

Figure 3 shows the variation in the height of the vegetation in all plots. The measured length of the sampled leaves in CGG has an average maximum length of 85 cm, for CG: 66 cm and for CP 48 cm. After 6 months, no further variation in measured length of grass was observed.

This shows that variations in the height of vegetation in the three treatments were similar in both qualitative and quantitative analysis.

Explanation to specific comments

2332, 1-4

The capacity of the pond is 48m x 123m x 2.1m. The experiment consists of three treatments (a) coir geotextiles with planted grass (CGG), (b) Coir geotextile alone (CG) and (c) control plot (CP); replicated four times. The height of the exposed slope of the embankment is about 3 m. Each side of the pond was divided in three equal parts for the three treatments.

2329, 4-5 'Coir' is the agricultural waste fibre obtained from the husk of the coconut fruit which surrounds the base shell. It provides the raw material for the coir industry. Coir fibres are of different types and are classified according to varying degree of colour, length and thickness. Length of coir varies from 50 mm to 150 mm and diameters vary from 0.2mm to 0.6mm. The fibre is of two types depending on the process of extraction: white fibre and brown fibre. White fibre is extracted after retting mature coconut husks for 9-12 months, followed by beating of the retted husks with mallet manually for thrashing out the coir pith. Brown fibre is extracted by mechanical means after soaking the husks for a short period in water. The brown fibre is relatively inferior in terms of quality. Brown coir is mainly used for ropes, rubberized coir and in upholstery. The extracted fibres are then spun into yarn of different weights. The yarn is classified in terms of type of fibre, colour (natural), twisting and spinning. The yarn is then con-

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verted into mats in handlooms, semi automatic looms or power looms. Scorage of yarn differs among different types of geotextiles. The scorage of the yarn is the number of strands that can be laid close to each other without overlapping in a length of 0.91m (1 yard). Coir is a lignocelluloses polymeric fibre with 45% lignin and 43% cellulose. Coir fibres are less sensitive to UV radiations due to leaching out of photo-sensitive materials from its surface during the retting process. It has low tenacity (a unit used to measure the strength of a fibre or yarn, which is usually calculated by dividing the breaking force by the linear density (linear density in rope specification is weight / unit length)) but the elongation is much higher (Ayyar et al, 2002). It is a natural biodegradable material with a highly crystalline structure with the spiral angle of the micro fibres ranging between 30-45o. This leads to a greater extensibility than in most other natural fibres. Its high lignin content contributes to higher durability and slow bio-degradation compared to other natural fibres (Balan & Rao, 1996). There are two types of coir mats (geotextiles) available: non-woven mats and woven mats. Non-woven mats are made from loose fibres, which are interlocked by needle punching or rubberizing. Woven mats are available in different mesh openings ranging from 3 to 25 mm. A higher density means a tighter mesh and less open area. Over the years many varieties have been developed in India and are now commercially available in different mesh matting with international trade names such as: MMA1, MMV1, MMR1 etc., where MM stands for mesh matting and A, V or R stands for the name of yarns based on the place of origin. Manufacturing details of different types of coir geotextiles are given in Table 1

Table 1 Manufacturing details of different types of coir geotextiles (adapted from Ayyar et al., 2002)

2331-18, 2335-14 The tensile strength test is carried out using wide-width strip tensile test for geotextiles, a uniaxial tensile test in which the entire width of a 200 mm wide specimen is gripped in the clamps and the gage length is 100 mm (ASTM standard D 4595-86). The unit is kN/m.

2335-3, 18 a. After 7 months, it was observed that tensile strength of geotextiles was

reduced by about 70 %. By that time a sustainable erosion control measure by the establishment of vegetation was observed in the CGG and CG plots whereas erosion persisted in the control plots. Hence the increase in the rate of degradation during the period did not affect the effectiveness of coir geotextiles as an erosion control measure.

b. Destructive soil samples were collected from the surface (top soil) to test the soil for nutrient contents. 2331- 24 The slope of the embankment is 700. Hence treatment was given with a combination of geotextile and vegetation. Ponds are natural depression on one side. (see figure for 2332,1-4). The water level in the pond fluctuates from season to season. Erosion is caused by both rainfall and runoff.

2335-7 Please read as 'it was observed as' instead of 'it is seen that'

2336-1 Please read as 'geotextile' instead of 'fabric'

Fig-1 In the Southwest monsoon, there is high intensity rainfall for short duration (peculiarity of this rainfall typically is in the form of an evening shower with a clear sky during the day. The average temperature is 26.50C) (GoK, 2002). During the study period, rainfall started on October 18th, with average rainfall varying between 40-120 mm/day. In the graph average monthly rainfall is shown and hence there was no large variation in moisture due to rainfall over the observation period.

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