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Application of Geo-synthetic Technology for Erosion Control of Tana Lake Catchment Areas and Blue Nile Banks (pp. 186-197)

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Abstract

This paper examined the use of geo-synthetic technology for the control of surface soil erosion. It highlighted the advantages of using a geo-synthetic polymer (soilBrowntac) for micro reinforcement. The methodology of application of the geo-synthetic polymer was described along with a field trial carried out by the author at Egashu river bank, Gelda river bank and Gumara river bank in the Amhara Region of Ethiopia. On the basis of the research results, it was concluded that the soilBrowntac polymer composite technique is effective and economical for use in the control of surface soil erosion. The research findings effectively laid to rest the question of whether or not geo-synthetic technology is really needed for the control of soil erosion in Ethiopia.

Key Words: SoilBrowntac, Soil stabilization, Grain size, Vegetation

Introduction

Soils vary considerably in their nature, properties and composition depending upon the location, and they exert a strong influence on the use of land. Soil conservation and regulated land use have become extremely essential due to the tremendous pressure of the present ecological imbalances (Anon, 1998). Increased human and livestock population resulting in improper land use, shifting cultivation/grazing, deforestation, water logging, mining etc., pose serious threats today. The growing pressure of these problems disturbs natural balance between soil forming and soil conserving forces on one hand and the soil eroding or depleting forces on the other.

Soil erosion and land degradation of natural or manmade slopes are prevalent due to various reasons. These slopes and river banks are mostly degraded by surface water runoff due to insufficient or poor vegetation cover (Rajan and Tewary, 1988). While natural vegetation for sustained erosion control is a proven choice, successful soil conservation depends mostly upon adequacy of natural vegetation forming process. However, due to changing weather conditions, progressive regeneration of natural vegetation may require sustained through-periods of extreme climatic change including droughts (Anon, 1998). This requires the help of external reinforcement to the root matrix. Different kinds of geo-fabrics and geo-composites are being extensively used for protection of hill as well as embankment slopes at the river banks by providing extremely dense vegetation support permanently and effectively, as well as in reducing threshold velocity of erosion (Dalal et al., 1992).

In this context, soil erosion control measures against surface runoff (primarily the surface water run-off due to rainfall and flooding of natural and manmade slopes like embankments, river banks etc) are discussed here.

Raw Materials

Polymer Composites – Soibrowntac

SoilBrowntac is a cost effective and innovative product that is engineered for today's challenging soil stabilisation problem. This product is a copolymer emulsion that is environmentally safe and biodegradable. SoilBrowntac is designed to work its way down into the soil to maximize the penetration depth (Raichur et al., 1992). Once cured, soilBrowntac becomes completely transparent, leaving the natural landscape to appear untouched. SoilBrowntac results depend on the application rate. Modest applications can create a light temporary surface crust. Heavy application can generate results similar to the qualities of cement.

SoilBrowntac Overview

- Physical Form - Mobile liquid
- Colour - White (transparent once cured)
- Odour - Mild
- Health Hazards - There are no known health hazards
- Synonyms - Soil stabilizer
- Chemical Family - Vinyl Acetate copolymer emulsion
- Intended Use - Soil stabilization

Salient Features

- Flexible when it dries
- Biodegradable
- Odourless when it dries
- Simple and easy to apply
- Transparent/clear when it dries
- Non-flammable/non-volatile
- Non-hazardous/non-corrosive
- Non-regulated for transportation

- Long and short solution is available
- Dyes and pigments can be added for colour
- Vegetation safe (will not harm vegetation)
- Water-resistant (will not break down with water)
- Non-tracking (will not be picked up onto vehicles)
- Non-leaching (will not continue to steep into the soil)
- Ultraviolet ray resistance (will not break down on exposure to sun)
- Non-dissipating (will not wash away with water once cured)
- Alkaline soil resistant (will not break down in alkaline soils)
- Self mixes with water for diluting (prior to applying to the soil)

Methodology

Application of soilBrowntac Polymer Composite

The below mentioned trial areas were selected for applying soilBrowntac geosynthetic solution to control soil erosion:

1. Egashu River Bank - Amhara Region
2. Gelda River Bank - Amhara Region
3. Gumara River Bank - Amhara Region

The application coverage rates of soilBrowntac polymer composite are shown in Table 1.

Table 1: Application Coverage Rates of SoilBrowntac Polymer Composite

S/No.	Place	Area	Type	Coverage rate Liter/m^2
1	Egashu River Bank	10 m^2	Light	0.10
2	Gelda River Bank	20 m^2	Average	0.27
3	Gumara River Bank	20 m^2	Heavy	0.58

Site Preparation

The soil in the selected areas was dried to be completely free of water. During the site preparation, the temperature of the site was kept 40ºF as per the prescription given by the soilbrowntac manufacturer. The simple spray nozzles were used to supply the geo-synthetic solution at the rate of 0.10litre/m2 for light application at Egashu river bank, 0.27litre/m2 for average application at Gelda river bank and 0.58litre/m2 for heavy application at Gumara river bank.

Preparation of SoilBrowntac Solution

The following steps were followed to prepare the soilBrowntac geo-synthetic solution:

The application equipment was filled with the recommended volume of water shown in Table 2 with respect to type of application. Next, the recommended volume of soilBrowntac concentrate (indicated in Table 2) was added dependent on the type of application. The foaming of the solution was prevented by adding soilBrowntac concentrate last directly into the water.

Table 2: Composition of SoilBrowntac Solution

S/No.	Composition of SoilBrowntac	Light Application	Average Application	Heavy Application
1	SoilBrowntac	200ml (1 part)	200ml (1 part)	500ml (1 part)
2	Water	3000ml (15 parts of soilBrowntac concentrate)	2400ml (12 parts of soilBrowntac concentrate)	4500ml (9 parts of soilBrowntac concentrate)
3	Total	3200ml	2600ml	5000ml

Application of SoilBrowbtac Solution on Prepared Site
The spray nozzles were set to provide an even coat over the treatment area with each pass. The spray rate was high enough to allow even coverage with multiple coats and low enough to prevent material from draining away from the treated area. Then the soilBrowntac solution was applied over the treatment area by spray nozzles.

Curing
The treated area was allowed to dry and cure for approximately 24 hours in an open atmosphere. The site was kept free from rain for a minimum of 72 hours after the application.

Soil Testing
Determination of Particle Size Distribution and Specific Gravity of Treated and Untreated Soil
This test was conducted to determine the soil size after and before treatment by using hydrometer analysis test (BSI, 1990).

Determination of the pH Value of the Treated and Untreated Sample
This test was conducted by using pH meter to analyse the effect of soilBrowntac on the pH value of the treated sample.
Cost Analysis
In order to determine the economical feasibility of the geo-synthetic technology, a cost analysis was conducted by considering material cost, labour cost and other other overheads that were incurred.

Results and Discussion
The results of the particle size analyses for the untreated and the treated soil samples are shown respectively in Tables 3 and 4.

Table 3: Hydrometer Analysis Test Results for Untreated Sample

Date	Time (minutes)	Reading in suspension (R_h)	Reading in dispersant solution (R_o)	Temperature (°C)	R_d (R_h-R_o)	Hr(mm) Effective depth	D(mm) Particle size	K(%) %passing
14/2/98EC	0.5	20	1	24	19	121	0.062	63.53
	1	19	1	24	18	125	0.045	60.18
	2	18	1	24	17	133	0.033	56.84
	4	16	1	24	15	137	0.023	50.15
	8	14	1	24	13	145	0.017	43.46
	30	11	0.75	25.6	10.25	157	0.009	34.27
	120	8	0.25	28.4	7.75	169	0.005	25.91
	480	6	0.25	27.8	5.75	177	0.002	19.22
15/2/98EC	1440	6	1	23.5	5	177	0.001	16.72

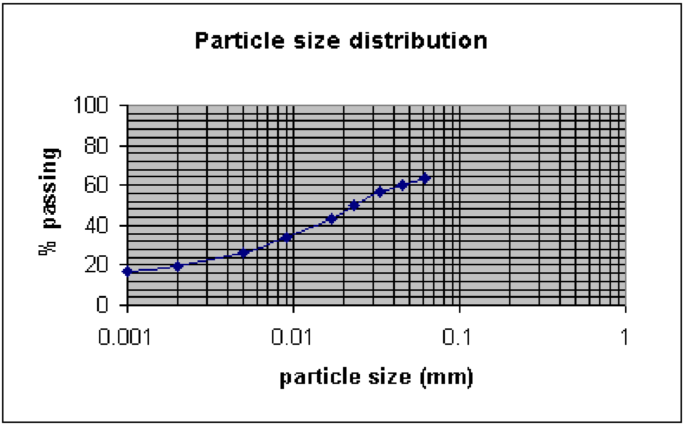

Fig: 1: Particle Size Distribution of Untreated Sample (Specific Gravity: 2.75)

Table 4: Hydrometer Analysis Test Results for Treated Sample

Date	Time (min)	Reading in suspension (R_h)	Reading in dispersant solution (R_o)	Temp. (ºC)	R_d (R_h-R_o)	Hr(mm) Effective depth	D(mm) Particle size	K(%) %passing
14/2/98EC	0.5	26	1	23.4	25	97	0.056	78.09
	1	24.5	1	23.4	23.5	103	0.041	73.4
	2	23	1	23.4	22	109	0.029	68.72
	4	21	1	23.4	20	117	0.022	62.47
	8	19	1	23.4	18	125	0.016	56.22
	30	15.5	1	25.2	14.5	139	0.008	45.29
	120	12	0.5	27.4	11.5	153	0.004	35.92
	480	10	0.25	27.8	9.75	161	0.002	30.46
15/2/98EC	1440	9.5	1	24.6	8.5	163	0.001	26.55

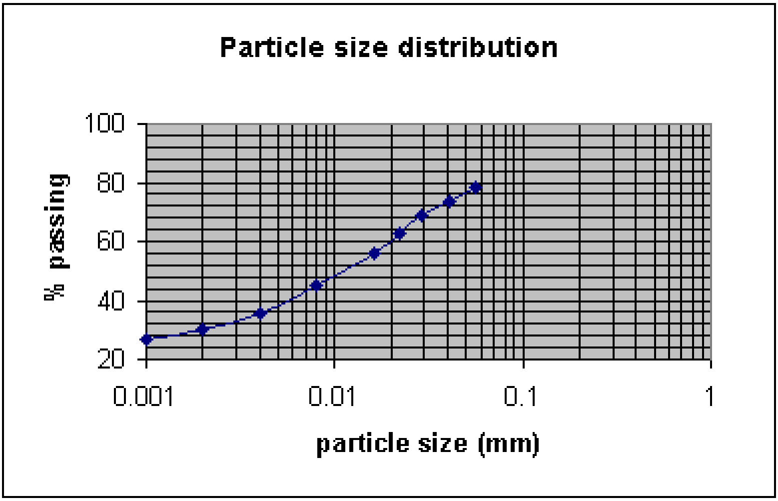

Fig.2 Particle Size Distribution of Treated Sample (Specific Gravity: 2.78)

Particle size distribution and specific gravity of untreated and treated sample was studied by using hydrometer test method (Sudhakaran, 2000). The results which are summarised in Tables 3 and 4 show the particle size distribution and K% (% passing) of treated and untreated soil respectively. It is seen that the presence of geo-synthetics in treated sample imparts low permeable characteristics to the treated soil sample and also disintegrate the soil in to fine particles.

From Table 4, it can be seen that the K% value (particle size 0.001 mm) of treated sample is 26.55 % as against the K value of the untreated sample which stands at 16.72% (Table 3). This may be due to the disintegration of the soil particles by the geo-synthetic polymer. It is believed that the soil crushing agent present in the geo-synthetic emulsion polymer thus reduces the cohesive bond energy existing in the soil particles (Hoekstra and Bercout, 1999). It is to be noted that there is a significant improvement in the soil compaction characteristics of treated sample. This may be due to the presence of soil solidifier in the polymer solution (Hudson, 1959).

Effect of SoilBrowntac on pH Value of the Treated Sample

The pH test results clearly indicated that the pH value of treated and untreated samples were 7.05 and 6.8 respectively. From the above pH values, it is noted that there is no significant effect on pH in the treated sample.

Permeability of the Treated and Untreated Samples

Figures 1 and 2 show that the K% of the untreated sample is lower than that of the treated sample at all the reading levels. This indicates that the untreated sample is more permeable than treated one. It is believed that the presence of soil solidifier in the geo-synthetic polymer solution increases the cohesive bond energy existing in the soil particles (Tewary, 1989).

Economical Advantages of Geo-synthetic Technology
As shown in Table 5, the cost of geo-synthetic technology is cheaper than the existing geo texile technology (Sudhakaran and Fernandez, 2000a, b). Hence, this technology could be conveniently adopted in developing countries like Ethiopia.

Table 5: Cost Analysis of Geo-synthetic Technology

S. No	Type	Cost per m^2
1	Heavy	USD 0. 5 (Birr 4)
2	Average	USD 0. 20 (Birr 1.6)
3	Light	USD 0. 065 (Birr 0. 5)

Conclusions
On the basis of these results, the following conclusions emerge:

1. Soil Brown polymer composite has been found to be effective in controlling loss of soil from river banks.
2. Presence of geo-fabrics and soilBrowntac polymer composites were found to significantly help the growth and preservation of the vegetation cover over what were initially denuded slopes.
3. It reduces maintenance cost.
4. Its design methodology is easy.

It can thus be predicted that designing with soilBrowntac will be more comprehensive, sophisticated and more common in the years to come and should soon emerge as a major discipline in its own right.

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