ISSN - 2277 - 2755

Journal of
Agricultural Science
and Environment

A COMPARATIVE ANALYSIS OF COCONUT, PALM FROND AND PALM STEM FIBRES AS EROSION CONTROL MATERIALS ON EMBANKMENTS

C.C. EGWUONWU[1] AND A.P. UZOIJE[2]

[1]Department of Agricultural Engineering, Federal University of Technology, Owerri. Nigeria.
[2]Department of Environmental Technology, Federal University of Technology, Owerri. Nigeria.
[1]**Corresponding author:** nnamdichuks2002@yahoo.com **Tel:** +2347032595476

ABSTRACT

The research focused on the use of fibres from coconut pud, palm stem and palm frond in erosion control on embankments. It compared single layer performance of the three fibres on three different slopes and a double layer performance of the coconut fibre. Two coconut fibre nets and a single net each for the palm stem and palm frond were used with a cell dimension of 2cm x 2cm and a boundary dimension of 360cm x 122cm. The fibres were in turn placed over a model of soil embankment in a soil bin. Rain was simulated for 30 minutes over the protected soil and the amount of soil loss determined. This soil loss was compared to the loss from the unprotected slope. The single and double layered coconut fibre were found to be more effective in reducing soil loss compared with the control experiment and fibres from palm frond and palm stem. For instance, for a slope of 3%, the soil loss from the single and double layered coconut fibres were 279.4g and 204.3, respectively, compared to 1051.6g, 322.80g and 310.60g for the unprotected soil, the palm stem fibre and palm frond fibre, respectively.

keywords: Coconut, palm frond, palm stem fibres, erosion control, embankments.

INTRODUCTION

Soil erosion involves the removal of soil by such natural agents as rainfall and wind. Erosion due to water is caused by raindrops of high kinetic energy striking the bare soil surface and loosening the bonds between the soil particles. Water in excess of the soils infiltration capacity runs down the slope and carries with it these detached particles.

Fullen and Brandsma (1995) reported that failure to control erosion on susceptible soils could have serious implications for long term soil fertility. They also reported positive associations between erosion rates and soil texture change. Biot and Lu (1995) found that yields were reduced by up to 45% on desurfaced experimental plots, indicating the potential long term impact of an eroded top soil.

Minimizing soil losses by erosion will not only safeguard soil fertility on susceptible sites but will help to reduce the off-farm impacts of agriculture, e.g., deposition on roads, silting of reservoirs and estuaries and the transport of agrochemical to surface waters (Withers and Jarvis, 1998).

Control of surface erosion on slope of embankments can be achieved by the use of geotextiles/geofibres. There is a wide range of geofibre/geotextile materials available ranging from biodegradable ones made of natural fibres from straw, coconut, raffia palm leaf and trunk, etc., to permanent ones made of synthetic materials which do not degrade when embedded in the soil.

These materials, however, are very effective in controlling erosion but they are presently imported. To import such materials here in Nigeria will involve a lot of foreign exchange and cost. Hence, the need for an extensive study to evolve similar materials that can be sourced locally and effectively control erosion like the ones obtainable overseas. Thus, the research into the use of local fibres.

MATERIALS AND METHODS

Three local fibres namely: coconut, palm frond and palm stem and a sandy soil collected from the premises of Federal University of Technology, Owerri were used for the study.

A number of preliminary laboratory soil tests were carried out on the soil sample used and this include:

- Grain size analysis for soil classification using the mechanical sieve shaker
- Shear strength test using the torvane
- Permeability test using the constant head permeameter.

The physical model used for the study include a rainfall simulator and the soil bin. The simulator has a single nozzle with serial no. 461.008.17GG and a floor area of $15m^2$. The height of simulator was 3.37m and the intensity of rainfall was 100mm/hr. It simulated raindrop sizes ranging from 1.5 to 5.0mm. The rectangular soil bin was used to collect the discharge or rainfall splash from the simulator and to exercise control over the effect of rain drops on the soil. The dimensions of the bin are 3.60m x 0.61m x 1.30m and made of metal sheets perforated all through the base.

The soil bin collector together with the soil loss collector were carefully put in place under the simulator framework. The base of the soil bin was overlain with filter cloth material to prevent soil loss through the perforations. The soil was then packed into the bin and compacted at eight runs of the roller compactor. The slopes at which the control test (bare soil surface) was carried out were 3, 6 and 9%.

The control test was carried out using the bare soil surface. Rainfall was simulated over the whole system for 30 minutes. The soil loss was collected, oven dried, weighed and recorded. The procedure was repeated for the different slopes in use.

The second test carried out was with the fibre nets. First with a single layer of each fibre type and then with a double layer of the coconut fibre net. The net(s) was/were used to cover the surface of the soil in the bin and was pegged down with pieces of stick to ensure firm contact with the soil surface. Rainfall was simulated over the whole system for 30 minutes. The soil loss was collected, oven dried, weighed and recorded. The procedure was repeated thrice for the different slopes and the different test materials.

RESULTS

The preliminary soil analysis result showed that the soil sample contained 96.06% sand and 3.94% silt and is therefore a sandy soil. The hydraulic conductivity of the soil sample was found to be 0.013cm/s whilst its *in situ* shear strength was determined to be

3.9kN/m2.

The tensile strength for the coconut, palm frond and palm stem fibres from tests conducted were 2.06x10⁹, 1.81x10⁹ and 1.43 x 10⁹N/m2, respectively.

The soil loss and the V_m factor are as shown in Table 1. The V_m factor is a ratio of soil loss from protected slope to that from unprotected slope. The lower the V_m factor, the more effective the material is for controlling soil loss.

Table 1: Soil loss, slope, percentage reduction and the v_m Factor

Material	Slope (%)	Soil Loss (g)	Soil Loss Reduction (%)	V_m Factor
Palm Stem Fibre	3	322.80	69.30	0.31
	6	640.30	66.09	0.34
	9	953.10	63.84	0.36
Palm Frond Fibre	3	310.60	70.46	0.30
	6	615.80	67.39	0.33
	9	940.70	64.31	0.36
Coconut Fibre (Single Layer)	3	279.00	73.47	0.27
	6	553.40	70.69	0.29
	9	886.20	66.38	0.34
Coconut Fibre (Double Layer)	3	204.30	80.57	0.19
	6	454.30	75.94	0.24
	9	767.50	70.88	0.29
Control (Bare Soil)	3	1051.60		
	6	1888.10		
	9	2635.70		

Table 2: Load, extension, tensile strain/strength for coconut fibre

Load (g)	Extension (cm)	Tensile Strain	Tensile Strength (N/m2)
148.40	0.20	0.0073	7.41×10^8
218.50	0.30	0.0109	1.09×10^9
294.40	0.40	0.0145	1.47×10^9
70.10	0.60	0.0218	1.85×10^9
412.20	0.80	0.0291	2.06×10^9

Table 3: Load, extension, tensile strain / strength for palm Frond fibre

Load (g)	Extension (cm)	Tensile Strain	Tensile Strength (N/m²)
148.40	0.10	0.0036	7.41 x 10^8
210.20	0.15	0.0054	1.05 x 10^9
286.10	0.20	0.0071	1.42 x 10^9
361.90	0.35	0.0125	1.81 x 10^9

Table 4: Load, extension, tensile strain / strength for palm stem fibre

Load (g)	Extension (cm)	Tensile Strain	Tensile Strength (N/m²)
145.00	0.10	0.0036	7.28 x 10^8
216.20	0.20	0.0071	1.08 X 10^9
286.40	0.35	0.0125	1.43 X 10^9

Table 5: Area, diameter and length of each fibre

Fibre	Length of Fibre (m)	Diameter of fibre (m)	Area of fibre (m²)
Coconut	0.275	5 x 10^{-5}	1.0 x 10^{-9}
Palm Stem	0.280	5 x 10^{-5}	1.0 x 10^{-9}
Palm Frond	0.280	5 x 10^{-5}	1.0 x 10^{-9}

DISCUSSION

The coconut fibre material showed a considerable reduction in soil loss compared with the control test as well as fibres from palm frond and stem as can be attested to in Table 1. The least soil loss occurred at a slope of 3% and the maximum at a slope of 9%. It can be said that the slope of the soil surface increases the velocity of runoff which in turn washes away more soil as the runoff flows through the soil surface. However, the amount of soil loss from each fibre compared to the bare soil surface was less. This was attributable to the fact that the velocity of runoff on the fibre laid on soil surface offered more resistance to the runoff compared to bare surface. Coconut fibre offered the highest resistance to runoff compared to the other fibres.

Another factor to buttress the fact that the coconut fibre was more effective in control-

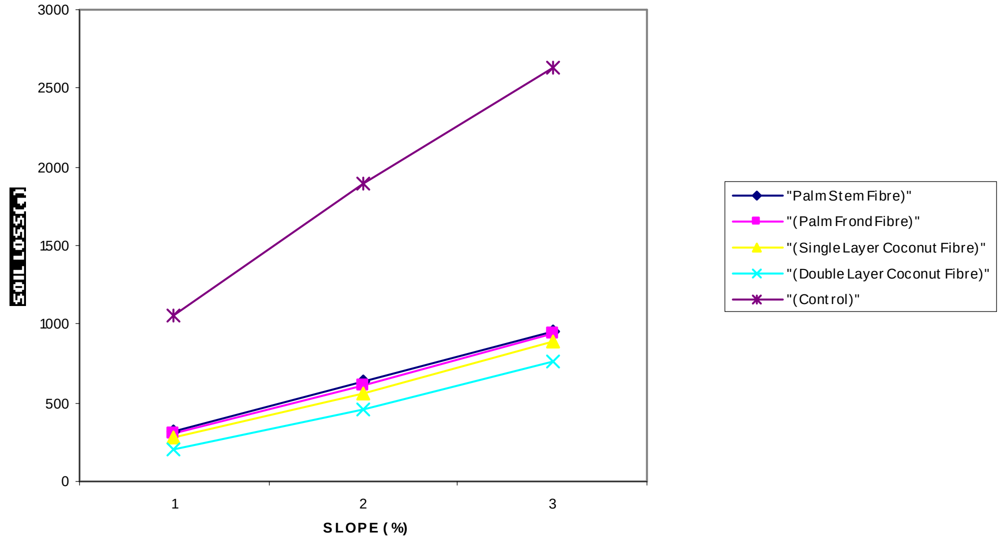

FIGURE 1: RELATIONSHIP BETWEEN SOIL LOSS AND SLOPE

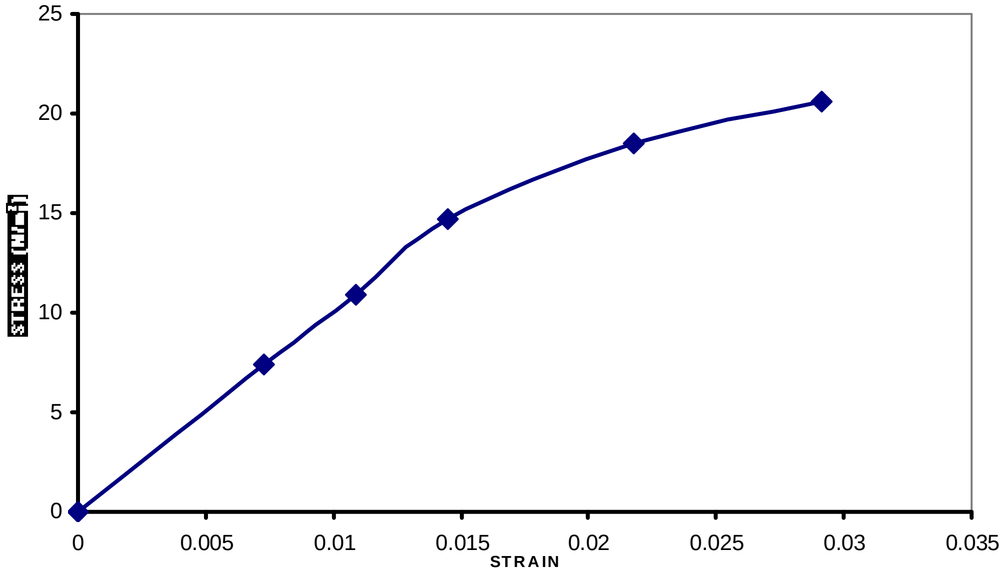

FIGURE 2: TENSILE STRESS AGAINST TENSILE STRAIN FOR COCONUT FIBRE

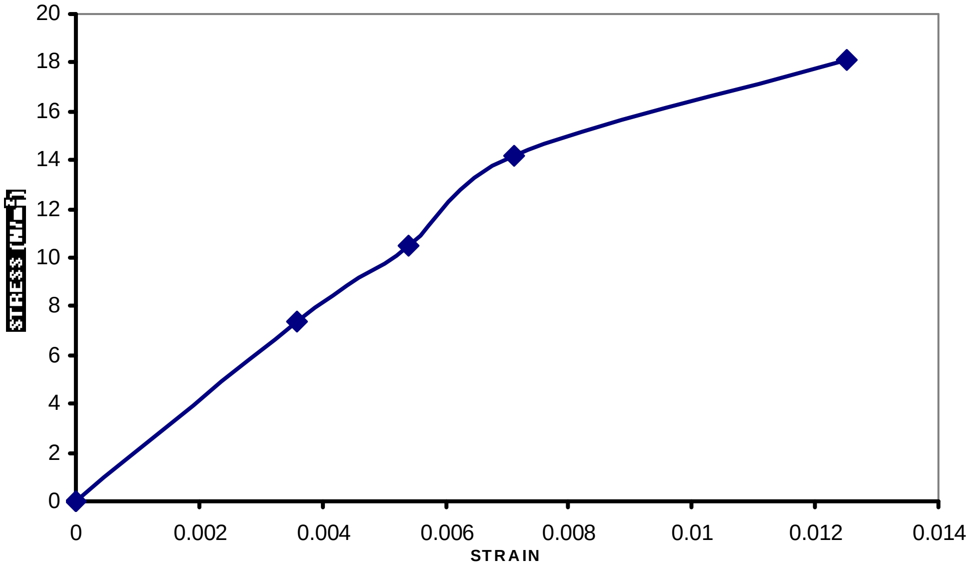

FIGURE 3: TENSILE STRESS VS TENSILE STRAIN FOR PALM FROND FIBRE

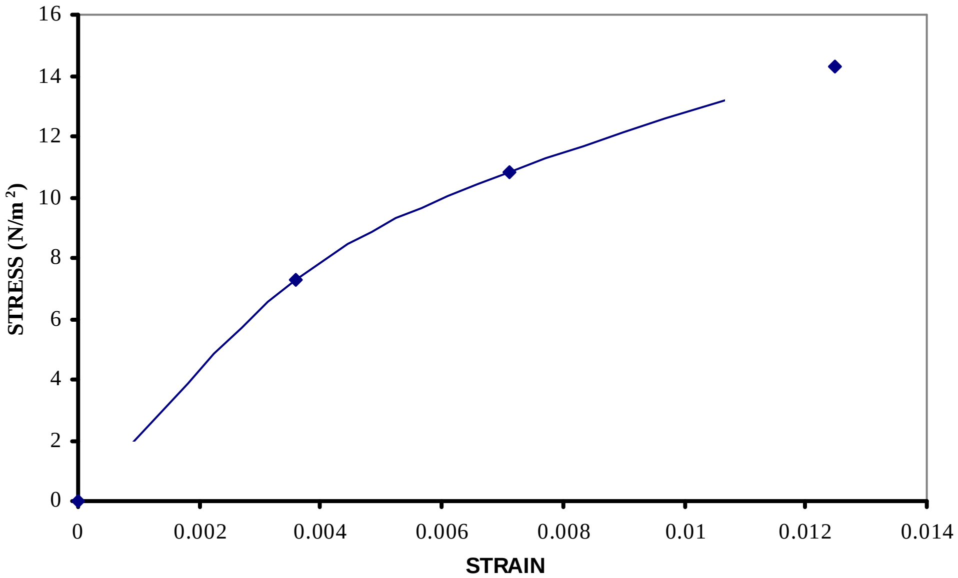

FIGURE 4: TENSILE STRESS VS TENSILE STRAIN FOR PALM STEM FIBRE

ling the amount of soil loss compared to fibres from the palm stem and frond is the V_M factor. The lower the V_M factor, the more effective the material is for controlling soil loss thus showing that the coconut fibre is a more effective material since its V_M factor is lower compared to the other fibres.

The coconut fibre had a higher tensile strength and yield stress of 2.06 x 10^9 and 1.76 x $10^9 N/m^2$, respectively, compared to 1.81 x 10^9 and 1.66 x 10^9 N/m^2, respectively for palm frond fibre and 1.43 x 10^9 and 1.27 x $10^9 N/m^2$, respectively, for palm stem fibre, this explains why it is more elastic and has a higher resistance to both water and mechanical wear and, thus, higher longetivity.

CONCLUSION AND RECOMMENDATIONS

Conclusion

The following conclusion was reached in this study:

The coconut fibre showed a considerable reduction in soil loss compared to palm frond and palm stem fibres. For a minimum soil slope of 3%, the soil loss from the coconut fibre was 289.50g and that from palm stem and frond fibres were 322.80 and 310.60g, respectively. Similarly, for a maximum slope of 9%, the soil loss was 896.20g for the coconut fibre and 953.10 and 940.70g, respectively, for palm stem and frond fibre.

The double layered coconut fibre was found to be most effective in erosion control. At a soil slope of 3%, the soil loss from the double and single layered coconut fibre was 249 and 289.4g, respectively, whilst for a slope of 9%, the soil loss was 812.50 and 896.20g, respectively.

The soil slope is a very important factor that must be reduced for effective control of erosion.

The mechanical qualities of the coconut fibre make it less prone to early decay. Thus, a reasonable life span is an added advantage for use in erosion control works.

RECOMMENDATIONS

Coconut fibres are elastic, resistant to both water and mechanical wear and thus highly recommended for use in erosion control works.

For effective erosion control, more than one layer of the fibre net should be used.

The best erosion control scheme has to be one that minimizes cost and also provides optimum performance and safety.

REFERENCES

Biot, Y., Lu. 1995. Loss of Yield caused by Soil Erosion on Sandy Soil in UK. *Soil use and Management Journal,* 11:157 – 162.

Fullen, M.A., Brandsma, R.T. 1995. Property Changes by Erosion of Loamy Sand Soils in East Shropshire, U. K. *Soil Technology Journal,* 8 : 1 – 15.

Withers, D.J.A., Jarvis, S.C. 1998. Mitigation Options for Diffuse Phosphorus Loss to Water. *Soil use and Management Journal*, 14 : 186 – 192.

(Manuscript received: 24th July, 2008; accepted: 2nd June, 2009).