Performances of Erosion Control Blanket Made From Palm Fiber On Reducing Erosion In The Slopes Of Lake Limboto Basin

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Abstract. Lake Limboto is one of the key lakes with severe siltation, caused by sediment delivered by river currents. This study aims to reduce the impact of sedimentation by controlling erosion with a palm fiber net with mesh dimensions of 5 cm x 5 cm and a thickness of 5 mm. The Palm fibre installation is installed on slopes with erosion potential; each location has a different slope: location 1 has a slope of 40o, location 2 has a slope of 45°, and location 3 has a slope of 50°. With the findings obtained, palm fiber nets erosion control was shown to be effective in repelling erosion. The first site has an 8:3 ratio, the second location has a 5:2 ratio, and the third place has a 1:0.5 ratio, net performance at each location of 42% location 1, 39% location 2, 41% location 3 and 0% at location 4. Differences in soil structure and slope of the slope generate variations in the data acquired from each location.

1 Introduction

Lake Limboto is a lake located in the nearby of Limboto city, Telaga biru district, Batudaa district and Gorontalo city of Gorontalo Province, Indonesia. The depth of this lake ranges from 5 to 8 meters. Guests and visitors may enjoy activities such as fishing, boating contests, and swimming at this lake. This lake is the location of the estuary of 23 rivers and serves as a flood control, fresh water source, flora and fauna habitat, mode of transit, recreation, and sports venue [1]. According to the Ministry of Public Works and Public Housing's PUPR Publication (2017) [2]. Limboto Lake is one of the key lakes with significant siltation, the immediate response needed for restoration measures. Lake Limboto, has a great potential to be one Geosite of aspiring Gorontalo geopark [3, 4], would disappear if the siltation process is not soon reversed.

Siltation of the lake floor caused by erosion and sedimentation from agricultural activities and illegal logging operations in the forest upstream of Lake Limboto, which is intended to serve as a catchment region.

Fig. 1. Limboto lake map showing the location is mainly in Telaga, Batudaa and Kota barat district (a). The photograph of Limboto lake from hills in Dembe village of Kota barat district of Gorontalo city showing the rapid siltation takes place.

As of 1991, the lake has narrowed by about 4,000 hectares, from an original extent of 7,000 hectares to 3,644.5 hectares, and is still declining in 2017, with the lake area barely reaching 2,639 hectares [5]. This shrinking process is further supported by the findings of [6], who discovered that the shrinkage of Limboto lake is driven by sedimentation causes and the withdrawal of land from the northern side of Sulawesi.

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Based on the results of analysis from [7], from 12 rivers upstream of Lake Limboto, Sub-watershed sequence with the largest sediment carrying potential to Limboto watershed is: Batulayar as much as 193,662 m^3, Biyonga Boluta as much as 123,095 m^3, Alo1 as much as 120,273 m^3, Also as much as 115,204 m^3, Molamahu as much as 73,058 m^3, Marisa as much as 57,075 m^3, Pulubala as much as 53,445 m^3, Pone as much as 40,254 m^3, Molamahu1 as much as 39,585 m^3, Pilolalenga as much as 32,306 m^3, Talumelito as much as 32,247 m^3, Pulubala2 as much as 31,267 m^3, Tuladengi as much as 28,908 m^3, Pone1 as much as 27,306 m^3, Payunga as much as 26,746 m^3, Biyonga boluta1 as much as 25,895 m^3, Pilolalenga1 as much as 21,841 m^3, Tabongo as much as 20,151 m^3, Pulubala1 as much as 17,741 m^3, and Tabongo1 as much as 11,031 m^3.

Sedimentation and eutrophication in Lake Limboto are caused by the activities of communities around Lake Limboto in the utilization of lake resources such as fish catching devices and fish farming activities in floating net cages [8]. Seeing the deteriorating condition of Lake Limboto, the Ministry of Environment designated Lake Limboto as one of the critical lakes in Indonesia due to sedimentation and eutrophication (4) .

Table 1. Rivers and their sediment carrying potential.

River	Volume (m^3)	River	Volume (m^3)
Batulayar	193,662	Pulubala	53,445
Biyonga Boluta	123,095	Pone	40,254
Alo1	120,273	Molamahu 1	39,585
Alo	115,204	Pilolalenga	32,306
Molamahu	73,058	Talumelito	32,247
Marisa	57,075	Pulubala2	31,267

Palm fibre (Dunula) nets are nets made from palm leaf slings, usually made like tennis nets, or customized as needed. The utilization of palm fibre nets is expected to be an alternative way to reduce erosion and sedimentation in the Lake Limboto area. The purpose of this research is to calculate the strength of the palm fibre net to reduce erosion on slopes and riverbanks in the Lake Limboto area.

2 Methods

The main material that will be used is the palm fiber net, with a mesh size of 5 cm x 5 cm, and a thickness of 5 mm (shown in Fig. 3). The fiber net was produced in Tulabolo village of Bonebolango regency Gorontalo with mesh design provided.

Palm trees grow a lot and are scattered in the Gorontalo province, so the procurement of this material is quite easy, there are even people who have sold this fiber rope in the traditional market.

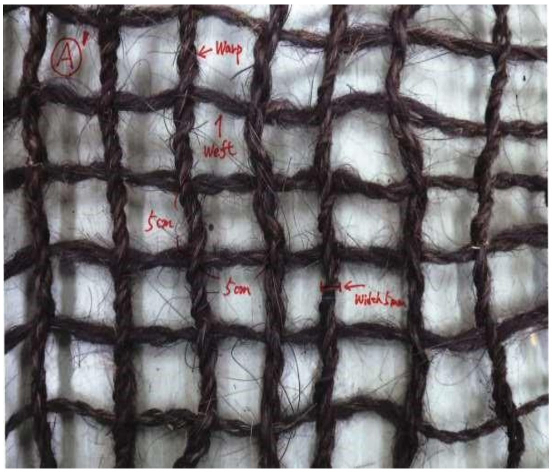

Fig. 2. Examples of dunula nets (fiber) with mesh dimensions of 5cm x 5cm, and 5mm thick.

There are many ways that can be used in making a net, in this dunula net we use type C (Fig**.** ure 3, and 4). This method is considered very effective in the defense of the net when applied to the oblique plane, because the fiber rope is woven and bind to each other so that the net will not easily shrink.

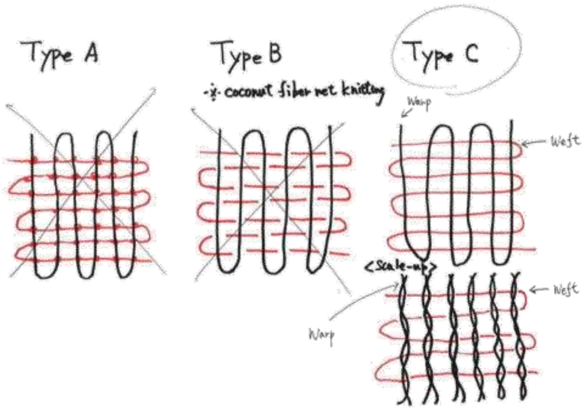

Fig. 3. Commonly used web binding methods.

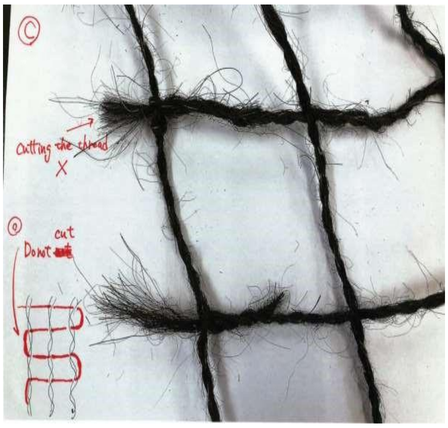

Fig. 4. In this dunula net, the rope on the side of the net will not be cut.

The installation of nets will be carried out on cliffs or riverbanks that flow to Limboto lake, namely: Alopohu River and Bionga River. These two rivers are the most sediment supply rivers among other rivers.

An observation station installation nets are first cleared of the grass so that the soil is exposed to the surface. The station will consist of two different parts, the other part will be fitted with netting while the other part will be left without a net, at the base each will be placed a sediment container (Fig. 5). This is so that we can compare data in the analysis process.

The main parameters that will be considered in this activity are:

1. Time / Length of experiment
2. Weather (Scorching heat and rain)
3. Slope
4. Soil type
5. Vegetation
6. Erosion rate
7. Net durability (quality)

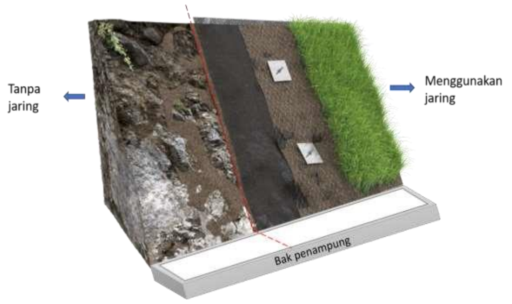

Fig. 5. Illustration of dunula net installation at the observation station.

3 Results and Discussions

Pressure from rainwater causes the release of soil particles then soil starches that are detached from the structure will be transported by the water. This process will be minimized because of the presence of nets as a retainer but there are still soil particles that escape and accommodate in the container box. While in other parts that do not have a net, soil particles transported by water will derail without retaining so that sedimentation in the part without nets will be more accommodated by the tank.

Fig. 6 . Sediment stuck in nets.

Fig.7. Sediment on the tank.

When retrieving data, the sediment is collected and measured using a bucket with a volume of 3,700 cm^2 (Fig. 7). The data retrieval process is carried out at a time starting from August 22, the sediment reservoir is emptied, and the next sediment collection and measurement is carried out on September 6, 2021.

Table 2. Data retrieval dates and locations

Part	10 Aug. 2021			22 Sept. 2021			06 Oct. 2021		
	Location			Location			Location		
	1	2	3	1	2	3	1	2	3
Net	5.5			6			8	15	1
No Net	3.5			2			3	6	0.5

Data is captured over the past three months to measure the palm fiber net's ability to reduce erosion under certain soil conditions. Data retrieval results are provided in the form of a graph of the volume of the soil against the time of data retrieval. Four locations were chosen as data capture places because they have a steep level of ground slope. Rainfall data is taken every month through Gorontalo Regency BMKG to measure the effect of rainfall on the volume of erosion produced.

Table 3. Data retrieval results

		August (Liter)	September (Liter)	October (Liter)
Location 1	Net	21.175	19.25	28.23
	No Net	44.275	46.2	71.87
Location 2	Net	0	30.8	24.38
	No Net	0	84.7	56.47
Location 3	Net	0	3.2	0
	No Net	0	7.7	0
Location 4	Net	0	0	0
	No Net	0	0	0

$$\frac{V_0}{V_d} \times 100\% = NF \qquad (1)$$

Data retrieval begins in August and ends in October. Soil erosion data can be seen in Table . In August location 1 has a high erosion rate when compared to other locations where there is still no erosion.

Weather conditions have a significant influence on the erosion process in these locations. Dry soil conditions at locations 2 to 4 make this region still not experiencing erosion. September is the beginning of long rains in Gorontalo Regency. Soil affected by rain will easily landslides as shown in the data. There is an increase in the amount of erosion in various net installation sites except at location 4.

In October, erosion conditions began to subside at location 3 and location 2. In the data collection of erosion over the last three months, location 1 has the highest erosion rate compared to other locations that occur every month followed by location 2 which only experienced erosion in September and October. Location 4 has the best conditions because it has never experienced erosion during three months of data retrieval. Things that affect the level of erosion of a location include the type of soil, and the condition of vegetation in each location. At location 4 and location 3, there is a dense enough vegetation area that lowers erosion rates and even prevents erosion in the region. High erosion rates at locations 1 and 2 can be caused by dry and sandy soil types as well as a lack of vegetation around the region.

Palm fibre nets have a significant influence on reducing erosion rates in locations that are prone to erosion. In August, location 1 had an erosion of 44 Liters which was reduced to 21 Liters with the installation of palm fibre nets. In the face of the rainy season precisely in September-October, palm fibre Nets can work optimally in reducing erosion rates with a reduction difference of 26 Liters at location 1 from the first 46 Liters, 53 Liters at location 2 from the first 84 Liters, 4 Liters at location 3 from the first 7 Liters. The performance of palm fibre nets can be affected by various aspects, ranging from soil type, slope of soil, to the process of installing palm fibre nets themselves. From the results obtained, it can be calculated the performance factor of palm fibre nets by:

$$\frac{V_0}{V_d} \times 100\% = NF \qquad (2)$$

V_0 = Soil volume without palm fiber net.
V_d = Soil volume with palm fiber net.
NF = Nets performance factor.

Based on the results of calculations of palm fiber net performance in reducing erosion, NF values range from 39%-42% which means palm fiber nets are able to reduce erosion rates between 39%-42% in the event of erosion (See Table 6). This value is obtained in soil types that have a density of 1382 kg/m^3 in dry conditions and 1592 kg/m^3 in wet conditions. Density values are obtained from the measurement and flattening of all soil samples at each location. Soil density values can affect the NF performance of the palm fiber net, so it is worth considering.

Table 4. Palm fiber nets installation location properties.

Property		Location			
		1	2	3	4
Slope of the Ground					
Density of Soil (kg/m³)	Dry Soil	1382	1382	1382	1382
	Wet Soil	1592	1592	1592	1592
Rainfall (milimeter)[1]	August	92	92	92	92
	September	237	237	237	237
	October	276	276	276	276
Palm fibre Net Performance (NF)		42%	39%	41%	0

[1]BMKG Gorontalo Regency, Indonesia [10]

4 Conclusion

Palm fibre nets provide cover for bare soil while also being used as a medium of vegetation (usually grass) as long-term erosion protection. Palm fibre nets function by protecting vacant land and dominant areas against rain and wind, providing a dense matrix of biodegradable materials that stabilize and support emerging vegetation and then decompose to further help improve plant quality. These nets also help increase precipitation infiltration and reduce soil crust and increase compaction. Palm fibre nets are designed and made of palm fiber ropes which is abundant in Gorontalo. From the results of the analysis conducted, palm fibre nets have a high performance in reducing erosion rates even in rainy season with a value that is close to 42% of the amount of erosion without the use of palm fibre nets.

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