ISSN 1880-7682
Volume 10, No. 3 **June 2012**

ISME/GLOMIS Electronic Journal

An electronic journal dedicated to enhance public awareness on the importance of mangrove ecosystems

Shoreline retreat of a degrading mangrove forest in Sungai Besar, Selangor, Malaysia

Introduction

Coastal erosion of muddy shores has become a serious problem threatening mangrove forests, agricultural crops, settlements and aquaculture ponds. The National Coastal Erosion study in 1986 alerted that 29% of the Malaysian coastline was in various stages of retreat (Ghazali, 2006). The progressive degradation of mangrove forests and loss of land prompted new protective measures such as the installation of geotubes to act as barriers to ameliorate high intensity waves that erode the shoreline. Geotubes are high strength woven geotextile filled with slurry of sand and water (Fig. 1). In Sungai Haji Dorani (3°38'N, 101°01'E), Sungai Besar in Selangor, Malaysia, four units of geotubes were installed to reduce the impact of erosion and mangrove degradation. The objective of our study was to assess the effectiveness of these geotubes in reducing coastal erosion and protecting the remaining mangrove belt.

Fig. 1. One of the four geotubes in Sungai Haji Dorani

Monitoring of vegetation and erosion

Six (4 x 4 m) quadrats were set up in each plot to determine species composition. Data on tree genera and diameter were collected on a bimonthly basis. Only trees with measurable bole diameters at 1.3 m height were reported. Experimental plots were established, one with geotubes (T1) and the other without geotubes (T2). Each plot had a 50 m long baseline aligned parallel to the eroding shore. Plastic pipes (0.5 m in length) were implanted at 1 m intervals along the baseline. The pipes with 30 cm exposed were painted and they each served as pins for measuring the perpendicular distance of the eroding scarp on a bimonthly basis (Fig. 2).

Fig. 2. Measuring the eroding scarp from the baseline

Subtracted values from the previous measurements for each pin would give the rate of shoreline retreat. The mean distance for each pin was calculated from February 2008 to February 2010 to estimate of the rate of erosion. For this study, only 27 pins were accounted for due to severe sand accumulation in May 2008. The pins were not replaced to reduce errors of measuring the distance of the eroding scarp. The mean erosion (m) was the sum of erosion at each pin divided by the number of remaining pins and expressed as mean erosion rate (m/yr). Area eroded (ha) was calculated by multiplying remaining baseline length (27 m) with the mean erosion.

Results and discussion

The number of genera of trees in T1 (*Avicennia*, *Sonneratia* and *Bruguiera*) remained the same over the two-year period (Table 1). However, out of two genera trees found in T2 (*Avicennia* and *Bruguiera*) in the beginning of the study, only the *Avicennia* trees remained in the first year. In the second year, all trees were eroded away. In T1, the mean abundance of trees showed slight decline from 18 ± 3.0 to 16 ± 3.0 (11%) in 2009 and from 16 ± 3.0 to 14 ± 2.0 (22%) in 2010. Significant reduction in the mean abundance of trees was evident in T2, 64% in 2009 and 100% in 2010. Basal area showed slight increase from 0.11 m^2 to 0.13 m^2 in T1. Basal area declined significantly in T2, 46% in 2009 and 100% in 2010.

Retreat of the eroding scarp based on distance from the baseline in T1 (with geotubes) and in T2 (without geotubes) from 2008 to 2010 is shown in Fig. 3.

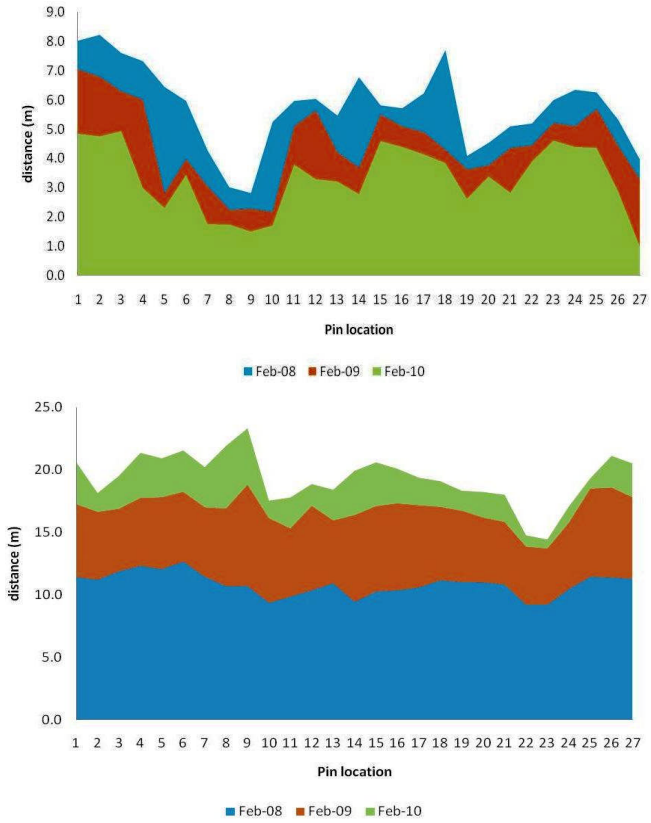

Fig. 3. Retreat of eroding scarp in T1 with geotubes (top) and in T2 without geotubes (bottom) from 2008 to 2010

In T1, the mean distance from the eroding scarp to the baseline significantly decreased by 35 m in 2009 and 31 m in 2010 (Table 2). However, the decrease was more pronounced in T2, 132 and in 2009 and 94 m in 2010. It was estimated that the mean erosion rate for T1 was between 1.1 and 1.3 m/yr and 3.5 to 4.9 m/yr for T2. Thus, the area of erosion was relatively higher in T2 (0.10 ha) than in T1 (0.03-0.04 ha). The loss of species, and declines in mean abundance and basal area in both plots were mainly due to severe erosion caused the scouring effect of the substrate and retreat of the eroding scarp. The uprooting and collapsing of trees was widespread in T2 (Fig. 4). Trees may have also succumbed to other environmental stresses such as increased salinity, wave tidal dynamics and wind effects that can degrade mangroves (Kathiresan, 2002).

Erosion can occur due to high intensity waves (Zamali, 1988), tree mortality (Ghazali, 2006) and sea-level rise (Wong, 2003). The average rate of retreat of shoreline in Malaysia was reported to be 1-8 m/yr (Zamali & Lee, 1995). Our results concur with Lee *et al*., (2010) who reported an erosion rate of 1.3 m/yr. During the monsoon months, waves of 2-3 m can batter the shoreline (Ghazali, 2006; Lee *et al*., 2010). Results of this study showed that the placement of geotubes may provide temporary protection of mangrove belt and stabilization of shorelines. Gradual deposition will allow stabilization and formation of soil aggregates for mangrove regeneration and improve the ecology of the coastal area (Hashim *et al*., 2010).

It is important to note that although geotubes do protect the shoreline from erosion to some extent, they can cause the adjacent areas to retreat (Gibeaut *et al*., 2003) and can create a ponding effect due to the alteration of wave patterns (Stanley & Lewis, 2009). However, a better understanding of the hydrological and substratum aspects of the study site is needed to assess the effects of geotubes in protecting eroding shoreline and the existing mangrove belt.

Fig. 4. Widespread uprooting and collapsing of trees in T2 (without geotubes)

Acknowledgements

The authors are grateful to the Mangrove and Associated Species Replanting of Coastal Shoreline Project for financial support and staff of the Soil Management Branch of Forest Research Institute Malaysia for assistance in this study.

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Table 1. Characteristics of the mangrove forest at Sungai Haji Dorani from 2008 to 2010

Mangrove forest	With geotubes (T1)			Without geotubes (T2)		
	Feb 08	Feb 09	Feb 10	Feb 08	Feb 09	Feb 10
Genera	A,B,S	A,B,S	A,B,S	A,B	A	–
Mean abundance	18 ± 3.0	16 ± 3.0	14 ± 2.0	8.3 ± 0.2	3.0 ± 0.4	–
Basal area (m^2)	0.11	0.12	0.13	0.11	0.06	–

A = *Avicennia*, B = *Bruguiera* and S = *Sonneratia*

Table 2. Erosion status of the mangrove forest at Sungai Haji Dorani from 2008 to 2010

Erosion status	With geotubes (T1)			Without geotubes (T2)		
	Feb 08	Feb 09	Feb 10	Feb 08	Feb 09	Feb 10
Mean distance (m)	156	121	90	293	161	67
Mean erosion (m)	15	3	12	11	17	14
Mean erosion rate (m/yr)	–	1.3	1.1	–	4.9	3.5
Area eroded (ha)	–	0.04	0.03	–	0.10	0.10