Soil physical changes of a coastal mudflat after wave breaker installation

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Abstract
A physical barrier made of woven geotextile materials and filled with sand was installed at Sungai Haji Dorani coastline to break wave energy and allow for mud stabilization. Four lines of erosion pins were installed to measure soil accreting level in both areas protected and not protected with geotube. Analysis of soil data collected revealed the fragility of this mudflat against wave direction and energy that brought about changes in mud composition and coastline erosion. Mud accretion was higher within the area protected by geotube, but reduced towards mid 2008. However, the area close to geotube facing landward did not experience erosion, most probably due to mud settlement underneath. There was change in soil profile with changing wave current.

Key Words
Mangrove forest, muddy soil, geotube, soil structure, *Avicennia*, *Rhizophora*.

Introduction
The aftermath of December 2004 tsunami that hit many countries in Asia including the west coast of Peninsular Malaysia, has sparked coastal rehabilitation programme at national and regional levels. The government of Malaysia, through the Ministry of Natural Resources and Environment has embarked on coastal planting programme with suitable tree species along the country coastline. Idle and degraded lands have been planted with suitable tree species aimed at creating a barrier to protect or lessen the impact from natural disaster. This planting programme covers variety of soil types but majority are mud and sand. One of the areas dedicated for research was the Sungai Haji Dorani coastline, within the proximity of Kuala Bernam Forest Reserve. The area was dominated by mud-flat of massive structure, and its shoreline was populated by *Avicennia* and *Brugeira* sp. and mixed species shrubs. This study was carried out to evaluate soil profile changes after geotube installation and the effect it has on the growth and survival of *Avicennia* and *Rhizophora* seedlings planted using three different techniques. Geotubes have been used in southeast Texas coast as temporary storm-surge protection and erosion-control structures (Gibeaut 2002).

Methods
Study Site
The experiment was established at a coastal mudflat in Kampung Sungai Haji Dorani (3° 38' N, 101° 01' E), adjacent to D'Muara Resort about 5 km from Sungai Besar town in Selangor. Annual rainfall, diurnal temperature and relative humidity are ~130 mm, 24–32°C, and 70–95%, respectively (Jeyanny *et al.* 2009).

Field experimental layout
Four sets of engineering structure made from woven geotextile material filled with sand were installed adjacent to each other in a row at 70 m distance from the shoreline. This structure was termed as geotube, installed to break wave energy hoping that in due course mud will stabilize within the area and newly planted seedlings survive better. Monitoring of changes in soil composition and mud accretion and erosion was carried out after the installation on routine basis. Graduated pins of 2 m length were placed at specified locations with initially 1.4 m submerged in mud and assumed as level 0. Placement of pins was illustrated in Figure 1. Soil accretion and erosion levels were measured on monthly basis, considering accreting when mud level at pin rose above 1.4 m and eroding if the level was below 1.4 m. The area without geotube installation was also measured as control. *Avicennia* dan *Rhizophora* seedlings were planted using various innovative planting techniques within the geotube area towards the land at six months after installation.

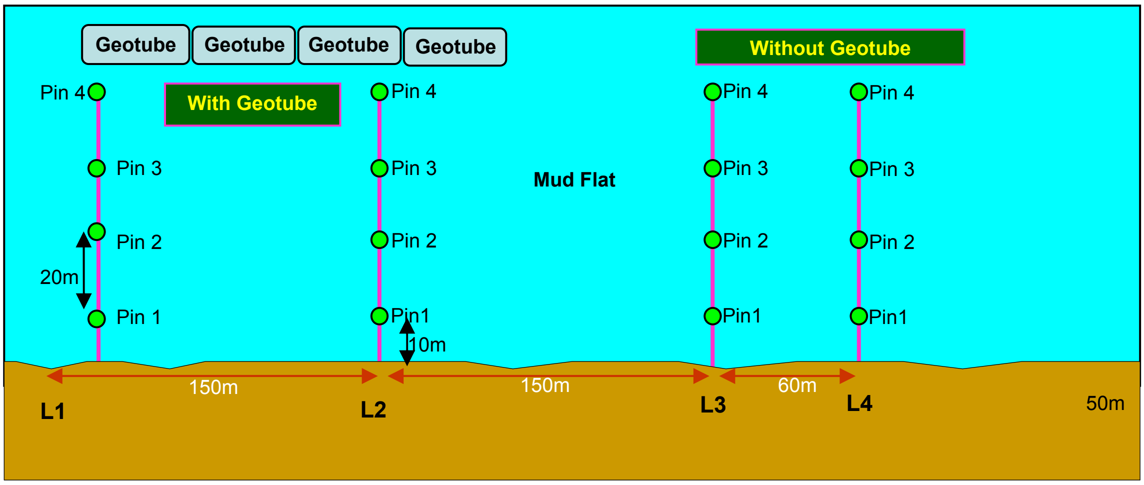

Figure 1. Location of measuring pins for monthly data collection on soil accretion and reduction. Land area (■) dominated by Avicennia and Brugeira, and sea area (■) where soils are exposed during low tide.

Data analysis

Data collected were treated individually and converted into graphical form.

Results

The area protected by geotube, which are presented by L1 & L2, showed an increase in sediment level consisting mixtures of mud, sand and broken shells from Julai 2007 to April 2008 (Figure 2). Highest sediment accretion recorded was 60 cm for Pin 1 at L1. Erosion started to take place gradually at Line 1 but rather drastic at Line 2. Accretion recur again close to the geotube area which were evident from the data collected at Pin 4 in Line 2. This was a good sign, showing the geotube was able to trap and settledown soil in the area and provide better soil environment for plants. At line 1, alternate erosion and accretion were recorded at all pins from May and September 2008. Change in wave energy could have caused wave turbulence at the edge of geotube and settlement of soil might have been disturbed.

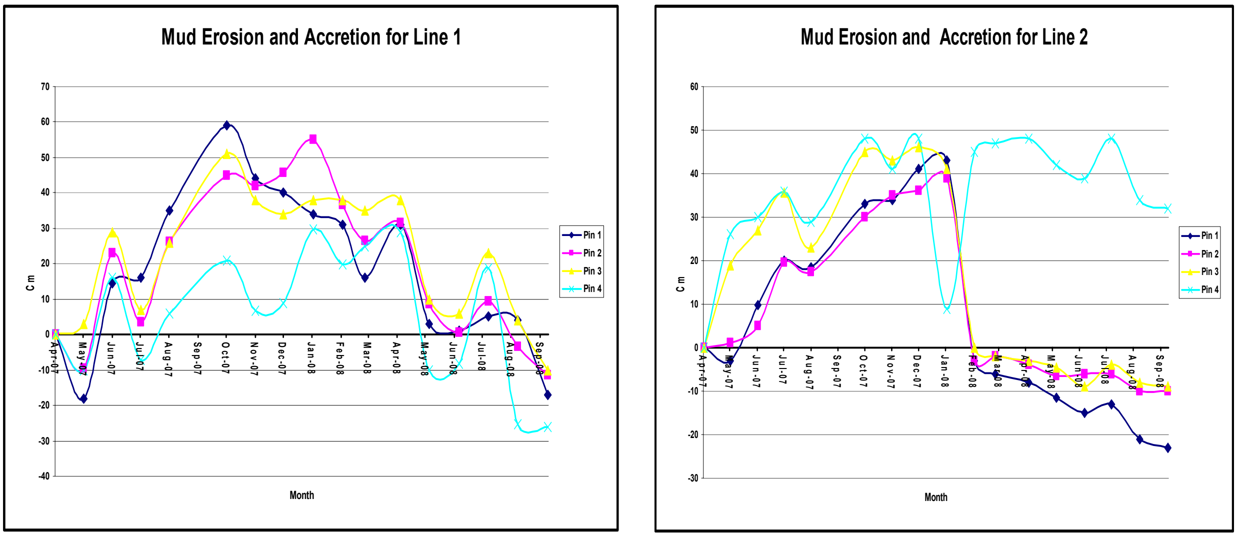

Figure 2. The trend in soil accretion and erosion (cm) within the mudflat area protected by geotube which was measured from April 2007 to September 2008.

In area without geotube protection measured at Line 3 and Line 4, less sediment accretion was recorded compared to the area with geotube. Only Pin 1 and Pin 2 showed accreting level while seaward area were experiencing decrease in sediment level throughout the measurement period (Figure 3). Highest sediment accretion recorded was 40 cm at Line 4 for Pins 1 dan 2. Severe soil erosion was recorded between Mei to September 2008. More than 40 cm soil was lost from Line 3 but at the same time there an accretion of nearly 40 cm at Line 4 at Pins 1 and 4. Changing wave pattern could have moved sediments in Line 3 to Line 4.

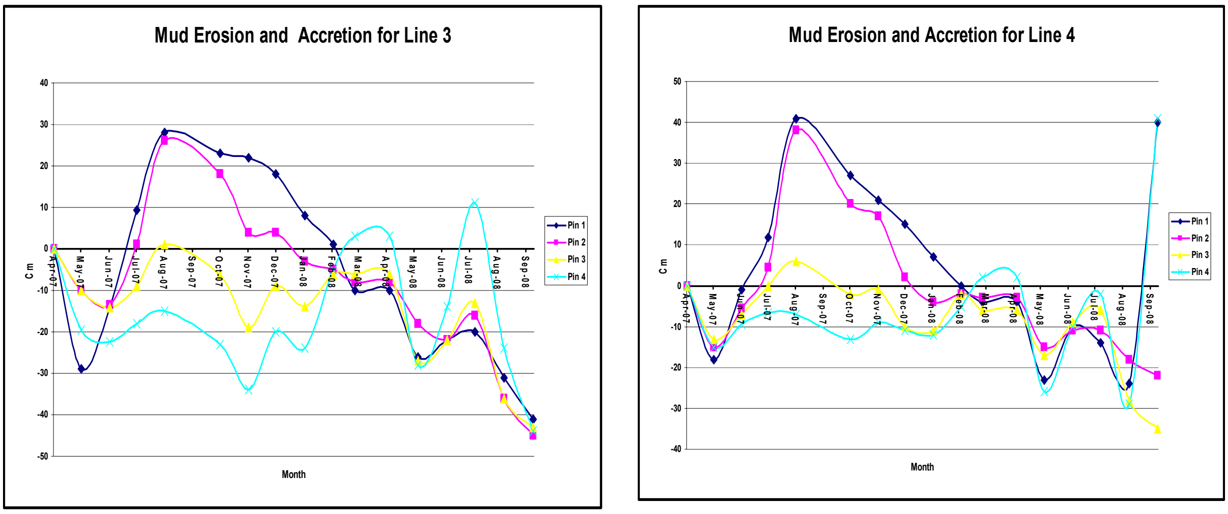

Figure 3. The trend in soil accretion and erosion (cm) within the mudflat area not protected by geotube which was measured from April 2007 to September 2008.

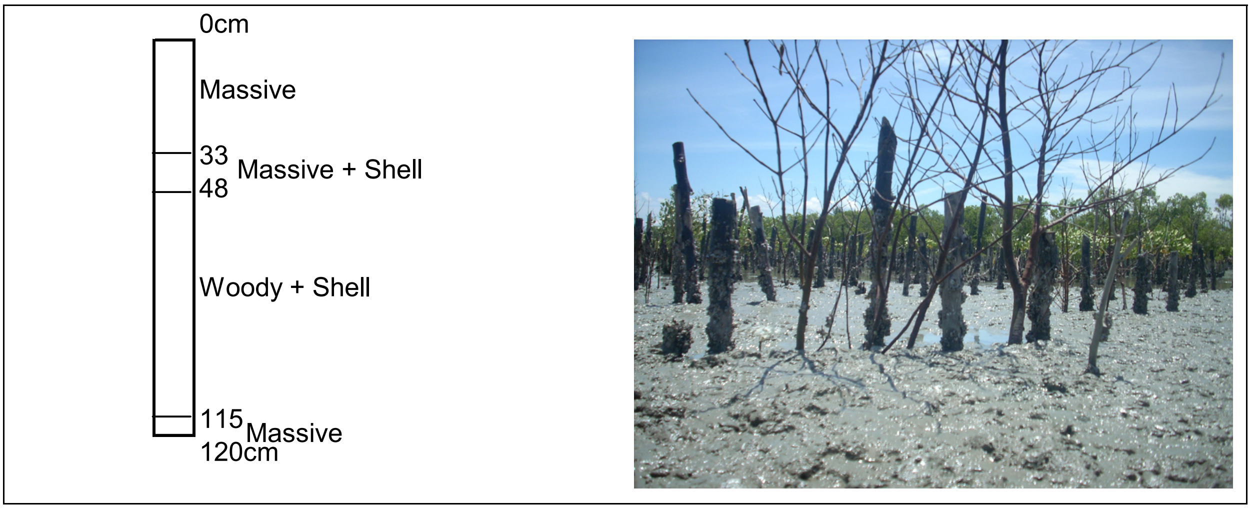

Figure 4. Soil profile description in mudflat area after wave-mud phenomenon in August 2009. The incidence caused drastic mud accretion and submerging pneumatophor roots causing death to *Avicennia* trees.

Alternate sand/shell and mud accretion brought about changes in species survivability. In August 2009, strong wave current brought along massive amount of mud leaving most of the area covered with mud for almost 33 cm (Figure 4). This led to sudden death of healthy *Avicennia* trees which were planted almost two years before. *Avicennia* could stand shallow mud level with sand/shell composition as long as its pneumatophor roots were visible (Wan Rasidah *et al.* 2008), unlike *Rhizophora* which prefers to sit on thicker mud. After one year of geotube installation, soil structure has yet to form and accretion level was higher at the area protected with geotube. Severe soil erosion occurred along the coast which was not protected by the wave breaker system. This erosion swiped along matured standing mangrove trees which were conserve for protecting the coastal area.

Conclusion

Geotube installation in fragile mudflat resulted in sedimentation and accreting level of sediment. However, the structure also led to sand movement and deposition which could disturbed growth of *Rhizophora*. This deposition was brought about by swirling wave after hitting the edge of geotube. Areas without geotube have lower soil accretion level.

References

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