VALUE OF MANGROVES IN COASTAL PROTECTION

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by

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Abstract

Nearly 30% of the coastline of Malaysia is undergoing erosion. Much of these areas are coastal mud-flats, fringed by mangroves. Behind the mangroves are usually agricultural areas that are protected by bunds from tidal inundation. These bunds are constructed by the Department of Irrigation and Drainage and it is the policy of the department to maintain a strip of mangroves between the bunds and the sea. Mangroves are knowned to reduce wave energy as waves travel through them. Thus, mangroves are used to protect the bunds from eroding. However, mangroves themselves are susceptible to erosion. Finding the best method in using this natural system in coastal protection is therefore important to the Department of Irrigation and Drainage. This paper look at the various methods of using the systems developed up to date.

1. Introduction

Mangroves occur along much of the west coast of Peninsular Malaysia. The sheltering effect of the island of Sumatra provides relatively calm sea in the Straits of Malacca if compared to the South China Sea that abuts the east coast of the peninsular. Rivers that discharges into the straits carries fine silt and mud into the straits. Due to the sheltering effect, the silt and mud get deposited along the coast building the alluvial plains that characteries much of the coastal areas of the west coast. On this fine silt and mud the mangroves find the necessary substrate to establish themselves.

Wave height along the west coast rarely exceed 1.5 metres. During the calm seasons the waves are usually below 1.0 meters. This provide excellent conditions for mangroves to take root.

Mangroves colonise the coastal mudflats in series of succession. The pioneer species, are the *Avicennia*. Their seeds drop from the trees and float in the water. During low tide, the seeds get lodged in the mud and the plants take root. In this manner, the trees can propagate further and further onto the mudflats.

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Inorder for the *Avicennia* to take root, the wave condition must be mild and the mud must be totally exposed for a certain time daily. For this reason, the trees are usually found above Mean Sea Level.

When the *Avicennia* have established themselves, the waves that breaks on the trees and the rising tide usually deposit debris and sediments behind the trees. This result in levees at the back of the trees. These levees restrict the ebb flow of the tide causing permanent pools of water. Fresh water from land and rain reduces the salinity of the water. Due to the constant inundation, the breathing roots of the *Avicennia* cannot take in oxigen and the trees cannot survive. New *Avicennia* trees also cannot take root as the seeds will remain floating in the water. In these conditions, the *Rhizophora* and the *Brugeria* species take over.

2. <u>DID Bunding Schemes</u>

As early as the 1950s until as late as the 1980s, the Department of Irrigation and Drainage were building bunds (earthen dykes) along the west coast within mangrove areas. The projects were implemented to create more agricultural lands by reclaiming the mangrove swamps. The criterion used in building the bunds was that there must be at least a 200 metres mangrove belt along the coast between the bunds and the sea to prevent the waves from damaging the bunds. This is because the bunds were contructed from earth and are susceptible to wave damage.

During the construction of the bund, a 200 metres width of mangrove belt was considered sufficient to reduce the wave energy such that the waves will not damage the bunds. Observations done in Sungai Besar, Selangor suggests that even a 50 metres wide belt of *Avicennia* is sufficient to reduce waves of 1 meter to a height less than 0.3 meter. Work done using a computer model provided by the consultants of the National Coastal Erosion Study 1986 suggests that 150 meters of mangrove width is needed to reduce the wave energy.

3. <u>Mechanism of Wave Attenuation</u>

Mangroves attenuate waves (reduce wave energy) by obstructing the waves with its roots and trunks. As a wave passes through the mangroves, the orbital motion of the water particles i.e. the mechanism transmitting the wave energy, is obstructed by the roots and the trunks of the mangroves. The closer the trees are together, the greater will be the attenuation of wave energy.

Mangroves need not be very old before they are significant as wave attenuators. As long as the trees are sufficiently close together and are as high as the in-coming wave, the trees will attenuate the waves. It has been observed that a 5 year new growth of *Avicennia* can already act as efficient wave attenuators.

4. Silt-trapping

Mangroves, especially *Avicennia*, with their roots systems, slow down the currents of the water that flows over over it. This water can be from two sources, i.e the tide and the fresh water discharge from the hinterland. The water usually carry sediments, in the form of suspended sediments and bed load. As the ability of water to carry sediments depends on the velocity of the flow, slowing the currents result in the sediments settling. In this way, the mangroves consolidate the soil and build up land.

5. Retarding Coastal Erosion

Erosion of the muddy coast usually starts with the lowering of the mud-flats infront of the mangroves. This cause the roots of the mangroves fringing the sea to be exposed. Eventually these trees collapse and the erosion continues further into the mangrove belt (Fig. 1).

The cause of the lowering of the mud-flats is still unknown. There are many possible reasons that can be accepted. Reduction of sediment contribution to the coast can be a factor. As the mud on the mud-flats is always in a dynamic state due to constant agitation by waves, the mud is always moving. When sediment contribution from the hinterland to the coast is reduced, there is not enough sediments to replenish the mud that is lost from the coast due to the waves.

Clay particles tend to flocculate in saline water. Thus, there is a greater tendency for clay particles to settle down in calm saline water than in fresh water. Reduction of wave action, maybe due to a series of calm seasons over a long period, can cause the clay particles to settle and thus build up the mud-flats. On the other hand, a series of extreme storms can cause erosion of the mud.

Observations along the west coast of Peninsular Malaysia suggests that mud-flats have a cycle of acretion and erosion. In one site, Sungai Burong, Pulau Pinang, this cycle is about 20 years. Mangroves have an important role to play in the acretion and erosion cycle of the muddy coast. The swamp, with its various species, act as a system in retarding erosion.

Avicennia are usually the first to topple when the mud-flat lowers. Erosion under the trees cause easily exposes the roots as the roots are extended along the surface, but do not penetrate deep in the mud. The soil under the trees is also soft, being newly formed, and is also susceptible to erosion.

As erosion propagates into the *Rhizophora* and *Brugeria* zones, the rate is slowed down. With their prop roots that grow deep into the mud, the *Rhizophora* and the *Brugeria* can anchor themselves in the soft clay and withstand the natural forces. The soils in this zone, having had more time to consolidate are also usually stronger.

Thus when the wave climate change and larger waves hit the coast, the mud-flats reduce in level and the *Avicennia* topple due to under scouring. However in the *Rhizophora* and the *Brugeria* zones, the combination of stronger soils and deep root system retards the erosion. When the next accretion cycle occurs, the *Avicennia* will colonise the mudflats again.

6. Damage of the System

In much of the west coast of the peninsular, the complete mangrove system has been damaged. Reclamation of the mangrove swamps for various development projects usually means the detruction of the *Rhizophora* and *Brugeria* zones. This is because these zones have stronger soils since the soil have had more time to consolidate,

Changes in drainage patterns can also affect the system. Reduction of sediment contribution to the coast due to these changes will result in coastal erosion. This reduction also means that there is no new build up of mud for the mangroves to colonise. Thus, in some cases, the coastline maybe under constant retreat.

7. Replanting of Mangroves

The Drainage and Irrigation Department had made several attempts at replanting of mangroves with varying degree of success. In the seventies, at Jeram, Tanjung Karang and Sungai Besar in Selangor, bamboo poles were split lengthwise and stuck into the mudflat. It was hoped that these bamboo poles would hold the mud-flat while the mangroves established themselves. There was success in some places but in most places the attempt result in failure. This was due to the mangroves being planted at a very low mud-flat level, making the daily inundation period by sea water too long and the wave action too strong.

where to plant

In Sungai Burong, Selangor, DID had a pilot project replanting 10 hectares of mangroves. 16,000 seedlings of *Rhizophora* were planted upon advise from FRIM. Although during the early years, the young mangroves suffer high mortality due to attacks by caterpillars, 20% of the trees survived and established themselves. *Avicennia* also colonised the area in time due to large stands of the species on both sides of the area. The seedlings were brought into the area by littoral currents and deposited in the area when the tide recedes.

The Sungai Burong experience reveals that;

a) *Avicennia* species grows well in tidal mudflats where the tidal flushing is most efficient, i.e. during low tide the mud is completely exposed, and there is no stagnant water. This condition usually occur at the fringe where the mangrove belt meets the sea.

b) Dunes of crushed shells and sand usually occur behind the *Avicennia* and prevent the water from draining completely. This make the area more suitable for *Rhizophora* species. The long seedlings of the *Rhizophora* can penetrate the soil when they drop and establish themselves and are also long enough not to be completely covered by water. *Avicennia* seedlings will remain afloat in this condition and will not be able to establish themselves. Furthermore, the breathing roots of the *Avicennia* wil always be covered by water and will not be able to take in air.

c) Planting a monocrop i.e. one species of mangroves will make the crop susceptible to pests and diseases. This is similar to a plantation problem where a certain pest can destroy large area of crop in one attack. The best way to avoid this problem is to diversify the species. There are over 50 species of mangroves to chose from and planting a mixture of species will give a better chance of the regenerated forest to survive.

8. Escarpment Protection

The Department of Irrigation and Drainage are also experimenting in a combination of artificial and natural method in coastal protection. The concept here is to protect the mangroves so that the mangroves can in turn protect the valuable agricultural line behind it. This method is called the escarpment protection and was first employed successfully at Sungai Burong, Sabak Bernam, Selangor to protect a stretch of 1.4 km of coastline (Fig. 2).

The soil underneath the mangrove forest is usually stronger than that of the deposited clay on the mudflat. Thus, when erosion occurs and the mudflat lowers, the soil develops a vertical face underneath the mangrove line. The vertical face ranges from 0.5 to 1.0 m. This face is called the escarpment.

Mangrove trees have always been regarded as a wave attenuator, reducing wave energy as the wave travel through the swamp. Due to this, many efforts to replant mangroves on eroding mud-flats have been tried inorder to arrest the erosion. However, mangroves cannot establish below Mean Sea Level (M.S.L). Since the levels of the eroded mudflats are generally below M.S.L., the efforts were not successful. Between M.S.L. and Mean High Water Spring (M.H.W.S.), mangroves grow very well and can provide adequate protection to the bund. The key is therefore to protect the soil beneath the mangroves, so that the trees will be able do to the rest of the work in reducing the wave energy. Thus, the escarpment protection concept was formulated.

The structure was constructed such that it will not have a detrimental effect on the mangrove ecosystem. The ebb flow must be able to go over the the structure freely so that there will be no stagnant pools developing behind the structure. This is because different mangrove species require different salinity and disturbing the ebb flow could effect the salinity regime.

The structure will protect the escarpment from erosion due to wave attack. Since the structure is low, wave will still penetrate during high tide. Mangrove trees will then act as a wave attenuator and prevent the wave energy from reaching the bund. This will therefore prevent the bund from being eroded. A mangrove belt of about 100 meters was provided as to act as a wave attenuator. This is considered sufficient to reduce the wave energy and protect the bund behind the belt.

A low structure has the advantage of being easily constructed. Building the structure on the escarpment will also avoid loading that would endanger the bund. Should there be any failure of the structure due to localised weak soil, there would be no immediate danger to the bund and flooding of agriculture land would not occur. The Drainage and Irrigation Department would have ample time to react to the failure before the bund is threatened.

Four years after construction, this method have been proven successful in Sungai Burong. The escarpment protection is preventing the soil underneath the mangroves from eroding and the mangroves are reducing the wave energy before the waves reach the bund. With the success of this method, this concept is being used along the adjacent coast to protect another 1.2 km of coastline.

9. Conclusions

Mangrove swamps are important in retarding coastal erosion and protecting the coast. The swamps act as a system in which trees in all the zones have different roles to play. Damage to the system can result in irriversible coastal erosion.

Mangrove replanting can be successful if the mangroves are planted in the right conditions. A lot failures can be attributed to mistakes such as planting on very low mud-flats and where the wave conditions are not favourable. Mono-cropping should be avoided to reduce damage due to pests. Here again, if the objective is to protect the coast, it is best to reestablish the system than just a certain species.

Where the lowering of the mud-flats is unavoidable and further retreat of mangroves is unacceptable, the escarpment protection is a feasible concept. This method is still cheaper than the conventional method of protection using revetments as it uses less material. It also has the added bonus of retaining the mangrove swamp that can serve as a habitat for the fauna that depends on the swamp.

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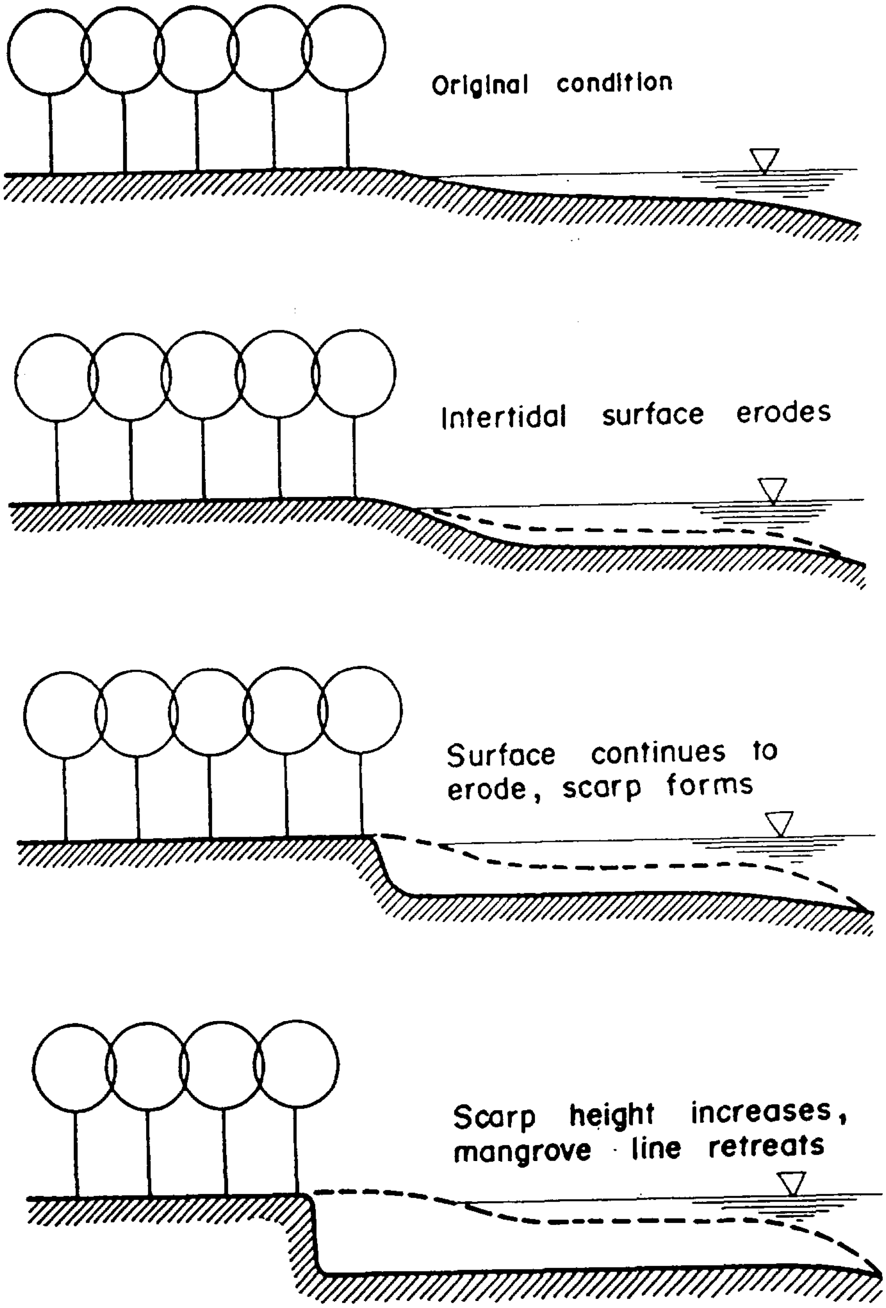

Fig. 1: Mangrove Retreat

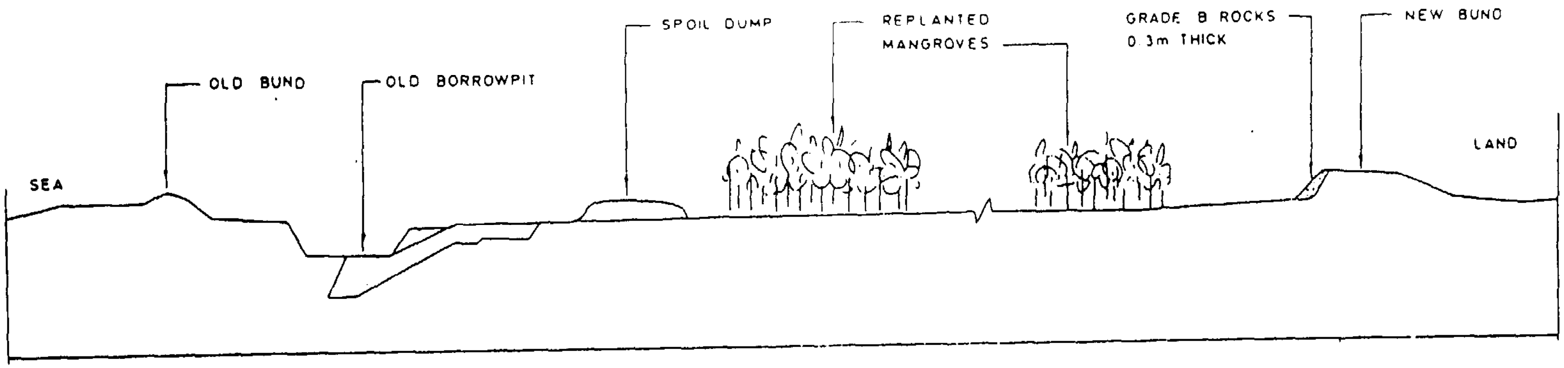

Fig. 2: Escarpment Protection