# Chapter 1

# Introduction

Mangroves are defined as woody trees and shrubs which flourish in mangrove habitats. Mangroves have a variety of means to adapt to any incoming uncertain environment. The principal mechanisms are exclusion of salt by the roots, tolerance of high tissue salt concentrations, and elimination of excess salt by secretion (Hogarth, 2007). The mangrove trees themselves, and the other inhabitants of the mangrove ecosystem, are adapted to their unpromising habitat, and can cope with periodic immersion and exposure by the tide, fluctuating salinity, low oxygen concentration in the water and being tropical-frequently high temperature (Spalding *et al*.,1997).

In general, mangrove forest is more threatened than other forests. As well as the normal disruptions that forests are prone to flood, cyclone and drought, the mangrove forest may have to contend with typhoons, coastal erosion, wildly fluctuating river discharge, and the tendency of delta channels to wander erratically to and fro. These fluctuations are superimposed on the predictable stresses of high salinity and soil anoxia, which also retard or reverse constant changes. Frequent changes, coupled with environmental stress, make it less likely that the succession of process will culminate in a recognizable climax community (Lugo, 1980).

In Peninsular Malaysia, the landward areas of many mangroves are reclaimed for agricultural purposes. Acid sulphate condition or seawater intrusions through neglect of bunds are some of the factors that motivate into some successful area (Ong & Gong, 1991). Malaysia's mangroves presently cover 577,558 ha, with 341,377 ha (59%) located in Sabah, 132,000 ha (23%) in Sarawak and 104,181 ha (18%) in the peninsular part of Malaysia ( Tan & Basiron, 2000; Table 1.1). The mangrove forests of peninsular Malaysia are mainly located on its west coast facing the Malacca Straits, while mangrove forests on its east coast facing the South China Sea are small and mainly restricted to river mouths (Chong, 2006).

The loss of mangrove forest could have immediate economic implication especially when the locals depend on the mangrove species as sources of timber or other economic activities. However, the greatest concern is the loss of mangrove environment which would have a whole range of effects and impacts, such a loss of fisheries, detritus, flora and fauna populations, and loss of shoreline. In Asia and Oceania, it has been estimated that 17 known species of plants and 15 known species of animals risk extinction as a result of various activities (Saenger, 1983).

Traditionally, the local populations depend a lot on the mangroves for its livelihood. Most of them live either on the landward edge as farmers or on the water's edge as fishermen. Timber is used for fuel, building material, pilings and fishing stakes.

Nipah or *Nypa fruticans*, provides leaves for thatching and cigarette papers, and the inflorescences can be tapped to produce sugar and alcohol.

The mangrove waterways provide abundant supply of much needed protein and cash in the form of fish, crabs, prawns and other shellfish (Ong & Gong, 1991).

In recent years, the increasing demand of land for aqua cultural, agricultural and industrial development has led to greater conversion and development of mangrove land. Impact studies on these conversion activities have never been critically conducted. Furthermore, the status and productivity of these projects have not been properly evaluated to justify such development. Therefore, it is imperative that the remaining forest resources be utilized and managed effectively to ensure maximum benefits on a long-term basis. The role of research and the mangrove forest should be given the right priority in relation to its many and various uses (Razani, 1982)

**Table: 1.1: Mangrove forest area and reserves in Malaysia; [a] = Tan & Basiron (2000); [b] = Chan et al., (1993); [c] = Ooi (1996).**

| Region | State | Total Length of Coasline (km)[c] | Gazetted Forest Reserve (ha)[a] | Stateland (ha)[a] | Total (ha)[a] | Density (ha) | Gazett-ed (ha km-[2])[b] |
|---|---|---|---|---|---|---|---|
| Peninsular Malaysia | Perlis | 20 | 0 | 20 | 20 | 1.0 | 0 |
| | Kedah | 148 | 7248 | 400 | 7648 | 51.7 | 11 |
| | Penang | 152 | 451 | 500 | 951 | 6.3 | 1 |
| | Perak | 230 | 43500 | 150 | 43650 | 189.8 | 21 |
| | Selangor | 213 | 15090 | 4500 | 19590 | 92.0 | 15 |
| | Negeri Sembilan | 58 | 454 | 200 | 654 | 11.3 | 3 |
| | Melaka | 73 | 166 | 100 | 266 | 3.6 | 2 |
| | Johor | 492 | 17832 | 6500 | 24322 | 49.5 | 10 |
| | Pahang | 271 | 2675 | 2000 | 4675 | 17.3 | 11 |
| | Terengganu | 244 | 1295 | 1000 | 2295 | 9.4 | 1 |
| | Kelantan | 71 | 0 | 100 | 100 | 1.4 | 0 |
| | Sarawak | 1035 | 73000 | 59000 | 132000 | 127.5 | 11 |
| East Malaysia | Sabah | 1743 | 328658 | 12719 | 341377 | 195.9 | 26 |
| | Labuan | 59 | 0 | 0 | 0 | 0.0 | 0 |
| | Total | 4809 | 490369 | 87189 | 577558 | 128.1 | 112 |

## Background of Study Area

This study was conducted at Carey Island, which is situated south of Port Klang in the state of Selangor. It is a huge island separated from the mainland by the Klang River and is connected by a bridge from Chondoi and Teluk Panglima Garang near Banting (Figure 1.1). Two sites were established, Site 1 contained good community of mangrove forest while Site 2 is a mixed-sandy mud degraded mangrove habitat. This study was carried out to determine variations in physical parameters at selected mangrove habitats between pure mangrove and degraded mangrove habitat.

## Objectives

1. To examine some water quality parameters, air physical factors and soil texture at a good and degraded mangrove sites in Carey Island.

2. To evaluate the effect of water quality parameters, air and soil texture properties on mangrove stands health and species adaptation.

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Study site located at Carey Island, Selangor.
Site 1 (N 02º54’26.4” and E 101º21’07.2”)
Site 2 (N 02º 49’26.4” and E 101º20’26.9”)

**Figure 1.1: Location of Study area (Site 1 and Site 2) of Carey Island.**

# Chapter 2

# Literature Review

## 2.1 Coastal Zone

The coastal zone of Malaysia has a special socio-economic and environmental significance. More than 70% of the population lives within the coastal area and a lot of economic activities such as urbanization, agriculture, recreation and eco-tourism, fisheries, aquaculture, oil and gas exploration are situated in the area.

With 4,800 km of coastline and a large percentage of population living within 5 km from it, demands of developments and industrialisation in these areas had made a very big impact on the resources and the coastline itself (Nor Hisham, 1999).

### 2.1.1 Malaysian Coastal zone

The shoreline along the Straits of Melaka is gradually growing westward as sediment is added to the coast by the series of small rivers that have their tributaries in the uplands of the Main Range. Strong, reversing tidal currents distribute the muddy sediment along the coast (Thia-Eng *et al.*, 1997). Submarine sandy shoals eventually build up until they are exposed to the rise and fall of the tides; then a system of tidal channels forms. These channels both confine the tidal flows and receive river discharge; thus they initiate the formation of estuaries. As a result of this process, the coastal lowlands have developed a characteristic environmental zonation that extends from the shoreline towards the hinterland.

A typical sequence is as follows: (1) Tidal Flats from the shoreline; they consist of fine-grained, often muddy, alternately exposed sand and wetted by the falling and rising tides; (2) Mangrove Swamp forest is at the back of the shoreline but above the high water mark; (3)Brackish Tidal Swamps forms a band landward of the mangroves and extends inland along the major rivers; (4) In many places, Freshwater Swamp are converted to oil palm plantations, occupies the lowlands between major streams. The lower parts of the main stream cuts channels into the hinterland surface as they flow toward the coastal lowlands (Nelson *et al*., 1982).

### 2.1.2 Wetland

Wetlands have often been described as being ecotones, which is transition zones between upland such as forests, farmlands and deepwater aquatic systems. Deepwater aquatic system includes rivers, lakes and estuaries. This niche in the landscape allows wetlands to function as organic exporters or inorganic nutrient sinks. In fact, this transitional position often leads to high biodiversity in wetlands, which “borrow” species from both aquatic and terrestrial systems. Rather than being simply ecotones, wetlands are ecosystems to themselves. They have some characteristics of deepwater system such as algae, benthic invertebrates, nekton, anoxic substrate and water movement. On the other hand, they also have vascular flora which is similar with the structure to those found in uplands. Some wetlands have the distinction of being the most productive ecosystem on Earth because of their connection to both uplands and aquatic systems (William & James, 2000).

Wetlands in Asia include many types of natural and constructed habitats

( Scott, 1989). Typical wetland types include:

• inter-tidal and estuarine areas, such as lagoons, exposed reefs, mud flats, sand flats and salt marshes (in temperate areas) and mangrove forests (in sub-tropical and tropical areas);

• rivers and their floodplain marshes, tributaries and lakes;

• permanent and temporary freshwater marshes and reed beds;

• tropical peat swamps and freshwater swamp forests; and,

• peat bogs and mires.

Less typical wetlands include seasonal features such as saline and/or alkaline lakes.

Asia also has a large area of constructed wetlands, such as seasonally wet rice fields, salt pans, aquaculture ponds and reservoirs.

## 2.2 Mangroves

Based on the World Mangrove Atlas, there are 51 mangrove plant species found in South and Southeast Asia (*Spalding et al.*, 1997). Countries that are on the list are Malaysia, Bangladesh, Brunei, Cambodia, China & Taiwan, Hong Kong, India, Indonesia, Japan, Myammar, Pakistan, Phillipines, Singapore, Sri Lanka, Thailand and Vietnam. However, 36 species are found in Malaysia. Based on the data given by (Yunus *et al.*, 2004) mangrove plant species recorded in Balik Pulau were 14 species: Jeruju putih (*Acanthus illicifolius*), Pia raya (*Acrostichum aureum*), Api-api putih (*Avicennia alba*), Api-api jambu (*Avicennia marina*), Api-api ludat (*Avicennia officinalis*), Bakau putih (*Bruguiera cylindrica*), Tumu (*Bruguiera gymnorhiza*), Lengadai (*Bruguiera parviflora*), Buta-buta (*Excoecaria agallocha*), Nipah (*Nypa fruticans*), Bakau minyak (*Rhizophora apiculata*), Gedebu (*Sonneratia ovata*) and Nyireh bunga (*Xylocarpus granatum*).There are three components of mangrove habitat: plants, aquatic animals and terrestrial animals. Mangrove trees are the basic structure of habitat upon which classification is made on the ecological community (e.g *Rhizophora*, *Nypa* swamp etc)

Mangrove plants are defined as trees, shrubs, palms and ferns, growing between the mean sea level and highest tide in coastal and estuarine throughout the tropics. Mangrove forest also forms the main resource for litter fall, and food for various animals, as well as socio-economic resource for human life (Norhayati *et al*., 2004).

### 2.2.1 Importance of the mangrove forests

It is undeniable that the mangrove resources are important and it is appreciated due to direct products derived from mangrove forest, and also the various functions provided by the resource from within and beyond its boundaries.

(a) Socio- economic

Traditionally, the mangrove forests are being managed for the production of fuel wood and poles, exploitation of which is being controlled by the respective State Forestry Department. In Matang Mangroves Perak, the total revenue collected by the state in terms of premiums and royalties is estimated to be about US $450,000 annually (Ong, 1978). Apart from this, it has been estimated that the Matang Mangrove forest provides direct employment for around 1,400 workers and indirect employment for another 1,000 workers in the timber extraction and processing industries (Tang & Hassan, 1984).

Mangroves are important resource, especially to the coastal communities. In the past, coastal communities depend on it for their subsistent living. For more than a century, the local people have traditionally used mangroves in Matang for various uses. Timber from the mangroves are utilized for firewood, poles for foundation, construction materials, fishing gear and even tanning extraction.

Due to this, Matang has become the largest producer of mangrove charcoal and blood clams (*Anadara granosa*) in Peninsular Malaysia. It also supports a large fishery industry as it does to the culture fisheries (Azahar & Nik Mohd Shah, 2003).

(b) Fisheries

In Peninsular Malaysia, few studies have been carried out by Leh and Sasekumar (1980) and Chong (1979) to show that our mangrove ecosystem is necessary and suitable to sustain production of the fishery resources. However this dependence of fish and prawns on the mangroves as nursery and feeding grounds has been reported. Thong and Sasekumar (1984) discovered the plant detritus constituted 11% of the diet of fish sampled during their study on the fish community of the Angsa Bank, adjacent to the coastal mangroves of Selangor.

Matang Mangroves have contributed significantly to Perak's high fisheries production, which is the highest in the country. Of the species identified by marine scientists, 60 to 100 per cent of fish and 75 to 99 per cent of prawns were juveniles, indicating the importance of Matang Mangroves as a nursery ground.

Cockle farming around Matang Mangroves meanwhile has also made a significant contribution, recording an annual market value of RM32.45 million (Malaysian Timber Council, 2009)

(c) Agriculture

The soils in coastal swamp forest are considered to be marginal for agricultural production due to their saline and anaerobic environment. However, through the drainage improvement, liming, control of the water table and fertilization (Kanapathy, 1971), mangrove forest can now be seen as one of the major alternatives for increasing arable land in Malaysia. This situation is because of more pressure to convert mangrove into agricultural land.

The major part of the remaining mangrove forest in Selangor has now become a part of a few offshore islands. The pressure to access more mangrove forest areas for agriculture and other development purposes will continue to increase in the future. Therefore, it is imperative that these alternative uses can be objectively evaluated to ensure that the optimum benefits are obtained on a long-term, sustained yield basis (Razani, 1982).

(d) Ecotourism

The unique mangrove ecosystem is one of the tropical rainforest's unique nature-tourism products. Macintosh and Ashton (2002) noted that the diverse plant and animal life associated with mangrove ecosystem can also provide opportunities for nature education, tourism and scientific study, thereby providing further social and economic values.

### 2.2.2 Adaptation in Mangroves

Extreme environmental conditions within mangrove forest such as flooding, prolonged hydro period, salinity, anoxic conditions and accumulation of toxic substances (e.g $H_2S$), are factors that significantly limit the non-halophytic and non-wetland plants to grow and reproduce (Lugo, 1980). Salinity is the major obstacle for other species to survive in mangrove ecosystems because plants must possess mechanisms to either exclude salt or mitigate its effects on living cells (Juliana & Nizam, 2005).

Worldwide, only 34 species have been identified as possessing these adaptations (true mangroves), 20 other species tolerate some salinity and are considered minor elements of mangroves.

Additional 60 species are considered mangrove associates (Tomlinson, 1986). The adaptations of mangroves to live in an intertidal environment have drawn human curiosity (Anon, 1998). These include the stilt roots of *Rhizophora*, the pneumatophores (breathing roots) of *Avicennia*, *Sonneratia* and *Xylocarpus*, knee roots of *Bruguiera*, and the prominent propagules (the seeds of the Rhizophoraceae) germinate whilst on the trees and grow into seedlings before they fall to the ground. Some of the plants (e.g *Avicennia*) also have salt glands on their leaves that excrete salt (Yunus *et al.*, 2004).

### 2.2.3 Mangrove and Coastal Erosion.

The mangrove forests, an important ecosystem type in the coastal zone, have various uses. Apart from being a source for production of fuel wood and poles, they provide nursery and breeding grounds for many commercial species of fish and prawns. The second role also contributes to the fishing industry and hence, to the socio-economic development of the coastal communities. The mangrove forest also helps in reducing coastal erosion and provides a habitat for some protected species of birds and animals. It may not be possible to put monetary values on these roles but they are important from the conservation viewpoint (Razani, 1982).

Coastal mangroves provide a number of goods and services to human society that have been highly valued (Balmford *et al.*, 2002). The mangrove systems minimize the action of waves and thus prevent the coast from erosion. The reduction of waves increased with the density of vegetation and the depth of water. This has been demonstrated in Vietnam.

In the tall mangrove forests, the rate of wave reduction per 100 m is 20% ( Mazda *et al.*, 1997). Another research has proved that mangroves form ‘live seawalls’, and cost effective as compared to the concrete seawalls and other structures for the protection of coastal erosion (Harada *et al.*, 2002).

Furthermore, mangroves act as a natural barrier to shoreline erosion and in fact stabilize fine sediments. They help the coast to accrete and reduce the effects of storm surges and flooding. Mangroves also maintain water quality by extracting nutrients from potentially euthropic situations and by increasing the limited availability of saline and anaerobic sediments to sequester or detoxify pollutants. They support a wide range of wildlife, and represent a renewable source of forest products and site for human settlement (Bann, 1998).

### 2.2.4. Mangroves and Pollution

Pollution comes in many forms, including exposure to hot-water out-flows, toxic heavy metals, pesticides, sewage, or oil spill. Sometimes the contamination is either accidental or deliberate, because mangroves are seen as valueless and it is only fit for dumping unwanted wastes (Hogarth, 2007).

Thermal pollution comes in the form of water from power –plant cooling systems. When *Rhizophora mangle* is exposed to a 5$^{o}$C rise in water temperature, it responds by decreasing leaf area and increasing the density of aerial roots. Seedlings are more vulnerable than adults to high temperatures (as to low temperatures), and a rise of 7-9 $^{o}$C is sufficient to cause 100% mortality (Lugo and Snedaker 1974; Pernetta 1993).

High temperatures also reduce the species richness of the mangrove fauna. Thermal pollution is more frequent, and it gets more serious when it involves heavy metals, pesticides, sewage, and petroleum products. Mangroves often face combinations of these pollutants.

Heavy metal contamination comes from mine tailings and industrial waste and includes in particular mercury, lead, cadmium, zinc and copper. Assay of heavy metals is simple, therefore it has information about their distribution and accumulation within mangroves habitat and rather less understanding of their biological effects. It accumulates in mangrove sediments, where it may not be in a position to have profound ecological effects. Mangrove trees themselves may be relatively immune to the toxic effects of heavy metals, but the mangrove fauna may be more vulnerable. While mercury, cadmium, and zinc are acutely toxic to crab larvae and heavy metals cause physiological stress and reduce reproduction, even at sub lethal concentrations. Moreover, accumulation in fish, shrimps or edible molluscs could present serious health problems for the human population (Ellison & Farnsworth, 1996; Peters *et al*., 1997).

While for herbicides and pesticides, it usually enters the mangal run-off from agricultural land. These may also have both acute and chronic effects on both mangrove animals and plants which also can accumulate in the tissues of food species. However, many of the compounds are strongly absorbed into the sediments, and easily degraded in anaerobic soils (Clough, 1983).

The impact of sewage pollution on mangroves depends on the amount involved. Mangrove growth and productivity may be limited by the available nitrogen and phosphorus, as well as by high salinity. Sewage is rich in both nutrients, and is low of salinity. Up to a certain level, it would be likely to enhance mangrove productivity, and field trials have shown that mangroves can provide a useful method of waste water treatment. High nutrient loads stimulate excessive algal growth and cause deoxygenation of the water by microbial activity.

However, the most obvious damage to mangroves comes from oil pollution. Between January 1974 and June 1990 there were at least 157 major oil spills from ships and barges in the tropics. More than half of these were close enough to the coast to present major threats to coastal ecosystems such as mangrove (Burns *et al*., 1994).

## 2.3 Mangrove Ecosystem Structure and Chemistry

### 2.3.1 Plant Zonation and Succession

The zonation of plant in mangrove wetlands led some researcher's e.g; Davis (1940) to speculate that each zone is a step in an autogenic successional process that leads to freshwater wetlands and eventually to tropical upland forests or pine forests. Egler (1952) considered each zone to be controlled by its physical environment to the point that it is in a steady state or at least a state of arrested succession (allogenic succession). For example, with a rising sea level, the mangrove zones migrate inland. During periods of decreasing sea level, the mangrove zones move seaward.

Spatial variation in species occurrence and abundance is frequently observed across environmental gradients in many types of ecosystems (Davis 1940; Smith III 1992; Mendelssohn & Mckee 2000). Mangroves exhibit zonation patterns in a number of different geographic regions (Mendelssohn & Mckee, 2000).

### 2.3.2 Mangrove Adaptations

Mangrove vegetation, particularly the dominant trees, has several adaptations that allow it to survive in an environment of high salinity, which is occasional harsh weather, and anoxic soil conditions. These physiological and morphological adaptations have been of interest to researchers and among some of the most distinguishing features that the layperson notices when first viewing these wetlands. Some of the adaptations are:

#### 2.3.2.1. Salinity Control

Mangroves are facultative halophytes; they do not require salt water for growth but are able to tolerate high salinity and thus, out compete other vascular plants that do not have salt tolerance. The ability of mangroves to live in saline soils depends on their ability to control concentration of salt in their tissues. Respectively, mangroves are similar to other halophytes. Mangroves have the ability to prevent salt from entering the plants at the roots (*salt exclusion)* and to excrete salt from the leaves. Salt exclusion at the roots is thought to be a result of reverse osmosis, which causes the roots to absorb only fresh water from salt water (William & James, 2000).

Among other, the root cell membranes of Mangrove species *Rhizophora, Avicennia*, and *Laguncularia* may act as ultra filters that exclude salt ions. Water absorbed into the root through the flattering membrane by the negative pressure in the xylem developed through transpiration at the leaves. This action counteracts the osmotic pressure caused by the solutions in the external root medium (Scholander *et al*., 1965; Scholander, 1968)

#### 2.3.2.2. Prop roots and Pneumotophores

Some of the most notable features of mangrove wetlands are the prop roots and drop roots of red mangrove (*Rhizophora*), the numerous small pneumatophores of the black mangrove (*Avicennia*) (reaching 20-30 cm above the sediments, although they can be up to 1m tall). The drop roots are special cases of the prop roots that extend from the branches and other upper parts of the stem directly to the ground, rooting only a few centimeters into the sediments.

Oxygen enters the plants through small pores, called lenticels that are found on both pneumatophores and prop and drop roots. When lenticels are exposed to the atmosphere during low tide, oxygen is absorbed from the air and some of it is transported and diffuses out of the roots through a system of aerenchyma tissue.

This maintains an aerobic macro layer around the root system. To stabilize the water level, prop roots or pneuematophores of mangroves will be continuously flooded. Those mangroves that have submerged pnuematophores or prop roots will soon die (Macnae, 1963; Day, 1981a).

**2.3.2.3 Salinity**

Mangrove swamps are found under conditions that provide a wide range of salinity. Davis (1940) summarized several major points about salinity in mangrove wetlands from his studies in Florida:

1. There is a wide annual variation in salinity in mangrove wetlands.
2. Salt water is not necessary for the survival of any mangrove species but only gives mangroves a competitive advantage over salt-intolerant species
3. Salinity is usually higher and fluctuates less in interstitial soil water than in the surface water of mangroves.
4. Salinity condition in the soil extends farther inland than normal high tide because of the light relief which prevents rapid leaching.

It is important for mangroves to control cytosolic salt concentration when living in intertidal zones with high salinity (Tomlinson, 1986). Some species can even accumulate saline ions as osmolytes to balance transmembrane osmotic potentials. Diverse strategies of salt management indicate that mangroves are adaptive to high salinity adaptability in the anatomic and physiological levels (Zhao *et al.*, 1999)

**2.3.2.4 Dissolved Oxygen**

When mangrove soils are flooded reduced oxygen condition will exist. The degree of reduction depends on the duration of flooding and the openness of the wetland to freshwater and tidal flows. Some oxygen transport to the rhizosphere occurs through the vegetation, and this contribution is locally significant (Thibodeau & Nickerson, 1986; Mckee *et al*., 1988)

Mazda *et al*., (1990) reported on the variations in dissolved oxygen, salinity and temperature in Japanese mangrove that is connected by tides to the ocean through a coral reef but is occasionally isolated by sand sill.

## 2.4 Relationship between Nutrients and Soil with Mangrove Habitat

### 2.4.1. Relationship between Nutrients with Mangrove Habitat

Plants require an adequate supply of mineral nutrients; particularly nitrate and phosphate. Soluble forms of inorganic nitrogen (except for ammonia) and phosphorus are extremely low in typical mangrove soils and the bulk being present in organic form. Availability to the mangroves depends on the nature of the mangrove soil and microbial activity within it. Where do nutrients such as nitrate and phosphate come from? Possible sources are rainfall, fresh water from rivers or runoff from the land, tide-borne soluble or particle-bound nutrients, fixation of atmospheric nitrogen by cyanobacteria, and released by microbial decomposition of organic material (Hogarth, 2007).

The nutrient contribution made directly by rainfall is probably small, but mangrove areas with heavy rainfall tend to have larger freshwater inflow from rivers or land runoff. Mangroves also have a nutrient source in regular tidal inundations. The relative importance of these sources is not clear, and will vary between different mangrove areas; and of course, nutrient may be lost as well as gained to river water and tides. The few cases that have been analyzed in any detail indicate that most nutrients available to mangroves are terrestrial in origin.

Based on a research, land drainage contributed between 10 and 20 times from the sea water, depending on season (Lugo *et al.*, 1976).Mangrove habitats are more likely to have a net gain of nutrients than a net loss (Rivera-Monroy *et al.*, 1995).

### 2.4.2 Relationship between Soils with Mangrove Habitat

Soil characteristics are one of the most important environmental factors which directly affect mangrove productivity and structure. The major physical and chemical properties of the mangrove soils are pH (hydrogen ion concentration), Eh (Redox, potential), salinity and particle size (Kathiresan, 2009).

The proportion of clay, silt and sand together with the grain size, dictate the permeability (or hydraulic conductivity) of the soil to water, which influence soil salinity and water content. Nutrient status is also affected by the physical composition of the soil with clay soils, which is higher in nutrients than sandy soils( English *et al*., 997).

Mangrove soil is basically anoxic and bacterial fermentation. Anaerobic respiration is the predominant biological process which lead to the formation of hydrogen sulphide (Kryger & Lee, 1995)

## 2.5 Relationship between Physical Parameters and Mangrove Habitat

### 2.5.1 Water Temperature

Water temperature influences the ecological process such as photosynthesis, aerobic respiration, the growth, reproduction, metabolism and the mobility of organism. Indeed, the rates of biochemical reactions usually doubled when temperature is increased by 10°C within the given tolerance range of an organism (ANZECC, 2000). Increasing temperature may raise plant and soil respiration by approximately 20%, resulting in less net carbon gain, increased methane emissions and decrease in soil carbon storage (Davidson & Janssens, 2006).

As mangroves and salt marshes have large carbon and nutrient stores in soils and plant biomass (Chmura *et al.*, 2003) increases in temperature and also increases in respiration may have negative effects on carbon balance. This may not be matched by increases in production, which in some cases may be reduced particularly in northern regions.

### 2.5.2 Dissolved Oxygen

Dissolved oxygen (DO) is the amount of oxygen dissolved in the water. DO concentration exists because of the function of temperature, salinity, and the biological activity in the water body. It is an important indicator since most aquatic plants and animals need it to survive. The river gains oxygen from the atmosphere through the aerating action of wind or turbulence (cascading water) and from plants through photosynthesis (Jasmin, 2006).

Dissolved oxygen concentration is affected by physical, chemical and biochemical activities in the water body (Bertram & Balance, 1996). DO concentration changes from normal range because they require oxygen in specified concentration ranges from respiration and efficient metabolism process and it also can have adverse physiological effects to most aquatic organisms (ANNZECC, 2000).

### 2.5.3 Total Dissolved Solids (TDS)

Water dissolves the minerals contained in the strata of soil. It filters through the ground water. But if it is surface water, when the minerals contained in the soil exceeded it will flow through (rivers/streams) and the mineral will stay still in (lakes, ponds, reservoirs).

The dissolved minerals in water are commonly referred to as Total Dissolved Solids (TDS). The TDS content of any type of water is expressed in milligrams /litre (mg/l) or in parts per million (ppm) and these units are equivalent. The minerals are basically compounds (salts) of Calcium (Ca), Magnesium (Mg) and Sodium (Na). The term ‘hardness in water’ is due to the compounds/salts of Ca and Mg such as Calcium or Magnesium Chloride, Calcium or Magnesium Sulphate (CaSo4, MgCl, etc). Some types of dissolved solids are specifically dangerous even in low quantities. This includes arsenic, fluorides and nitrates. There are certain standards for the acceptable amounts of these elements in water and in some cases like fluoride, there is some disagreement as to what constitutes safe levels (IWP, 2008).

Thus TDS incorporates dissolved ionic minerals, both cations and anions. Cations are elements from the left side of the periodic table (metals) and when they react they usually become positive ions. Cations include ions such as sodium, potassium, magnesium, calcium, barium, zinc, iron and copper. Elements from the right side of the periodic table that react with metals take electrons to form negative ions called anions. Anions includes ions such as fluoride, chloride, bromide, iodine, sulfide, chlorate, nitrate, permanganate, sulfate, and phosphate (Chemistry Department, University of Florida, 2004)

**2.5.4. pH**

pH is an expression of hydrogen ion concentration in water. Specifically, pH is the negative logarithm of hydrogen ion (H+) concentration (mol/L) in an aqueous solution:

$$pH = -\log10(H+)$$

The term is used to indicate the degree of basicity or acidity of a solution ranked on a scale of 0 to 14, with pH 7 being neutral. As the concentration of H+ ions in solution increases, acidity increases and pH gets lower, below 7. When pH is above 7, the solution is basic. Because pH is a logarithmic function, one unit change in pH (e.g., from 7 to 6) indicates a

10x change in hydrogen ion concentration in that solution. However, what is actually measured is hydrogen ion activity, not concentration (Cormier, Suter, Yuan, & Zheng, 2011). Changes in pH can also lead to indirect impacts on aquatic organisms because it can alter the biological availability of metals, the speciation of nutrients and the toxicities of ammonium, aluminium and cyanide (ANZECC, 2000).

### 2.5.5. Conductivity

Conductivity is a measure of the ability of water to pass an electrical current. Conductivity in water is affected by the presence of inorganic dissolved solids such as chloride, nitrate, sulfate, and phosphate anions (ions that carry a negative charge) or sodium, magnesium, calcium, iron, and aluminum cations (ions that carry a positive charge). In water, organic compounds like oil, phenol, alcohol, and sugar do not conduct electrical current very well and causing it to have a low conductivity. Conductivity is also affected by temperature: the warmer the water, the higher the conductivity. For this reason, conductivity is reported at 25 degrees Celsius (Cormier *et al.*, 2011).

### 2.5.6 Salinity

It is important for mangroves to control cytosolic salt concentration when it is in the intertidal zones with high salinity (Tomlinson, 1986). Salinity is a very important factor to most aquatic organisms and it functions optimally in a small range of salinity levels. When salinity extremely changes, an organism may lose the ability to regulate its internal ion concentration. Indeed, ‘osmo-regulation’ process may become energetically expensive that the organism dies due to the direct physiological effects.

These phenomena also become more vulnerable to biotic pressures such as predation, competition, disease or parasitism. Besides, shifting salinity distributions can affect the distributions of macrobenthos, rooted vegetation such as seagrasses and seasile organism (Alber, 2002). Different mangrove species may adopt different strategies for adaptation to high salinity due to their differential ability of salt tolerance (Liang *et al.*, 2008)

### 2.5.7 Relative Humidity

The relative humidity of air can be expressed by partial vapor and air pressure - density of the vapor and air - or by the actual mass of the vapor and air. Humidity has been reported to modify the response to salinity in several plant species, presumably because of interactive effects of these factors on carbon gain in relation to water use and hence also ion uptake (Ball & Farquhar, 1984).

## 2.6 Degradation of Mangrove

Historical records indicate that the original extent of mangrove forests has declined because of the pressure from human activity. For example in Southeast Asia, Malaysia lost 12% from 1980 to 1990 (Ong, 1995). Philippines originally had 4,300 km2 but now has 1,200 $km^2$ (Primavera, 2000); Thailand had 5,500 $km^2$ in 1961 but 2,470 $km^2$ in 1986 (Aksornkoae, 1993); and Vietnam originally 4,000 $km^2$ has change to 2,525 $km^2$ (Spalding *et al.*, 1997). Ong (1995) considers that the loss of 1% mangrove area per year in Malaysia is an estimation of mangrove destruction in the Asia-Pacific region.

Underestimating the total economic value of mangroves and the impacts of human activities is the major factors contributing to the widespread loss and degradation of mangrove ecosystems (Gilbert & Janssen, 1998). Serious environmental, social and economic impacts are associated with the decline and degradation of mangroves. For example in Vietnam where mangrove loss due to the usage of defoliants during the Vietnam war, logging and aquaculture have led to coastal erosion, salinity intrusion and decline in natural shrimp and mud crab (*Scylla*) populations (Hong & San, 1993).

The fundamental cause of mangrove forest loss is the increase in human population living near the coastal zone. Ong (1995) considers that burgeoning populations are possibly the biggest cause of mangrove destruction and degradation. Malaysia's mangroves have declined over 45% from an estimated 1.1 million hectares to the current estimate of 564,970 hectares. Though the government has established a national committee to oversee research and replanting matters, remaining mangroves continue to be threatened through illegal encroachment and drainage of mangroves (Wetlands International Malaysia, 2007).

Humans inhabit mangroves in many places, usually belonging to traditional local communities that harvest fish and other natural resources but in recent years the coastal areas have come under intense pressure for development. Mangroves have been over exploited or converted to various other forms of land use, for example agriculture, aquaculture, salt ponds, terrestrial forestry, urban and industrial development and construction of dikes and roads (Macintosh & Zisman, 1997)

### 2.7 Mangrove Conservation and Management

Asia has the largest mangrove area of any region, and the mangroves are exceptional for their high biodiversity (especially in South and Southeast Asia). More than 50 mangrove species (the highest mangrove species diversity in the world) grow along its coasts, some of which (*Aegiceras floridum, Camptostemon philippinensis, Heritiera globosa*) are endemic to the region. Some of the species, even though relatively common in some countries, are considered rare in the region as a whole (e.g. *Ceriops decandra*, *Osbornia octodonta*, *Scyphiphora hydrophyllacea*, *Sonneratia ovata*). *Kandelia candel* is an interesting case: it is found as far north as Japan and is a common species in Hong Kong, but appears to be truly rare in Southeast Asia (FAO, 2006)

Community-based mangrove management can be initiated from the local communities themselves if they see other successful rehabilitation programmes in the surrounding area. In most instances though community-based mangrove management is firstly promoted by local or international NGOs or government departments. Local NGOs involved in mangrove management projects often play the role as advisor, monitor and evaluator of the community project activities. The reasons for the success of the Buswang project in the Philippines was because the local NGO helped monitor the project, provided training courses for the families in leadership, development, enterprise management, environmental awareness, environmental laws and enforcement and suggested alternative livelihoods that were nondestructive to the mangrove (Macintosh & Ashton, 2002).The Matang Mangrove Forest Reserve, peninsular Malaysia, is another large forest in the region.

This mangrove area is commonly known as the best-managed mangrove forest in Malaysia and among the best-managed worldwide.

Sustainable production of fuelwood and poles from almost all the mangrove area began in 1902–1904, and the entire reserve came under intensive management by the Perak State Forest Department in 1908 (FAO, 2006; Wetlands International Malaysia, 2006).

# Chapter 3

# Materials and Methods

## 3.1 Description of study site

The location of the two study areas (Site 1 and Site 2) were recorded by using Global Positioning System (GPS). Site 1 (N 02º54'26.4" and E 101º21'07.2") contains good community of mangrove forest (Plate 3.1) while Site 2 (N 02º 49'26.4" and E 101º20'26.9") is a mixed sandy-mud degraded mangrove habitat (Plate 3.2), facing the Straits of Malacca.

## 3.2 Methodology

Three stations (1, 2, and 3) were located in Site 1 and four stations (1, 2, 3, and 4) were located in Site 2. For each station, 80 meter long line transect was set up. In Site 1, four sampling point were set for every 20 meter of transect (4 x 3 = 12 sampling points). In Site

2, the same procedures were applied but with 16 sampling points (4 x 4 =16). Data is collected once a month for six months consecutively. The physical parameters were water and soil while for vegetation, line transects sampling were carried out from the land towards the sea.

### 3.2.1. Water parameters

The data is collected according to temperature, pH, salinity, conductivity, dissolved oxygen (DO), and also total dissolved solid (TDS). The parameter chosen for data collection follows (Ahmad-Shah, 1991). The monthly samplings were carried out from February 2008

until July 2008. There were three replicates made for each sampling point at both sites. Replicates of water samples were collected from the surface during low tide every month.

**(a) Dissolved oxygen and temperature**

Dissolved Oxygen and temperature of sea water were taken and measured using MI 605 portable dissolved oxygen meter. This equipment can be used to measure DO value and temperature of water surface. Unit of dissolved oxygen is parts per million (ppm) whereas unit of temperature is Celsius. DO measurements at the site were recorded at each plot together with temperature at the same time every week.

**(b) pH, conductivity and TDS**

pH, conductivity and TDS were measured by using MI805 combined meter. Unit for conductivity is mS while TDS denote part per million (ppm). At least 250 ml of sea water from the surface were taken and transferred to the lab where the physical analysis was conducted to determine pH, conductivity and TDS.

**(c) Salinity**

Salinity was determined by using salinity refracts meters and the unit is part per thousand (ppt). In-situ measurement was conducted at both sites.

**(d) Relative Humidity**

Relative Humidity (RH) was determined by using hand-held relative humidity instrument, once a week for every month, in the morning. There were 28 measurements for every month recorded for both sites. The unit is percentage (%).

### 3.2.2. Light intensity

Light intensity is identified by using Digital Light Meter which is placed under the canopy with gaps between them. Three measurements were taken randomly from each station. The light intensity sampling was carried out in February until July 2008 specifically from 11 to 1 pm. Unit of light intensity sampling is expressed in Lux.

### 3.2.3 Soil sampling:

A total of 168 soil samples were collected from the study area (Site 1 and Site 2). The samples were collected at 0-10 cm depth every month. Sampling should be done by fixed depth and 0-10 cm is mandatory sampling status of layers to be sampled (Sampling and Analysis of Soil, 2006).

**Table 3.1: Chosen location in Carey Island for soil sampling**

| Location | No of station | No of soil samples for 6 months |
|---|---|---|
| 1. Site 1 – along Langat River | 3 stations (4 replicates for each station) | 72 |
| 2. Site 2 –sea line (Degrading mangrove habitat) | 4 stations (4 replicates for each station) | 96 |

### 3.2.4 Soil Analysis

All the samples were air dried before the determination of particle size analysis. The air dried samples were thoroughly mixed and roll to break up clods. Then, they were passed through a 2mm sieve in determining the quantity of gravel in soil is separating the sample into material less than and greater than 2 mm. All samples are taken for particle soil analysis by using LS particle analyzer machine. For soil classification, three main fractions are used; sand (50-2000 μm), silt (2-50 μm) and clay (‹ 2 μm) on a triangular system (Balkema, 1986). After the percent of sand, silt and clay has been determined by the machine, the USDA soil texture triangle was used to classify the texture (Figure 3.1).

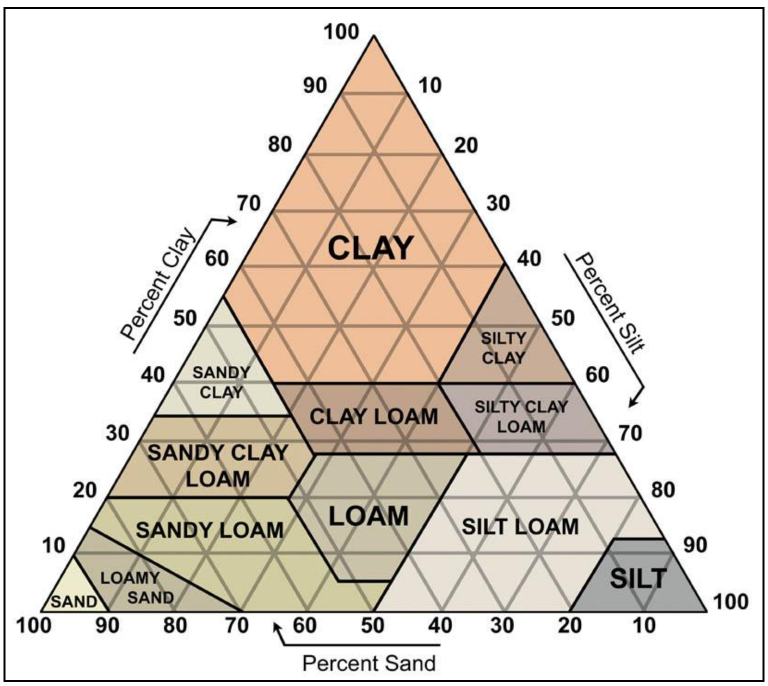


**Figure 3.1: Soil texture triangle based on the percentage of sand, silt, and clay that shows the 12 major textural classes.**

(Source: United States Department of Agriculture USDA)

### 3.2.5 Line Transect Sampling

Line transect sampling was carried out by placing at least 80 meter long line transect for both sites. The line transect includes every species which touch or near the line. Species in every 20 meter were recorded.

## 3.3 Statistical Analysis

Data for physical parameters were recorded every month during 6 months study. Tables and graphs were constructed using these data. Some of the data were analyzed using Microsoft Excell 2008 and Independent Samples t-test by using Statistical Package for the Social Sciences (SPSS) software version 19.0 to determine significant difference between the two sites.

**Plate 3.1: Study location of Site 1: Near Langat River**

**Plate 3.2: Study location of Site 2: Degraded mangrove area**

# Chapter 4

# Results

## 4.1 Physical Parameter

The results of physical parameter, which includes water parameter, soil analysis and light intensity, are shown in Tables 4.1.1, 4.1.2 and 4.1.3 respectively. Elements of water parameter collected are temperature, pH, salinity, conductivity, dissolved oxygen (DO), Relative Humidity (RH) and Total Dissolved Solid (TDS). Soil analysis results include the percentage of soil particle for both sites.

### 4.1.1. Water Parameter

Average water quality and standard deviations of temperature, pH, salinity, conductivity, and dissolved oxygen (DO) and Total Dissolved Solid (TDS) from February 2008 to July 2008 were calculated in Table 4.1.1. Relative humidity is also included in this table.

**Temperature**

Figure 4.1.1 shows the average of monthly surface water temperature in Site 1 and Site 2. The water temperature range from 28.18 ºC to 33.03 ºC in site 1 and site 2 is on the range of 26.73 ºC to 27.9 ºC. Water temperature in site 1 is higher compared to site 2. Water temperature in site 1 and 2 increased from May to July 2008. From the t-test, the t-value recorded was 6.368. The probability value ($p< 0.05$) showed that there were significant differences in temperature between the two sites throughout the study period.

**Dissolved Oxygen**

Figure 4.1.2 shows the average of monthly dissolved oxygen in Site 1 and Site 2. Dissolved oxygen concentration is in the range of 2.41 to 5.02 ppm in site 1 while site 2 recorded 0.56 to 6.02ppm from February 2008 to July 2008. For site 1, the value of dissolved oxygen slightly dropped from February to April, however the values increase after that particular period. At site 2, the concentration of dissolved oxygen was quite high in February but dropped in March and remained low until July. From the t-test, the t-value recorded was 1.991. The probability value ($p>0.05$) shows that there was no significant difference of dissolved oxygen between the two sites.

**Salinity**

Figure 4.1.3 shows the average monthly salinity for both sites (site 1 and site 2) during the study at Carey Island. The monthly average of salinity from February 2008 to July 2008 at site 1 varied from 26.67 to 28.75ppt. At site 2, the monthly average of salinity ranged from 25.42 to 29.58 ppt. For site 1 the highest salinity occurred in March. At site 2, the highest salinity occurred from February to April but dropped drastically in May. From the t-test, the t-value recorded was 4.418. The probability value ($p < 0.05$) showed that there were significant differences of salinity between the two sites throughout the study period.

**Conductivity**

Figure 4.1.4 demonstrates that the conductivity from the range 54.51 mS (milliseimens) to 77.02 mS for site 1 while site 2 from the range 22.69mS to 54.51 mS. At site 1, conductivity increased from February to April, dropped in May and increased again. At site 2, the lowest conductivity was recorded in March.

From the t-test, the t-value recorded was 3.842.The probability value ($p > 0.05$) showed that there was no difference in dissolved oxygen between the two sites.

**pH**

The average PHs for each station at site 1 and site 2 are shown in Figure 4.1.5. The range of pH in Site 2 was slightly acidic 6.44 to alkaline 7.63. For Site 1, the pH values were slightly alkaline from 7.11 to 8.05 (Fig. 5). pH changed to alkaline level in May and July 2008 in Site 1. The pH range is from alkaline to acidic for site 2 throughout the 6 months. From the t-test, the t-value recorded was 3.869. The probability value ($p < 0.05$) showed that there were differences of pH between the two sites throughout the study period.

**Total Dissolved Solid (TDS)**

For TDS, the content of dissolved solid increased from February to April in Site 1 while in Site 2 there was not much difference in the average TDS for 6 months.  The range of TDS in Site 1 was 10470 ppm to 44167 ppm while the range for Site 2 was 25958 ppm to 32616 ppm. The highest value of TDS in Site 1was recorded in June 2008. From the t-test, the t-value recorded was 5.196. The probability value (p>0.05) shows that there was no significant difference of TDS between the two sites. The average TDS for each station at site 1 and site 2 are shown in Figure 4.1.6.

**Relative Humidity (Rh)**

The range of average relative humidity (Rh) in Site 1 was 56.87% to 74.31% while the range for Site 2 was 47.65% to 79.22%. The lowest value of RH was recorded in March 2008 at Site 2. At Site 1 there was not much difference in the average of Rh for 6 months. From the t-test, the t-value recorded was – 1.932. The probability value (p>0.05) shows that there was no significant difference of Rh between the two sites.

**Table 4.1.1: Average of water parameter measurements of temperatures, dissolved oxygen (DO), salinity, conductivity, pH, RH and total dissolved solid (TDS) during study periods (each month) at Carey Island.**

| Para -meter/ Site | Tempe - ratures (•C) | D0 (ppm) | Salinity (ppt) | Conductivity (mS) | pH | TDS (ppm) | Rh (%) |
|---|---|---|---|---|---|---|---|
| February | | | | | | | |
| 1 | 33.03 (±3.88 ) | 5.02 (±1.20) | 27.08 (±5.37) | 47.83 (±11.36) | 7.11 (±0.37) | 10471 (±5687) | 59.51 (±17.12 ) |
| 2 | 26.73 (±0.64) | 6.02 (±0.43) | 27.92 (±3.96) | 54.51 (±8.83) | 7.41 (±0.17) | 25958 (±5065) | 79.22 (±2.43) |
| March | | | | | | | |
| 1 | 27.85 (±0.3) | 3.17 (±1.32) | 28.75 (±2.26) | 54.51 (±8.7) | 7.28 (±0.25) | 18711 (±3818) | 68.42 (±9.05) |
| 2 | 27.12 (±0.38) | 1.61 (±0.07) | 28.75 (±4.33) | 22.69 (±15.46) | 7.48 (±0.39) | 26150 (±11471) | 47.65 (±3.45) |
| April | | | | | | | |
| 1 | 29.37 (±2.44) | 2.41 (±0.79) | 26.67 (±2.99) | 70.36 (±18.9) | 7.75 (±0.34) | 32167 (±9426) | 63.0 (±4.93) |
| 2 | 27.13 (±0.92) | 0.56 (±0.066) | 29.58 (±1.44) | 53.75 (±13.35) | 7.63 (±0.08) | 26617 (±2184) | 75.47 (±4.82) |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| May | | | | | | | |
| 1 | 28.18 (±0.54) | 4.03 (±0.47) | 27.5 (±2.61) | 55.3 (±17.03) | 8.05 (± 0.09) | 32200 (±9620) | 56.87 (±3.05) |
| 2 | 27.00 (±0.33) | 1.49 (±0.38) | 25.42 (±3.96) | 50.22 (±4.45) | 6.84 (±0.28) | 27167 (±10960) | 66.13 (±5.07) |
| June | | | | | | | |
| 1 | 28.77 (±0.47) | 3.77 (±0.51) | 27.42 (±2.31) | 77.02 (±5.91) | 7.97 (±0.08) | 44167 (±2593) | 67.98 (±0.08) |
| 2 | 27.03 (±0.33) | 0.92 (±0.13) | 25.83 (±4.17) | 45.84 (±8.32.) | 6.44 (±0.42) | 32617 (±4013) | 76.55 (±4.66) |
| July | | | | | | | |
| 1 | 28.94 (±0.37) | 4.96 (±0.21) | 26.67 (±2.06) | 76.97 (±3.34) | 8.01 (±0.47) | 35508 (±2991) | 74.31 (±11.76 |
| 2 | 27.9 (±1.17) | 1.01 (±0.09) | 25.83 (±3.58) | 49.38 (±5.19) | 6.99 (±0.45) | 30608 (±2995) | 75.5 (±3.33) |

### 4.1.2 Light Intensity

Site 1 has high light intensity and also supports a good community of mangrove forest. The range of average light intensity was from 215.5 x 100 Lux to 453.33 x 100. Lux (Table 4.1.2). In Site 2, the range of average light intensity was about 24,000 Lux to 88,375 Lux and the higher light intensity was definitely due to direct sunlight. From the t-test, the t-value recorded was -4.142. The probability value ($p<0.05$) shows that there were differences of light intensities between the two sites.

### 4.1.3. Soil Particle Size Analysis

The percentage of soil particle in Figure 4.1.8 and Figure 4.1.9 showed that both sites contained silt and clay but has a very small percentage of sand at Site 1 which was not recorded in the figure. Site 2 contained the highest percentage of sand between the range 43.98% to 51.95 %. For silt composition, Site 1 contained the highest percentage of silt with 84.71% while the lowest silt composition was recorded at Site 2 with 43.98%. At site 1, the composition of clay was between the range 15.29% to 27.85% while in Site 2, the range was from 3.87% to 13.97%. This shows that the range at site 2 was quite low compared to Site 1. Average of soil percentage of sand, silt and clay for two sites during 6 months (Table 4.1.3) recorded that both sites contained percentage of silt with the highest percentage recorded at Site 1 with 75.78% while Site 2 recorded highest percentage of sand with 45.19 %.

**4.2 Existing vegetation**

Existing vegetation recorded at site 1 were *Avicennia*, *Rhizophora*, S*onneratia* and *Bruguiera*. Only some species such as *Rhizophora* and *Bruguiera* were found at the Site 2. Refer to plate 4.3 (a), 4.3(b), 4.3 (c) and 4.3 (d).

**Plate 4.3 (a) :** *Rhizophora* sp

**Plate 4.3 (b):** *Avicennia* sp

**Plate 4.3 (c):** *Sonneratia* sp

**Plate 4.3 (d)** *Bruguiera* sp

**Table 4.1.2: Species diversity for Site 1 and Site 2**

| Species | Site 1 | Site 2 |
|---|---|---|
| *Avicennia alba* | 4 | 1 |
| *Avicennia marina* | 1 | - |
| *Sonneratia alba* | 2 | - |
| *Rhizophora apiculata* | 3 | 4 |
| *Sonneratia caseolaris* | 1 | - |
| *Avicennia officinalis* | 1 | 1 |
| *Bruguiera parviflora* | 1 | - |
| *Rhizophora Mucronata* | 7 | - |
| *Scaevola taccada* | - | 1 |

| | | |
|---|---|---|
| *Bruiguiera gymnoriza* | - | 1 |
| Total | 20 | 8 |

*Numbers in the table = Amount of trees found for each species.

Table 4.1.2 shows number of species found in Site 1 and Site 2 which is touching or near to the line transect sampling. Line transect sampling was carried out by laying at least 80 meter long line transect for both sites. More species were found in Site 1(8 species recorded with total number of vegetations are 20). Only few species were found in site 2 (5 species with total number of vegetations are 8 only).

**Table 4.1.3: Average Light intensity of Site 1 and Site 2 for 6 months (February- July 2008)**

| Light Intensity (x 100 Lux) | | |
|---|---|---|
| | Site 1 | Site 2 |
| Month | | |
| February | 326.83 (± 327) | 298 (± 73.85 ) |
| March | 215.5 (± 298.63 ) | 883.75 (± 828.66) |
| April | 222.08 (±208.08 ) | 240 (± 47.47) |
| May | 310.46 (±221.49 ) | 999.5 (± 127.33 ) |
| June | 453.33(± 294.85) | 861.5 (± 125.75 ) |
| July | 364.17 (± 318.47) | 585 (± 249.52 ) |

**Table 4.1.4: Average of soil percentage of sand, silt and clay for two sites for 6 month (February to July 2008)**

| Site | Sand (%) | Silt (%) | Clay (%) | Soil Type |
|---|---|---|---|---|
| **1** | 0.33 | 75.78 | 24.05 | Silt |
| **2** | 45.19 | 48.19 | 6.59 | Loam |

Table 4.1.4 shows the average of soil percentage of sand, silt and clay of both sites. A soil triangle (Figure 3.1) was used to determine soil textural class from the results of particle analyzer equipment. Based on the soil triangle, soil type of Site 1 was determined as silt loam and the soil type of Site 2 was loam.

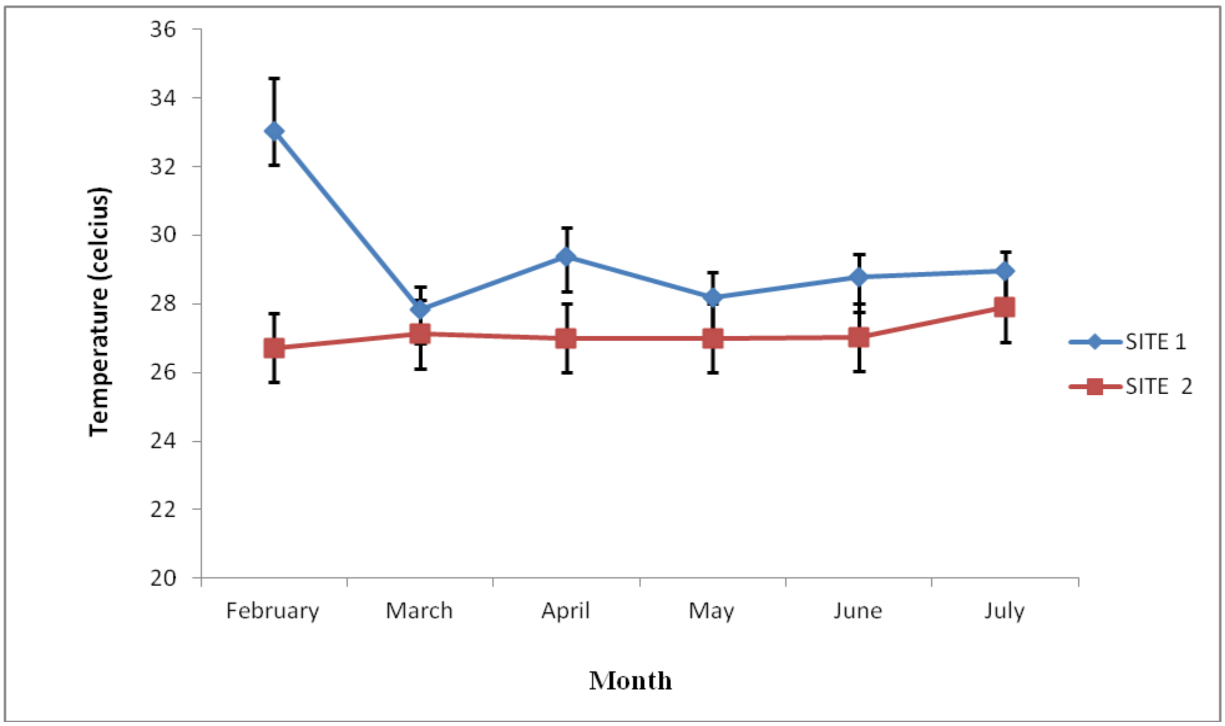


**Figure 4.1.1: The average monthly temperature for 6 months at Study Site in Carey Island (February to July 2008)**

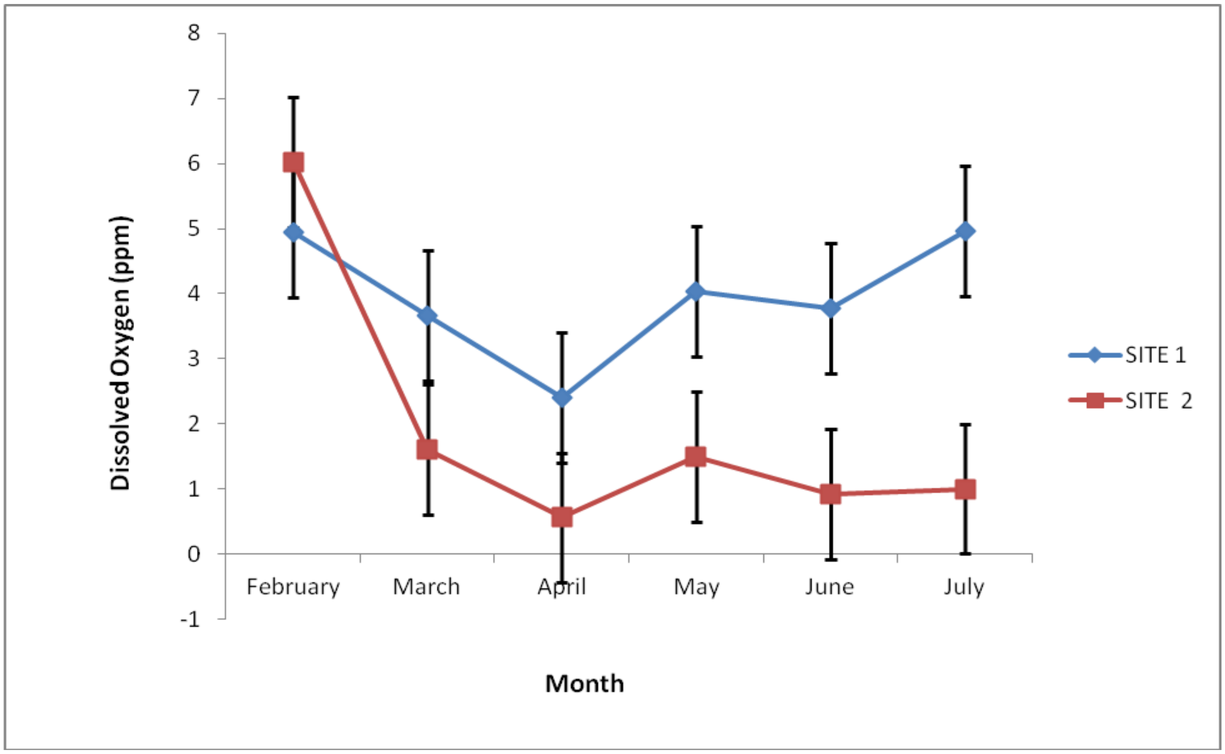


**Figure 4.1.2: The average monthly dissolved oxygen for 6 months at Study Site in Carey Island (February to July 2008)**

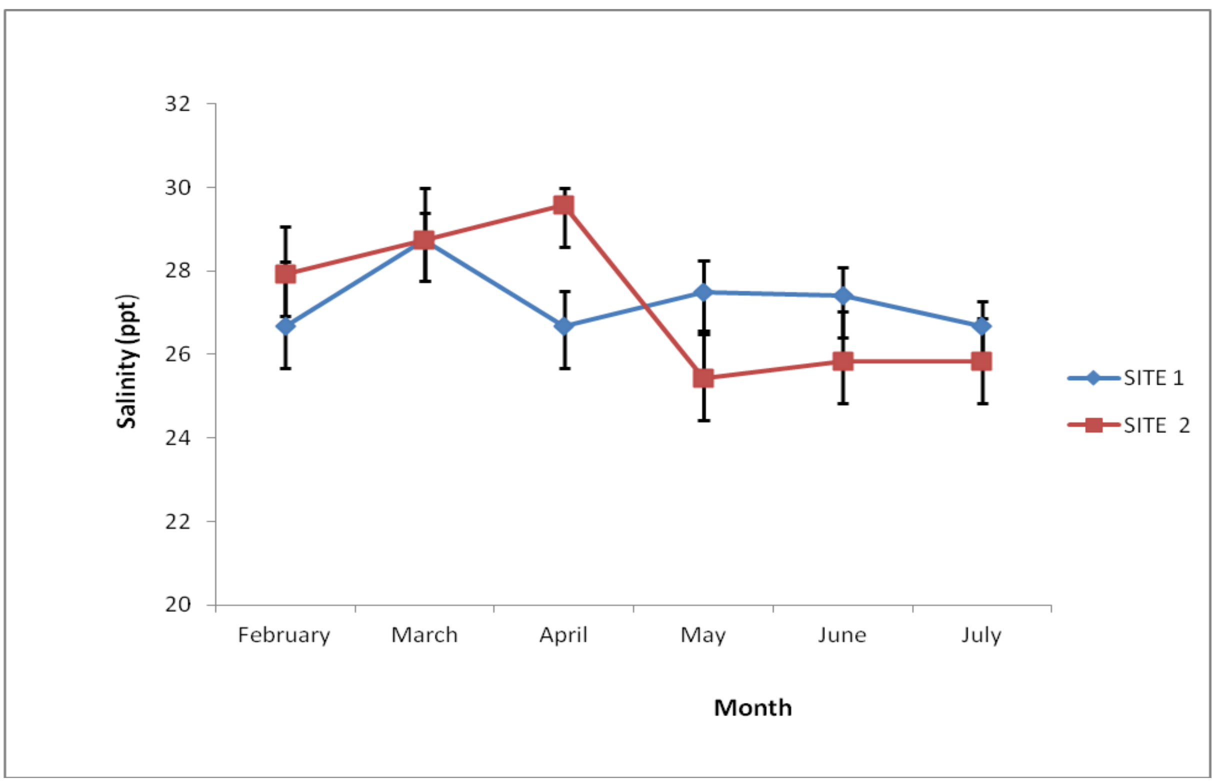

**Figure 4.1.3: The average monthly salinity for 6 months at Study Site in Carey Island (February to July 2008)**

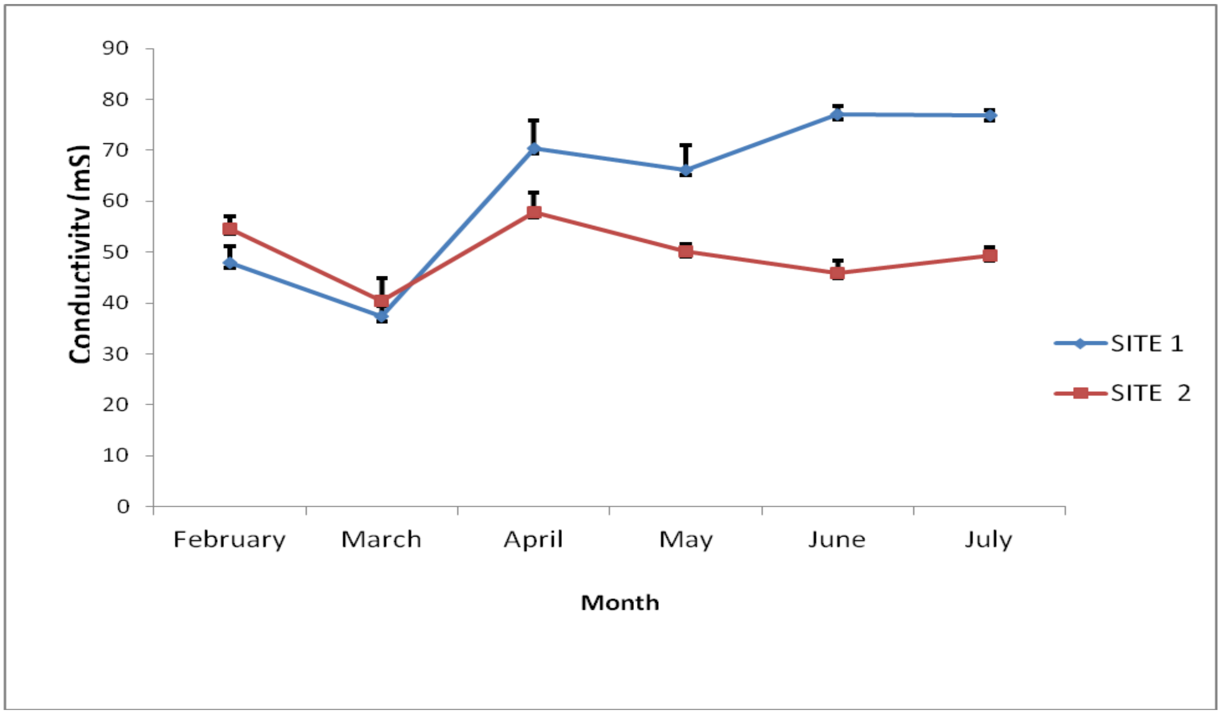


**Figure 4.1.4: The average monthly conductivity for 6 months at Study Site in Carey Island (February to July 2008)**

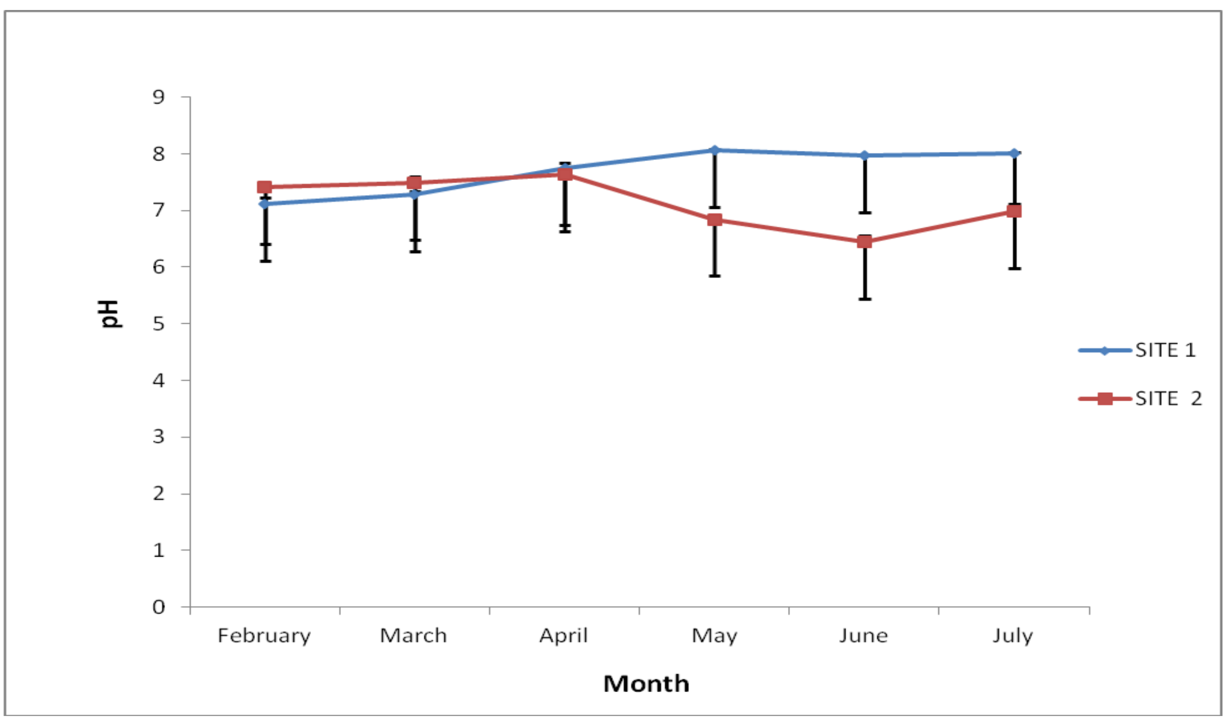

**Figure 4.1.5: The average monthly pH for 6 months at Study Site in Carey Island (February to July 2008)**

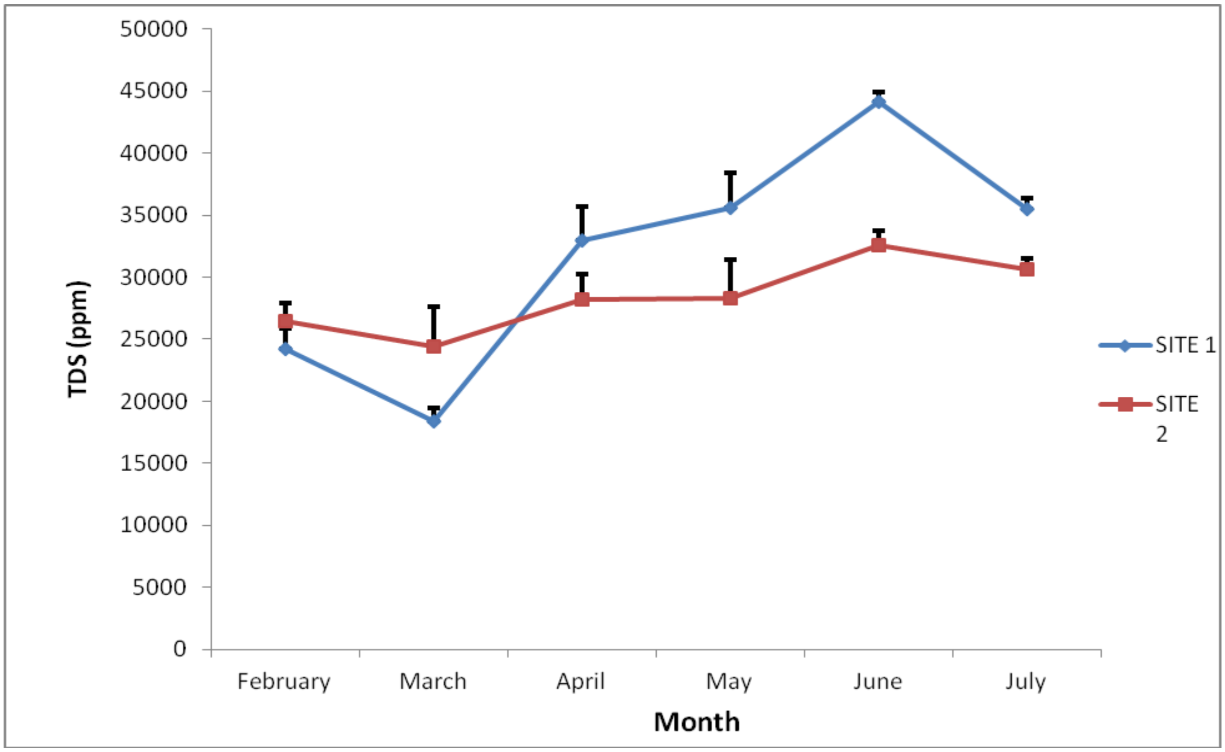


**Figure 4.1.6: The average monthly Total Dissolved Solids (TDS) for 6 months at Study Site in Carey Island (February to July 2008)**

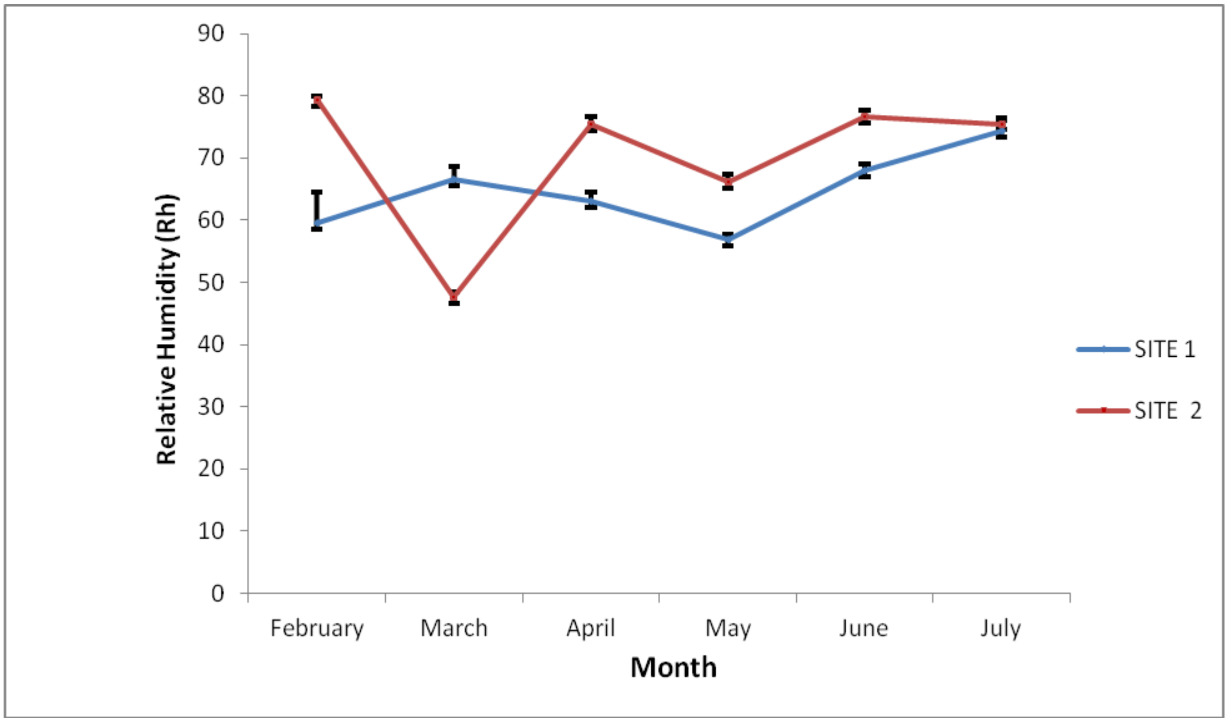


**Figure 4.1.7: The average monthly Relative Humidity (Rh) for 6 months at Study Site in Carey Island (February to July 2008)**

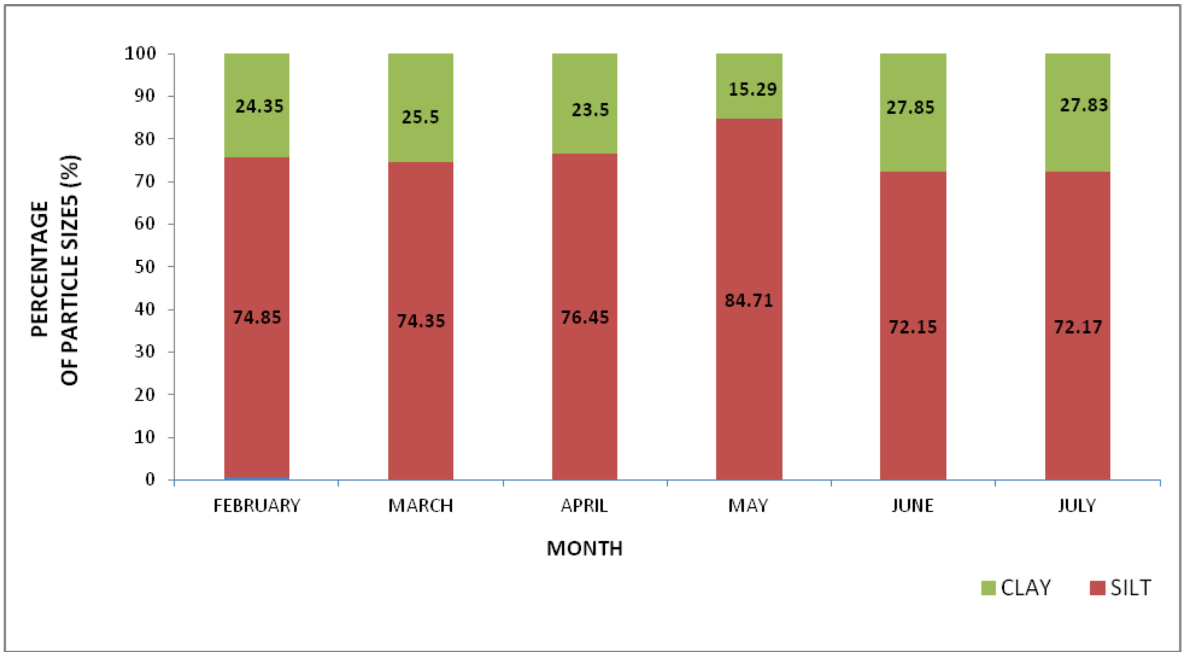


**Figure 4.1.8: Percentage of soil particle(silt and clay) for Site 1.**

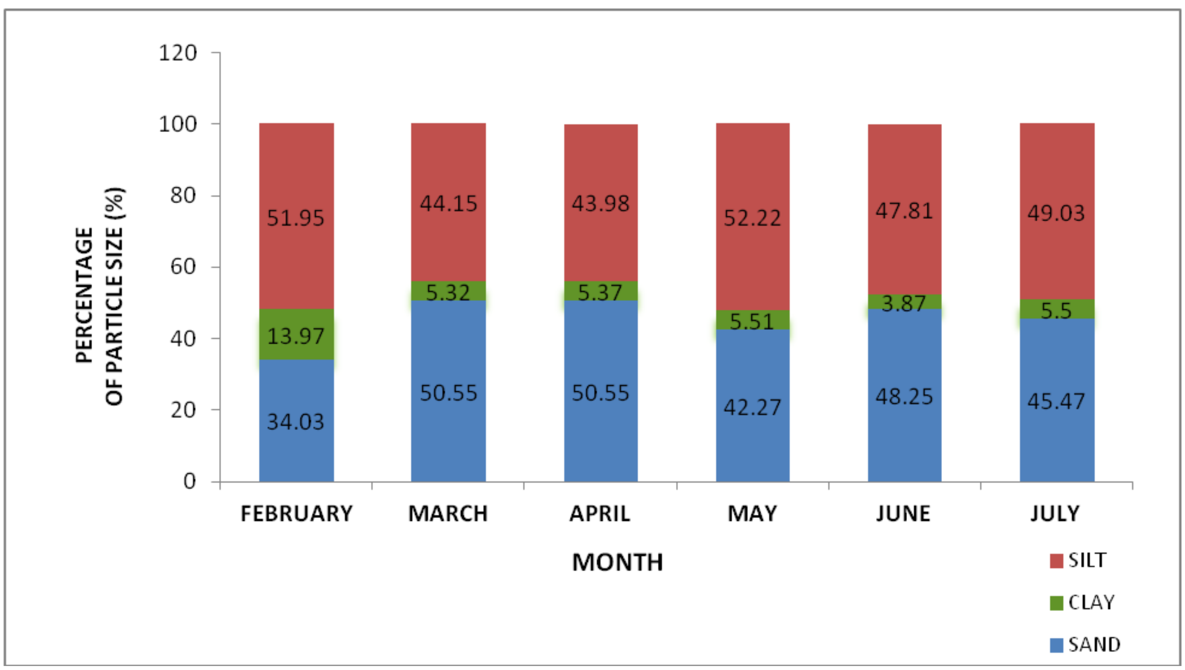


**Figure 4.1.9: Percentage of soil particle (sand, silt and clay) for Site 2.**

**Table 4.1.5: The total mean of variables of water samples at both sites during 6 months.**

| Variables | Means ± sd | | |
|---|---|---|---|
| | Site 1 | Site 2 | T-Test |
| Temperature (°C) | 29.34 (± 2.52)<br>N=72 | 20.31(± 11.81)<br>N=96 | * |
| pH | 6.84 (± 1.38)<br>N=72 | 5.30 (± 3.14)<br>N=96 | * |
| Salinity(ppt) | 27.3 (±3.13)<br>N=72 | 20.8 (±12.17)<br>N=96 | * |
| TDS(ppm) | 31 886 (±11 068)<br>N=72 | 21 180 (±14 615)<br>N=96 | ns |
| DO (ppm) | 2.01 (±1.89)<br>N=72 | 1.42 (±1.84)<br>N=96 | ns |
| EC (mS) | 60.53 (±18.82)<br>N=72 | 39.89 (±26.78)<br>N=96 | ns |
| Rh (%) | 65.04 (± 10.27)<br>N=72 | 68.98 (± 14.83)<br>N=96 | ns |

ns= not significant difference ( $P > 0.05$).

* = significant difference ($P < 0.05$).

Table 4.1.5 shows that there was a significant difference in temperature ($F= 138.2$ $P= 0.00$, $N= 168$), pH ($F=62.68$, $P= 0.00$, $N=168$), salinity ($F= 62.67$, $P= 0.00$, $N=168$), between the two sites. The mean of temperature, salinity and pH at site 1 were higher than site 2. But the table shows that there was no significant difference between the two sites in the mean of TDS (F=2.596, P= 0.109, N= 168), DO (F=3.310, P= 0.071, N= 168) and EC ( F=3.842, P= 0.052, N= 168). There was no significant difference also for relative humidity (RH) percentage (F=1.662, P= 0.199, N= 168). There was not much difference between the mean value of RH for both sites. The mean value of dissolved oxygen at site 2 was less than site 1 which was 1.42 ppm only. The mean value for TDS and EC were also less than site 1. TDS mean value was 21180 ppm and EC 39.89 mS.

# Chapter 5

## Discussion

### 5.1 Physical-chemical parameters

### 5.1.1. Water Quality

In this study, mean temperature recorded was 27.0 (± 0.89) to 33.03 (± 1.88) °C for Site 1 and Site 2. The low temperature of seawater during February to July coincides with the period of Northwest and Southwest monsoon. The Northeast Monsoon brings in more rainfall compared to the Southwest Monsoon (Malaysian Meteorological Department, 2008). Chong (1993) recorded the mean temperature was 30.04 (± 0.62) °C in the Klang straits. The results of current study was higher than Chong (1993) but quite similar to Ong (2008) which shows 28.30 (± 0.71) to 34.8 (± 0.69) °C. The results of Kamaruzzaman *et al.*, (2006) of Setiu Estuary recorded 32.02 (±0.82) °C also almost near to this study.

Surface water temperature at Site 1 was higher compared to Site 2 throughout the 6 months. At Site 1, the water temperatures changed significantly. This was probably due to the rainfall. Rainfall can influence the air and water temperature, the salinity of the surface and ground, which in turn affect the survival of mangrove species (Guyana Mangrove Restoration Project, 2006). There is a slight increase of water temperature at Site 2 between June and July. Site 2 is featuring the loss of mangrove species. The climatic factors, temperature, rainfall and wind give a huge influence on the composition and quality of mangrove vegetation (Hong, 1991).

Both sites record high and almost constant salinity (25.42-29.58 ppt) but became slightly lower during May to July. The low salinity values recorded in May to July were due to seasonal factors.

The lower salinity occurred during the beginning of Southwest Monsoon which starts in May and ends in October. The results of current study were lower than Chong (1993) and Kamaruzzaman *et al.*, (2006). Chong recorded 30.25 ppt while Kamaruzzaman *et al.*, obtained 30.6 ppt. Lower result of salinity in this study may due to Southwest Monsoon. When the southwest monsoon prevails, the surface temperature is high and salinity is low. Mangroves grow in areas with surface water salinity from 0 to 40 parts per thousand (Hutchings & Saenger, 1987).

There was a significant difference in salinity between the two sites. Site 2 which was degraded records very low salinity values for 3 months in a row (May-July). Salinity at high levels also affects mangroves. Salinity fluctuations also have negative effect on the photosynthesis and growth of plants ( Lin & Sternberg, 1993).

The pH values recorded during this study for Site 1, were slightly alkaline from 7.11 to 8.05. pH changed to alkaline level in May and July 2008 in Site 1.The range of pH in Site 2 was slightly acidic 6.44 to alkaline 7.63. pH for site 2 was slightly acidic, this may due to losses of mangroves at this site and man-made pressures through fishing activities. The pH range is from alkaline to acidic for site 2 throughout the 6 months. There were significant differences of pH between the two sites throughout the study period. These values are still within the accepted limits of the pH range, which is 6.6 to 8.5 for primary contact recreation and aqualculture (USEPA, 1976). Besides man-made pressures, the mangroves are degraded by environmental stress factors. Numerous case studies describe mangrove losses over time, but information on the status and trends of mangrove area at the global level is scarce (Kathiresan & Bingham, 2001).

In this study, dissolved oxygen was from the range 1.01 ppm to 6.02 ppm. The lowest value was recorded during April 2008 in Site 2 which was about 0.56 ppm corresponded with Inter monsoon period in April to May. Record of the lowest value during this period is much lower compared to Ong (2008) who reported that dissolved oxygen concentration between the range 2.93 to 4.9 ppm while Chong (1993) reported that dissolved oxygen between the range 4.2-6.4 ppm. Meanwhile, Kamaruzzaman *et al.*,

(2006) recorded the average dissolved oxygen was 5.74 (± 0.83) ppm quite similar to study by Chong (1993).

Dissolved oxygen concentration in Site 2 was also lower compared to Site 1. Lack of dissolved oxygen at this site may cause solid from dissolved solids in water to decrease the photosynthetic rate in water. The presence of solids could be attributed to the eroded coastline that occurred at Site 2. The concentration of dissolved oxygen in water depends on the temperature, salinity, depth and turbulence (Ong, 2008). There was no significant difference in dissolved oxygen between the two sites. Lack of dissolved oxygen may cause solid from dissolved solid and suspended solids in water to decrease the photosynthetic rate in water (Ong, 2008). The presence of solid may be contributed by the eroded coastline especially in Site 2 which faced the erosion by the tidal waves.

Both sites have high total dissolved solids (TDS). High contents of TDS in Site 1 could be due to wave-energy transport of soil and suspended particles in seawater while in Site 2; it could be due to erosion of the coastline. There were no significant differences in TDS between the two sites.

The range of conductivity value for both sites was high (22.69-77.02 mS) compared to the normal range of conductivity. The normal range of conductivity level in full strength of seawater (35 ppt) has a conductivity of 53 miliSeimens (Smith III, 1992). This phenomenon may be caused by the seawater being mixed with other source (Ong, 2008). There was no significant difference in conductivity between the two sites. The loss of mangrove habitats has declined fishery resources, livelihood, and biodiversity loss. Besides over-hunting and accidental death in fishing nets, loss of mangrove and sea grass habitats are considered to be a major cause for the serious decline in the population of marine mammals such as Manatees and Dugongs (Alvarez-Leon, 2001).

In overall, the water parameters featured high and almost constant salinity, high water temperature, high conductivity but relatively low dissolved oxygen concentration and high Total Dissolved Solid (TDS) in Site 1. On the other hand, Site 2 recorded high salinity with low water temperature. Site 2 also featured relatively low dissolved oxygen and high TDS. The water pH for both sites from 6.54-8.16. These results are compared with water quality reported by other researchers as shown in Table 5.1.1.

**Table 5.1.1: Comparison of water quality range from this study to those other study**

| Studies / Location | Temperature | DO (ppm) | Salinity (ppt) | Conductivity (mS) | pH |
|---|---|---|---|---|---|
| 1.Chong (1993) Klang Staits | 30.04 (± 0.62) | 4.2-6.4 | 30.25 (± 1.36) | - | 8.06 (± 0.17) |
| 2. Kamaruzzaman et al., (2006) Setiu Estuary, Terengganu. | 32.02 (± 0.82) | 5.74 (± 0.83) | 30.6 (± 1.40) | - | 8.07 (± 0.08) |
| 3. Ong (2008) Sungai Besar, Selangor. | 28.30 (± 0.71) - 34.8(±0.69) | 2.93 (± 0.29) - 4.90 (±0.20) | 21.53 (± 1.16) - 32.47 (±0.61) | 28.05 (± 1.06) - 44.21(±0.20) | 6.42 (± 0.27) - 8.7 (±0.05) |
| 4. This Study | 27.0(± 0.89) - 33.03(± 1.88) | 1.01 (±1.05) - 6.02 (±2.03) | 25.42(±1.76) - 28.75 (±0.77) | 22.69(±12.67) - 77.02 (±11.88) | 6.44(±0.45) - 8.05 (±0.41) |

### 5.1.2. Relative Humidity (Rh)

Average percentages of Relative Humidity (Rh) almost constant for Site 1 but fluctuated at Site 2. The ranges of Rh value for both sites were 47.65 % to 79.22 %. Overall, the Rh percentage was high for both study sites. High percentages of humidity for both sites may have been due to the increased density of vegetation cover and subsequent higher levels of transpiration. Humidity does not seem to be a factor influencing the distribution of plant species across the study site.

Maximum humidity generally occurs about daybreak, at the time of minimum temperature. After sunrise, humidity drops rapidly and reaches a minimum at about the time of maximum temperature. It rises more gradually from late afternoon through the night. The daily range of humidity is usually greatest when the daily range of temperature is greatest (Forest Encyclopedia Network, 2008).

### 5.1.3 Soil Characteristic in relation to vegetation.

Soil condition is considered as a main factor in the restoration of terrestrial habitats (Bradshaw, 1987). In this study, Site 1 was dominated by silt and average percentages of silt for 6 months are between 72-76.5%. In terms of physical properties, all the soil samples collected have a clay texture for both sites. But percentage of clay in Site 1 is higher compared to Site 2. Site 1 was dominated with silt and content of silt from 60% to 93%. Based on the soil triangle, soil type of Site 1 was determined as silt loam (0.33% of sand, 75.78% of silt and 24.05% of clay).

Site 2 was dominated with sand and silt loam. The sand content from 60% to 99% while silt content ranges from 59% to 89%. Organic content in clay is higher compared to sand (Lihan *et al.*, 2006).

High organic content contributed to species diversity in Site 1. This results supported by study from George (1982) who indicated that clay and silt component contribute more than 95% of the total weight in his study on mangrove area in Kuantan. Four species were found in Site 1: *Avicennia, Rhizophora*, *Sonneratia* and *Bruguiera*. Another study from Ukpong (1997) recorded that silt was dominant and the most variable particle size fraction in mangrove swamp of Nigeria. A principal of component analysis of soil data indicated the first three dominant components influencing the vegetation were salinity, nutrient and soil texture. In this study, high percentages of silt content may contribute to the variety of species growth at Site 1.

Average percentage of sand for 6 months was in the range from 34 to 50.55% and average for silt is from 44-52.22% in Site 2. Some species were only found in Site 2 such as *Rhizophora* and *Bruguiera.* According to Chong (1993) who conducted a study for the eroding stretch of beach from Jeram to Sungai Serdang, the relative amounts of silt and clay fractions were smaller and the sediment also contained a high amount of fine and coarse shell materials.

In this study, only few species were found in site 2, this is because the sand percentage is higher and this coincided with Chong's Study. Based on the soil triangle, soil type of Site 2 was determined as loam (45.19 % of sand, 48.19% of silt and 6.59% of clay). The high percentage of sand at this site leads to loss of mangrove species.

This statement is supported by Kathiresan (2000) who recorded 88.75% of sand composition (including coarse, medium and fine sands), 12.39% course silt and 2.14% silt and clay composition in degrading mangrove habitat in Pichavaram.

Typical of intertidal areas, silt and clay is the main component of Mangrove sediment. They ranged from 60-95% for the Matang mangroves as compared to only 45-

95% for the Kemaman Mangroves (Lokman *et al*., 2004). These study results are compared with percentage of silt and clay reported by other researchers as shown in Table 5.1.2.

**Table 5.1.2: Comparison of soil component from this study to those other study**.

| Soil Component / Location /Studies | Kemaman Mangroves (Saad *et al*., 1999) | Larut Matang Mangroves (Lokman *et al*., 2004). | This Study | |
|---|---|---|---|---|
| | | | Site 1 | Site 2 |
| % Silt and Clay | 45-95 | 60-93 | 72-98 | 47-55 |
| % Sand | 5-55 | 5-40 | 2-28 | 45-53 |

Table 5.1.2 recorded that Kemaman Mangroves have almost same percentage of silt and clay with Site 2 (this study) while Larut Matang mangroves percentages of silt and clay quite near to Site 1 in this study. Having more silt and clay with less sand content resulted in the mean grain size of the Larut Matang mangroves to be finer compared to mean grain size of the Kemaman mangroves (Lokman *et al*., 2004). This statement can be applied to this study which indicated that mean grain size of of Site 1 more finely compared to Site 2.

One implication of having more clay is that sediment becomes stronger as mud particles tend to adsorb themselves to one another to form flocs. These clay flocs take a lot more energy to disperse than unconsolidated sandy sediments. Once the flocs settle onto the mud surface and their content of water are reduced, they become much stronger and gives strength to mangrove soil (Lokman *et al*., 2004). The strength of mangrove soil which contained high percentages of silt and clay contributed to diversity of species found at Site 1 compared to Site 2 with low percentages of silt and clay. Vegetation can grow better with the help of fertile and strength mangrove soil.

### 5.1.4. Light intensity

The light intensity for Site 1, where data were taken under canopy and gap area, was in the range from 3300 to 103,600 Lux. This result was quite low compared with a study by Kathiresan (2000) who recorded the light intensity in a luxuriant mangrove habitat as 26860 Lux in Pichavaram.  In the degraded mangrove site (Site 2), the light intensity was higher from 15,400 to 109,700 Lux, as the habitat was more exposed. These results agreed with a study by Ong (2008) who recorded 38043 Lux in degrading mangrove habitats as well as Kathiresan (2000) recorded 38043 Lux. Sunlight intensity and duration influences the levels of photosynthetic productivity. The shade of mature plants restricted the growth and distribution of ground covers, including the growth of mangrove seedlings.

## 5.2 Erosion and Mangrove Degradation at the Study Site

Currently, Site 2 in Carey Island faces the coastline erosion due to several factors. One of the factors is fishing and shipping activities. Speedboat for fishing and industrial ship also can cause shoreline erosion as well as pollute the sea. Our human activity combined with natural factors have caused serious erosion at the study site. As a result, the mangrove habitat is depleted and it was shown by the decrease in mangrove vegetation in site 2.

The species found here are *Rhizophora* and *Bruguiera* only. When the mud level around the mangrove trees are lowered due to erosion, the vegetation roots was exposed to the sea (Ong, 2008).

At site 2, most of the mangrove trees were collapsed due to strong wave during high tide and the seeds of the mangroves were washed away by the waves. This phenomenon happened because Site 2 is facing the open sea and frequently exposed to strong waves and wind. Besides that, the thin layer of mangrove showed that this area received physical stress from inland activities compared to Site 1 which was less exposed to inland activities.

Neglecting or ignoring the physical environment and processes that shapes and allow the mangroves to remain in its location will result in erosion and finally vegetation die-off or destruction due to erosion. When this happens, all management and conservation efforts will finally come to naught (Lokman *et al*., 2004).

# Chapter 6

# Conclusion

Comparison between the two mangrove habitats shows that in Site 1; the water parameters featured high and almost constant salinity, high water temperature, high conductivity but relatively low dissolved oxygen concentration and high TDS. On the other hand, Site 2 ; high in salinity but lower water temperature. Site 2 also featured relatively low dissolved oxygen and high TDS. The water pH for both sites is from 6.54 to 8.16. These results indicated that there were differences between water temperature and salinity in these two sites but the TDS and conductivity showed not much difference. The T-Test also resulted that there were significant differences for temperature, pH and salinity between the two sites. These results indicated that some of the physical parameters were changed due to degradation of the mangrove but some parameters are not influenced by the changes.

For the soil physical characteristic, Site 1 showed the high percentage of silt but Site 2 dominated by high percentage of sand composition. The soil texture analysis indicated that degraded mangrove in site 2 featured high amount of fine and course material which leads to the loss of mangrove vegetations. The roots of mangroves trees may die due to the sand composition on the surface of mangrove habitat and the soil condition changed became unsuitable for mangroves to grow. Both sites contained percentage of clay however percentage of clay in Site 1 is higher compared to Site 2 . Organic content in clay is higher compared to sand in Site 2. This may be contributing factors that cause more species of mangroves at Site 1.

For the light intensity, t-test showed differences between the two sites. The light intensity for Site 1 is lower, where data was taken under canopy and gap area but for the degraded mangrove site (Site 2), the light intensity was higher and the habitat was more exposed. The results indicated that there are fewer mangroves trees in the degraded site because most of them have fallen.

It is necessary to propose project to replant mangrove trees especially in site 2 which is degrading and throughout the period of this study, a hard engineering structure known as breakwater was installed in Site 2 area in January 2009. This integrated approach for mangrove restoration protects the restoration area from strong wave action (Hashim *et al.*, 2010). The breakwater at Site 2 can become a study site for mangrove replanting and coastline protection education, either for universities or other research institutions in future. For the future approach, a-bio technical method which involves hard and soft engineering structure can be applied in order to improve the degraded site and to protect the non-degraded site. As a recommendation, the respective authority should review the policy and regulation in order to conserve our mangrove forest.

Last but not least, forestry officers, academicians and researchers should exchange ideas and work together in the management of our mangroves.

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## Appendix 1

### Table 1.1 : One- Sample Statistics of Water Temperature

| | N | Mean | Std. Deviation | Std. Error Mean |
|---|---|---|---|---|
| WTEMPFEB1 | 12 | 33.0333 | 3.88899 | 1.12265 |
| WTEMPFEB2 | 12 | 26.7250 | .64262 | .18551 |
| WTEMPMAC1 | 12 | 27.8333 | .29949 | .08646 |
| WTEMPMAC2 | 12 | 27.1167 | .38573 | .11135 |
| WTEMPAPR1 | 12 | 29.3667 | 2.44106 | .70467 |
| WTEMPAPR2 | 12 | 27.0000 | .32753 | .09455 |
| WTEMPMAY1 | 12 | 28.1750 | .53957 | .15576 |
| WTEMPMAY2 | 12 | 27.0000 | .32753 | .09455 |
| WTEMPJUN1 | 12 | 28.7667 | .46969 | .13559 |
| WTEMPJUN2 | 12 | 27.0250 | .32787 | .09465 |
| WTEMJULY1 | 12 | 28.9417 | .36546 | .10550 |
| WTEMJULY2 | 12 | 27.9000 | 1.17473 | .33912 |

### Table 1.2: One- Sample Statistics of Salinity

| | N | Mean | Std. Deviation | Std. Error Mean |
|---|---|---|---|---|
| SALFEB1 | 12 | 26.6667 | 5.36543 | 1.54887 |
| SALFEB2 | 12 | 27.9167 | 3.96481 | 1.14454 |
| SALMAC1 | 12 | 28.7500 | 2.26134 | .65279 |
| SALMAC2 | 12 | 28.7500 | 4.33013 | 1.25000 |
| SALAPR1 | 12 | 26.6667 | 2.99495 | .86457 |
| SALAPR2 | 12 | 29.5833 | 1.44338 | .41667 |
| SALMAY1 | 12 | 27.5000 | 2.61116 | .75378 |
| SALMAY2 | 12 | 25.4167 | 3.96481 | 1.14454 |
| SALJUNE1 | 12 | 27.4167 | 2.31432 | .66809 |
| SALJUNE2 | 12 | 25.8333 | 4.17424 | 1.20500 |
| SALJULY1 | 12 | 26.6667 | 2.05971 | .59459 |
| SALJULY2 | 12 | 25.8333 | 3.58870 | 1.03597 |

## Appendix 2

## Table 2.1 : One- Sample Statistics of pH

| | N | Mean | Std. Deviation | Std. Error Mean |
|---|---|---|---|---|
| PHFEB1 | 12 | 7.1108 | .36850 | .10638 |
| PHFEB2 | 12 | 7.4125 | .16998 | .04907 |
| PHMAC1 | 12 | 7.2758 | .24582 | .07096 |
| PHMAC2 | 12 | 7.4800 | .39178 | .11310 |
| PHAPRL1 | 12 | 7.7483 | .33951 | .09801 |
| PHAPRL2 | 12 | 7.6283 | .27584 | .07963 |
| PHMAY1 | 12 | 8.0542 | .09895 | .02856 |
| PHMAY2 | 12 | 6.8433 | .28202 | .08141 |
| PHJUNE1 | 12 | 7.9708 | .08229 | .02376 |
| PHJUNE2 | 12 | 6.4417 | .42069 | .12144 |
| PHJULY1 | 12 | 8.0050 | .05568 | .01607 |
| PHJULY2 | 12 | 6.9883 | .45017 | .12995 |

## Table 2.2: One- Sample Statistics of Dissolved Oxygen

| | N | Mean | Std. Deviation | Std. Error Mean |
|---|---|---|---|---|
| DOFEB1 | 12 | 4.9483 | 1.20144 | .34683 |
| DOFEB2 | 12 | 6.0217 | .43085 | .12438 |
| DOMAC1 | 12 | 3.6617 | 1.31892 | .38074 |
| DOMAC2 | 12 | 1.6142 | .06947 | .02006 |
| DOAPR1 | 12 | 2.4108 | .79008 | .22808 |
| DOAPRL2 | 12 | .5617 | .06562 | .01894 |
| DOMAY1 | 12 | 4.0292 | .46928 | .13547 |
| DOMAY2 | 12 | 1.4900 | .37613 | .10858 |
| DOJUNE1 | 12 | 3.7742 | .50649 | .14621 |
| DOJUNE2 | 12 | .9242 | .13153 | .03797 |
| DOJULY1 | 12 | 4.9583 | .20524 | .05925 |
| DOJULY2 | 12 | 1.0058 | .09288 | .02681 |

## Appendix 3

### Table 3.1: One- Sample Statistics of TDS

| | N | Mean | Std. Deviation | Std. Error Mean |
|---|---|---|---|---|
| TDSFEB1 | 12 | 24200.0000 | 5687.62612 | 1641.87624 |
| TDSFEB2 | 12 | 26416.6667 | 5075.58028 | 1465.19382 |
| TDSMAC1 | 12 | 18375.0000 | 3818.88251 | 1102.41642 |
| TDSMAC2 | 12 | 24450.0000 | 10881.30173 | 3141.16124 |
| TDSAPR1 | 12 | 32950.0000 | 9426.70288 | 2721.25472 |
| TDSAPR2 | 12 | 28225.0000 | 6942.11456 | 2004.01585 |
| TDSMAY1 | 12 | 35600.0000 | 9620.43280 | 2777.17973 |
| TDSMAY2 | 12 | 28275.0000 | 10960.02032 | 3163.88534 |
| TDSJUNE1 | 12 | 44166.6667 | 2593.11443 | 748.56766 |
| TDSJUNE2 | 12 | 32616.6667 | 4013.12241 | 1158.48865 |
| TDSJULY1 | 12 | 35508.3333 | 2991.94626 | 863.70049 |
| TDSJULY2 | 12 | 30608.3333 | 2995.28670 | 864.66479 |

### Table 3.2: One- Sample Statistics of Conductivity

| | N | Mean | Std. Deviation | Std. Error Mean |
|---|---|---|---|---|
| CONFEB1 | 12 | 47.8250 | 11.36455 | 3.28066 |
| CONFEB2 | 12 | 54.5083 | 8.83366 | 2.55006 |
| CONMAC1 | 12 | 37.3167 | 8.69669 | 2.51052 |
| CONMAC2 | 12 | 40.4758 | 15.46869 | 4.46543 |
| CONAPRL1 | 12 | 70.3583 | 18.90082 | 5.45620 |
| CONAPRL2 | 12 | 57.7333 | 13.35742 | 3.85595 |
| CONMAY1 | 12 | 66.0417 | 17.02744 | 4.91540 |
| CONMAY2 | 12 | 50.2167 | 4.44846 | 1.28416 |
| CONJUN1 | 12 | 77.0250 | 5.90810 | 1.70552 |
| CONJUN2 | 12 | 45.8417 | 8.32253 | 2.40251 |
| CONJULY1 | 12 | 76.9167 | 3.33598 | .96302 |
| CONJULY2 | 12 | 49.3833 | 5.19140 | 1.49863 |

## Appendix 4

## Table :4.1 One- Sample Statistics of Relative Humidity

**One-Sample Statistics**

| | N | Mean | Std. Deviation | Std. Error Mean |
|---|---|---|---|---|
| RHFEB1 | 12 | 59.5167 | 17.12695 | 4.94412 |
| RHFEB2 | 16 | 79.2250 | 2.43132 | .60783 |
| RHMAC1 | 12 | 66.5333 | 7.38873 | 2.13294 |
| RHMAC2 | 16 | 47.6500 | 3.45447 | .86362 |
| RHAPRIL1 | 12 | 63.0583 | 4.93235 | 1.42385 |
| RHAPRIL2 | 16 | 75.4750 | 4.82072 | 1.20518 |
| RHMAY1 | 12 | 56.8758 | 3.04782 | .87983 |
| RHMAY2 | 16 | 66.1250 | 5.07090 | 1.26772 |
| RHJUN1 | 12 | 67.9833 | 3.38226 | .97637 |
| RHJUN2 | 16 | 76.5500 | 4.66619 | 1.16655 |
| RHJULY1 | 12 | 74.3167 | 6.04466 | 1.74494 |
| RHJULY2 | 16 | 75.5000 | 3.32826 | .83207 |

**Appendix 5**

**Vegetation in Site 1**

**Station 1**

Rep 1.1 – *Avicennia alba*
*Avicennia marina*
*Sonneratia alba*

Rep 1.2- *Avicennia alba*
*Rhizophora apiculata*

Rep 1.3- *Avicennia alba*
*Sonneratia caseolaris*
*Rhizophora apiculata*

Rep 1.4- *Avicennia alba*

**Station 2**

Rep 2.1-*Avicennia officinalis*
*Bruguiera parviflora*

Rep 2.2- *Rhizophora apiculata*
*Rhizophora mucronata*

Rep 2.3- *Rhizophora mucronata*

Rep 2.4- *Rhizophora mucronata*

**Station 3**

Rep 3.1- *Rhizophora mucronata*
*Sonneratia alba*

Rep 3.2- *Rhizophora mucronata*

Rep 3.3- *Rhizophora mucronata*

Rep 3.4- *Rhizophora mucronata*

**Vegetation in Site 2**

**Station 1**

**Rap 1.1-** *Rhizophora apiculata*
*Scaevola taccada*

**Rap 1.2-***Avicennia alba*
*Rhizophora apiculata*

**Rap 1.3** - *Rhizophora apiculata*
*Bruguiera gymnorrhiza*

**Rap 1.4**- *Rhizophora apiculata*
*Avicennia officinalis*

## Appendix 6

## Table 6.1 : Means and Standard Deviation for each parameter at both sites

**Group Statistics**

| | SITE | N | Mean | Std. Deviation | Std. Error Mean |
|---|---|---|---|---|---|
| light | Site 1 | 72 | 94311.1111 | 157926.88499 | 18611.86188 |
| | Site 2 | 96 | 284912.5000 | 365461.76854 | 37299.78556 |
| watertemp | Site 1 | 72 | 29.3417 | 2.52630 | .29773 |
| | Site 2 | 96 | 20.3198 | 11.81294 | 1.20565 |
| ph | Site 1 | 72 | 6.8421 | 1.38233 | .16291 |
| | Site 2 | 96 | 5.3075 | 3.14368 | .32085 |
| d0 | Site 1 | 72 | 2.0072 | 1.89338 | .22314 |
| | Site 2 | 96 | 1.4285 | 1.84308 | .18811 |
| ec | Site 1 | 72 | 60.5361111 | 18.81963543 | 2.21791531 |
| | Site 2 | 96 | 39.8927083 | 26.77848015 | 2.73306719 |
| tds | Site 1 | 72 | 31886.1111 | 11068.77737 | 1304.46792 |
| | Site 2 | 96 | 21180.2083 | 14615.18763 | 1491.65634 |
| rh | Site 1 | 72 | 65.0418 | 10.27730 | 1.21119 |
| | Site 2 | 96 | 68.9812 | 14.83155 | 1.51374 |

## Appendix 7

## Independent sample Test for Light intensity, water temperature, do, pH, salinity, TDS, conductivity and relative humidity.

**Independent Samples Test**

| | | Levene's Test for Equality of Variances | | t-test for Equality of Means | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | 95% Confidence Interval of the Difference | |
| | | F | Sig. | t | df | Sig. (2-tailed) | Mean Difference | Std. Error Difference | Lower | Upper |
| light | Equal variances assumed | 78.236 | .000 | -4.142 | 166 | .000 | -190601.38889 | 46012.01028 | -281445.55860 | -99757.21918 |
| | Equal variances not assumed | | | -4.572 | 136.845 | .000 | -190601.38889 | 41685.43397 | -273032.29982 | -108170.47796 |

**Independent Samples Test**

| | | Levene's Test for Equality of Variances | | t-test for Equality of Means | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | 95% Confidence Interval of the Difference | |
| | | F | Sig. | t | df | Sig. (2-tailed) | Mean Difference | Std. Error Difference | Lower | Upper |
| watertemp | Equal variances assumed | 138.194 | .000 | 6.368 | 166 | .000 | 9.02187 | 1.41683 | 6.22455 | 11.81920 |
| | Equal variances not assumed | | | 7.265 | 106.410 | .000 | 9.02187 | 1.24187 | 6.55986 | 11.48389 |

**Independent Samples Test**

| | | Levene's Test for Equality of Variances | | t-test for Equality of Means | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | 95% Confidence Interval of the Difference | |
| | | F | Sig. | t | df | Sig. (2-tailed) | Mean Difference | Std. Error Difference | Lower | Upper |
| d0 | Equal variances assumed | 3.310 | .071 | 1.991 | 166 | .048 | .57868 | .29072 | .00469 | 1.15267 |
| | Equal variances not assumed | | | 1.983 | 150.839 | .049 | .57868 | .29185 | .00204 | 1.15532 |

**Independent Samples Test**

| | | Levene's Test for Equality of Variances | | t-test for Equality of Means | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | 95% Confidence Interval of the Difference | |
| | | F | Sig. | t | df | Sig. (2-tailed) | Mean Difference | Std. Error Difference | Lower | Upper |
| ph | Equal variances assumed | 62.678 | .000 | 3.869 | 166 | .000 | 1.53458 | .39665 | .75145 | 2.31771 |
| | Equal variances not assumed | | | 4.265 | 138.022 | .000 | 1.53458 | .35984 | .82307 | 2.24609 |

**Independent Samples Test**

| | | Levene's Test for Equality of Variances | | t-test for Equality of Means | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | 95% Confidence Interval of the Difference | |
| | | F | Sig. | t | df | Sig. (2-tailed) | Mean Difference | Std. Error Difference | Lower | Upper |
| tds | Equal variances assumed | 2.596 | .109 | 5.196 | 166 | .000 | 10705.90278 | 2060.30358 | 6638.12640 | 14773.67915 |
| | Equal variances not assumed | | | 5.403 | 165.978 | .000 | 10705.90278 | 1981.58401 | 6793.54326 | 14618.26230 |

**Independent Samples Test**

| | | Levene's Test for Equality of Variances | | t-test for Equality of Means | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | 95% Confidence Interval of the Difference | |
| | | F | Sig. | t | df | Sig. (2-tailed) | Mean Difference | Std. Error Difference | Lower | Upper |
| ec | Equal variances assumed | 3.842 | .052 | 5.586 | 166 | .000 | 20643.40278 | 3695.46937 | 13347.22415 | 27939.58141 |
| | Equal variances not assumed | | | 5.865 | 165.365 | .000 | 20643.40278 | 3519.77336 | 13693.91511 | 27592.89045 |

**Independent Samples Test**

| | | Levene's Test for Equality of Variances | | t-test for Equality of Means | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | 95% Confidence Interval of the Difference | |
| | | F | Sig. | t | df | Sig. (2-tailed) | Mean Difference | Std. Error Difference | Lower | Upper |
| rh | Equal variances assumed | 1.662 | .199 | -1.932 | 166 | .055 | -3.93944 | 2.03908 | -7.96531 | .08643 |
| | Equal variances not assumed | | | -2.032 | 165.057 | .044 | -3.93944 | 1.93866 | -7.76721 | -.11168 |

**Independent Samples Test**

| | | Levene's Test for Equality of Variances | | t-test for Equality of Means | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | 95% Confidence Interval of the Difference | |
| | | F | Sig. | t | df | Sig. (2-tailed) | Mean Difference | Std. Error Difference | Lower | Upper |
| salinity | Equal variances assumed | 88.019 | .000 | 4.418 | 166 | .000 | 6.50000 | 1.47115 | 3.59543 | 9.40457 |
| | Equal variances not assumed | | | 5.014 | 111.378 | .000 | 6.50000 | 1.29644 | 3.93111 | 9.06889 |