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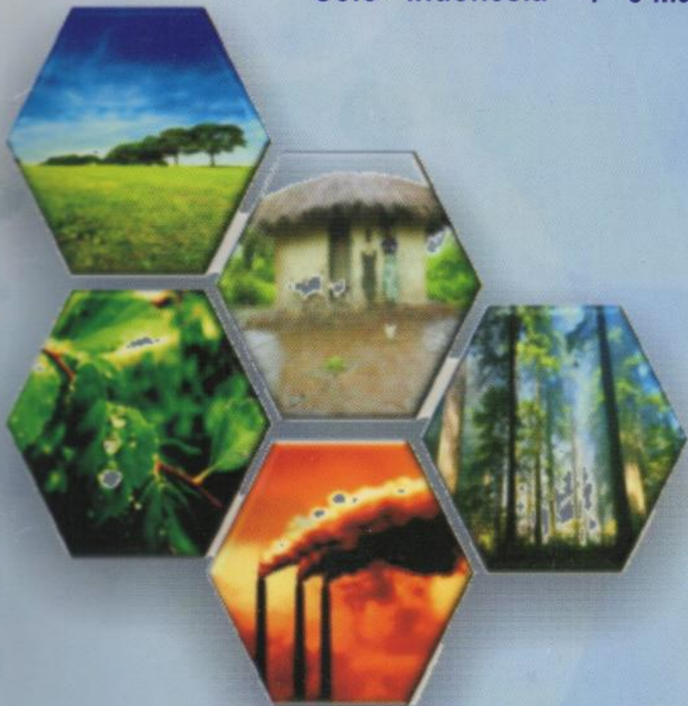

Editors :

SA Kristiawan, PhD
Dr. Puguh Karyanto
Dr.(Tech) Sholihin As'ad
Prof. Dr. Sobriyah
Setiono, MSc

Collaboration of
Environmental Science Department of Postgraduate Program &
Civil Engineering Department
Sebelas Maret University (UNS Solo)
Jl. Ir. Sutami 36A Surakarta Ph. 0271.821490 e-mail: eicm2011@gmail.com

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ENVIRONMENTAL INSIGHT for CLIMATE CHANGE MITIGATION

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PREFACE

Many human activities induce climate change. The future change in our climate could be accelerating if an escalation of CO_2 concentration in atmosphere from industrial and daily human activities fails to be controlled. The impacts of climate change are widespread and complex, and are projected to various aspects according to the timing and magnitude of change, as well as according to adaptive capacity. It is clear, however, that climate change impacts have serious implications for the livelihoods of billions of people worldwide, and pose one of the greatest challenges to development in our time. Therefore, urgent actions are required to respond on a global scale to avoid irreversible damages imposed by climate change.

Assessments of climate change impact on a variety of area and facets are the first steps toward better planning in and developing the mitigation, preservation and adaptation strategies. This proceeding compiles articles categorized in six chapters which reflect the broad spectrum and perspectives of authors in dealing with impact of climate change and developing mitigation, preservation and adaptation strategies. The first chapter comprises investigations of climate change effect on climatology and ecosystem. The chapter also offers approaches to combat the effect and provide protocols which could help in recovering environment. Chapter two assesses interrelation between water resources and land management with environment and climate change including protocols to preserve the resources. Aspects of climate change impact on urban planning and housing are presented in chapter three. In chapter four, environmental awareness is implemented in construction activities and their product such as introduction of low energy building, utilization of waste materials and possible obtaining renewable energy from non fossil fuel. Politic, economic and social issues related to climate change are dealt in chapter five. And the last chapter suggests the use of vegetation for obtaining healthy food and medicine with less impact on environment.

The knowledge shared in this proceeding may contribute in our efforts to make the earth be a better place.

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The Editors

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MANGROVE SOIL CHARACTERISTICS AND GROWTH OF REPLANTED *Rhizophora apiculata* BL. AT VARIOUS ECOSYSTEMS IN INDONESIA

Munandar[1], Sarno[2], Rujito A. Suwignyo[1], Sabaruddin[3], and A Nose[4]

[1)] Department of Agronomy, Faculty of Agriculture Sriwijaya University, Indonesia.
email: munandar_mun@ymail.com.
[2)]Department of Biology, Faculty of MIPA Sriwijaya University, Indonesia.
[3)] Graduate School of Agricultural Sciences Sriwijaya University.
[4)] Faculty of Agriculture, Saga University, Honjo-machi, Saga-Shi, 840-8502, Japan.

Abstract

Soils are physical foundation of every ecosystem. Soils determine growth and productivity of mangrove forest. This study investigated soil characteristics and its relationship with growth of replanted *Rhizophora apiculata* BL. mangroves at four locations of mangrove forest ecosystems in Indonesia. The research was conducted at Sungai Asam, Riau and East Lampung of the east coast of Sumatera island, at Cilacap of south coast of Java island and at Denpasar of south coast of Bali island. At each research location, growth variables of thirty mangrove stands were measured, and soil samples were collected and analyzed. Results of the studies indicated that soil in four locations of replanted *Rhizophora apiculata* BL mangroves forest in Indonesia has different characteristics. Soil texture of mangrove soil in Riau and East Lampung of Sumatera Island were clay, while those in Cilacap and Bali were respectively sandy clay loam and loam. Mangrove soil in Riau had high pH, low salinity, and high availability of nutrients, in the contrary mangrove soil in Cilacap had low pH, high salinity, and low availability of nutrients, while the characteristics of mangrove soil in East Lampung and Denpasar Bali were in the range in between the values of mangrove soil in Cilacap and in Ria. Growth indicated by parameters of root and plant height, stem diameter, crown volume and biomass production were higher in *Rhizophora apiculata* BL stands grown in Riau and Lampung of Sumatra Islands than those grown in Cilacap of Java and Denpasar of Bali Islands. Soil properties and salinity might be responsible for the discrepancy between mangrove growth in Sumatera and in Java and Bali. Mangroves grew in Sumatra Island developed higher than those grew in Cilacap of Jawa and in Denpasar of Bali, because soils of mangrove in Sumatera were more fertile than those in Jawa and Bali. Mangrove soil in Sumatera was fertile due to compared with the mangrove soil in Java and Bali due to they had high pH, C-organic, total N and available P, Na content and SAR , and low salinity and exchangeable aluminum and H ion; while mangrove soil in Jawa was less fertile due to it had low pH, low C-organic, total N and available P and Na content, and high salinity, exchangeable aluminum and hydrogen ion. The study suggest that ecological aspect of degraded mangrove is going to be rehabilitated should be taken in to consideration, particularly in developing methods of replanting techniques and selecting the species suitable for the selected sites.

Keywords: mangrove, growth, soil,ecosystem,Indonesia.

1. INTRODUCTION

Mangrove play an important ecological role in Indonesia, it is serving as a refuge for wildlife and protecting again coastal erosion and sea wave. Indonesian has 9, 2 million ha mangrove areas, consisted of 3, 7 million ha of the forest concession area and 5, 5 million ha in the non-forest concession areas. (Kusmana,

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2010). Indonesian mangrove comprises nearly 22 per cent of the global total mangrove or about 60 per cent of the mangrove in the south East Asia (Willkie and Fortuna, 2003). The mangrove forest distributed along 95.181 km coastline in 17.000 island, but the most extensive mangroves forest are found in Sumatra (over 570 000 ha), Java (33,800 ha), Kalimantan (1,139,000 ha), Sulawesi (256,800 ha), Lesser Sundas 15,400 ha, Moluccas 148,710 ha and in Papua (1,326,ha) (Kusmana, 2010; Willkie and Fortuna,2003; and Atmaja and Soerojo.1994) (Figure 1).

Over the last decades, a vast track of Indonesian mangrove forest has been destroyed to make way for commercial ponds and beachside development. About 70% (6.44 million ha) of Indonesian remaining mangrove forest (9.2 million) are damaged due to human activities. Loss of mangrove areas (25%) are used for fish and shrimp ponds and 75 % are converted to agriculture and plantations, coastal community settlement and overexploited of commercial logging (Giessen *et a.l*,2006; NACA, 2009.). The protective role that mangrove forest can play to protect our shorelines against the action of waves, wind and current water has received a great deal attention in the aftermath of the Dec. 26th 2004 tsunami that devastated coastal region in South Asia, South East Asia and East Africa (Jayatissa and Wikramasinghe,2006). During this tsunami, human casualties and damages to property in many areas such in Simeuleu Island of Aceh Indonesia were relatively low partly due to the dense mangroves forest around the island, which buffer some of the energy (LaCerve and McAdoo, 2006),

Program is in the progress for promoting rehabilitation and replanting, establishing coastal greenbelts and developing community base-management. The Dec. 26th 2004 tsunami and the huge earthquake brought up the urgency and danger of this ongoing mangrove loss, as well as the urgent need to rehabilitate the degraded coastline areas back to mangrove forest (Miththapala, 2008). Indonesian government during the period of 2001 to 2005 has replanted 19,918 ha of mangrove forest along its vulnerable coastline around the country, as well as replanting 3,973 ha of mangrove forest in tsunami devastated Province of Aceh on North Sumatra by National Movement of Forest and Land Rehabilitation(Department of Forestry,2005). So far the success rate of mangrove replanting in Indonesia was very low, between 15 to 40 % (Babo and Froehlich,1998), and it is not easy to have the planted individuals continue to grow successfully. The failure of post tsunami mangrove replanting programs was also reported in many South and South East Asian Countries as in Bangladesh, Srilanka Thailand, Philippines Malaysia and Singapore (Lewis III, 2001; Malakoff, 2008; Amarasinghe, 2010; Ariff, 2010).

Failure of many post tsunami mangrove rehabilitation projects may caused by the rehabilitation methods which did take account into ecological variables of mangrove forest. In order to achieve a successful mangrove forest rehabilitation program, an appropriate ecological mangrove rehabilitation management is required. The environment of mangrove forests vary from high nutrient and low salinity in the estuaries to hyper saline and low nutrient in the coastlines of many islands and continental in the tropics (Medina, *et al.*, 2010). Sound management of mangrove rehabilitation program should be based on the knowledge of ecology of the mangrove forest and be site-specific management (Matsui *et al.*, 2008.); since zonal structure of mangrove forests differs from place to place, and each targeted degraded mangrove forest areas to be rehabilitated have different environmental conditions.

One of important mangrove ecological variables should be considered is soil characteristics. Soils are the physical foundation for every ecosystem (Sreeja, *at al*. 2009) Many studies indicated that soil properties determined the productivity and structure of the mangrove forest. Soil characteristic pH, salinity, K, Na, C-organic, total N, and Cation Exchange Capacity (CEC) determined the occurrence pattern of mangrove forest community in Talidendang Besar, Riau, and the east coastline of Sumatra (Kusman *et a.,* 2008). The availability of N and P

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concentration regulates mangrove development and become determinant factors of mangrove structural development in Australia (Boto and Wellington. 1984). Because of high salinity and limited nutrient availability in the soil, the morphological characteristics of mangrove communities are not uniform, and mangrove near the sea usually grow dwarf (Medina *et al.*, 2010).
Structure of mangrove in Indonesia varies from place to place depending on coastal physiographic and tidal dynamics (Tomascik, 1977). The degraded mangrove areas that should be rehabilitated exist almost in all big islands in Indonesia which have different mangrove ecological characteristics. A good understanding of mangrove growth characteristics at different mangrove ecosystem (Ong *et al.*, 2004) as well as recognition of the variables dynamics of the ecosystems (Saenger, 1999), are crucial for the management of mangrove forests So far little information is available relating the soil characteristic of mangrove soil and its relationship with the growth of mangrove forest at different ecosystems in Indonesia. This article is reporting studies (1) to investigate physical and chemical characteristic of soil in four locations of replanted mangroves forests in Indonesia, (2) to evaluate the growth and biomass production of replanted mangrove forest grown at different locations in Indonesia, and (3) to find out the relationship between soil properties with growth and biomass production of replanted mangrove forest.

2. MATERIALS AND METHODS

2.1. Study sites

The study was conducted during the period of July 2007 to June 2009 at four locations of different replanted mangrove ecosystems in Indonesia(Fig.1). Two locations were at east coast of Sumatera island: Sungai Asam, Riau (Lat. 0° 36’ N to 1° 07’ S, and Long. 102^{o} 32` to $104^{o}$ 10`E) and East Lampung (Lat. 3° 45’ to 6° N and Long. 105^{o} 45’ to 103^{o} 48` E); one location was at Cilacap, south coast of Java island (Lat. $7^{\circ}$ 30` – 7^{o} 45` 20 S and Long. $102^{\circ}$ 4’ 30” E) and one location was at Denpasar, south coast of Bali island (Lat. $3^{\circ}$ 45’ - $6^{\circ}$ S; Long. $105^{o}$ 45’-$103^{o}$ 48` E) (Figure 1).According to Schmidt and Ferguson (1951), Riau areas are located within the climatic type A, where East Lampung, Cilacap Jawa, and Denpasar Bali are covered by B climatic types. The four locations were chosen because only at those locations were found the replanted mangrove stands which the date of planting is known. The age of replanted mangroves stands in Riau was 4, 5, and 6 year old, in East Lampung was 13 year old, in Cilacap was 4, 5, and 6 year old and in Bali was 14 year old.

2.2. Determination Soil Characteristics

Three sample sites of 10 x 10 m, respectively was 10, 100 and 200 m distance from the river bank were established at each research location for each age of mangrove forest community to explore soil characteristics, and growth of mangrove forest. Soil sample then was taken up to a depth of 20 cm, collected in labeled polyethylene bags and composed. They were brought to the laboratory for physic-chemical analysis. The analysis was conducted by using various standard soil testing procedures. Particle size distribution was determined by the Bouyoucos hydrometer method, while chemical analysis determined following the standard methods. Soil reaction (pH) was measured at 1:1 water suspension, then measured by Ph meter. Total nitrogen determined by the Kjeldahl method. Organic carbon was determined by the wet oxidation of Black method. Available phosphor content was extracted by Bray P1 solution and measured on Spectrophotometer. Sodium and potassium were extracted with 1 N Ammonium acetate solution at pH 7, and the sodium and potassium content were determined by flame photometer. Calcium and magnesium were extracted with EDTA solution and determined with Biuret method. Salinity of water was measured by a handrefractometer.

2.3. Measurement of Growth and Biomass Production

Growth of mangrove forest community was observed in 10 mangrove stands at each site, so there were 30 mangrove stands in three sample sites at each location for each age of

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mangrove forest community. Stem diameter at 30 and 130 cm for stems taller than 40 and 150 cm, respectively, root height, stem height, height to base of crown (CRWNHT), total height (TOTHT), crown length (CRWNL) and width (CRWNW) and stand density were recorded. The product [CRWNHT * CRWNL * CRWNW] provided an index of crown volume (CRWNV). Total biomass of a stand (kg/stand) was determined by alometric method (Ross *et al.,* 2001) with formula: lnTOTWT= 2,528+(1,129 Ln (LnD2))+(0,156 Ln(Ln CRWNV)) x Wood Density. Wood density was obtained by direct measurement from the relationship between volume and weight of many plant organs of 2,4 and 6 year old mangrove stands in Riau.

3. RESULT AND DISCUSSION

There was a difference in physical properties amongst soil in four locations of mangrove forest ecosystem in Indonesia. Soil of mangrove forest in Sumatera Island of Riau and East Lampung had higher percentages of clay fraction, respectively 41.50% and 59.77%, compared with the soil in Cilacap of Jawa island (25.93%) and Denpasar of Bali (16.79%). Soil of mangrove in Cilacap of Jawa Island and Denpasar of Bali had high percentages of sand fraction respectively 59.62% and 47.48%(Table 1). Therefore the soil in Riau and East Lampung of Sumatera were classified as clay texture, while soil in Cilacap of Jawa and Denpasar Bali were classified as sandy clay loam and as loam texture respectively.

Mangrove soil of four locations had different pH. Soil pH was lower in the mangrove soil of Jawa and Bali islands than in Sumatera Island. It was around neutral (6.7) at mangrove soil in East Lampung, slightly acid (5.70) in Riau, acid in Denpasar Bali and very acid in Cilacap of Jawa. Salinity was highest in mangrove soil in Cilacap (30 ppt), followed by soil in Bali (22 ppt) and Riau (20 pt) and was lowest in East Lampung mangrove soil(12 ppt)(Table 1). The trend of C-organic and total N contents were relative almost same in four locations. C-organic was highest (6.6%) in the mangrove soil at Riau, followed by Bali mangrove soil (3.83%), and Cilacap mangrove soil (3.1%) and was the lowest in mangrove soil from East Lampung(2.35%). Total N was also highest in Riau mangrove soil, and was lowest in East Lampung soil (0.19%). The C/N ratio of soil in the four locations, was relatively not different, it ranged from the lowest one 12.4 in East Lampung mangrove soil, to the highest one 16.5 in Riau mangrove soil(Table 2). The observed C/N ratio in four locations were still in the common range of C/N 8:1 – 15:1 and it indicated that organic matters in the soil at four mangrove locations would be in high degree of decomposition (Brady and Weil, 2007) as a results of high microbial activity in wet environment which fragment organic matter producing organic rich rhizosfer horizon (Effiong and Ayolagha,2010).

Available phosphorus content was different among four soils. It was very high in mangrove soil from East Lampung (51.15 ppm), almost the same in the mangrove soil from Riau and Bali (28 ppm) and was very low in mangrove soil from Cilacap. Available K was very high in mangrove soil from Bali (4.7 me/100 g), almost same in the mangrove soil from Riau and East Lampung (1.9 me/100g) and was very low in the Cilacap mangrove soil. Exchangeable Ca was highest in the Riau mangrove soil, and relatively same in the soil from three locations. Available Mg was relatively almost the same in the mangrove soil in Riau, East Lampung, and Cilacap and was lowest in Bali mangrove soil (Table 2).

Na content and Sodium Adsorption Ratio (SAR) were very low in mangrove soil from Cilacap respectively 4.89 me/100 g and 2.1; and it was comparatively high in the mangrove soil in respectively Riau, East Lampung and Bali, respectively 20.3; 15.23 and 13.59 me/100 g for Na content; and 6.59; 8.84; 7.96 % for SAR. Exchangeable aluminum and H were relatively high in the mangrove soil in Cilacap, 1.59 and 0.68 me/100 g. Cation exchange capacity (CEC) was low in Cilacap mangrove soil (15.6 me/100 g)., and was relative high in the mangrove soil from East Lampung (25.23 me/100 g) , Bali (27.4 me/100 g) and Riau (36.5 me/100 g) (Table 3).

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We compared the growth of mangrove which had the same age. In the four mangrove plantation locations, 4, 5 and 6 year old mangrove stands were found in Riau and in Cilacap, and 13-14 years old mangrove were found in Lampung and Bali. The observed growth parameters of these mangrove stands were presented in Table 4, 5, 6, 7, 8, 9. There was a great difference in growth across four mangrove locations. The Table 4 showed that stilt root height of 4,5,6 year old mangrove stands planted in Riau were shorter, averaged about 14 cm, compared with those planted in Cilacap. In the 13-14 years old stands, stilt root height of mangroves grown in Bali was 20 cm higher than that grown in Lampung.

The stem and total plant height in 4,5,6 year old stands were higher in mangrove grown in Riau compared with those in Cilacap, while in 13-14 year old stands, it was higher in mangroves grown in Lampung compared with that grow in Bali. The height of stem and plants of 4,5, and 6 year old mangrove in Riau was almost four times the height of stem and plant the mangroves grown in Cilacap; while the plant height of 13-14 year old mangrove planted in Bali was only 60% the height of mangrove grown in Lampung (Table 5 and 6).
Averaged stem diameter of 4,5, and 6 years old mangrove stands grown in Ria (5.1 cm) were thicker compared with the stem diameter of mangrove stand grown in Cilacap (3.1 cm); while in 13-14 old mangrove stand, mangroves planted in Lampung had a ticker stem diameter (7.8 cm) than that grown in Bali (Table 7).

The crown volume was a result of multiplication among width, length and height of plant canopy. It was about 4 times larger in 4, 5, and 6 year old mangrove stands grown in Riau compared with those grown in Cilacap. In 13-14 years old mangrove stand cultivated in Lampung, its crown volume was almost 1,3 times larger than the crown volume of the same age mangrove cultivated in Bali (Table 8).
Stand biomass of 4, 5, and 6 year old mangroves grown in Riau respectively were 3.4; 2.7 and 5.1 kg/stand. It was almost 9 times of the biomass of the same old mangroves grown in Cilacap. Stand biomass of 13-14 years old mangrove grown in Lampung(37.0 kg/stand) was 1,5 times larger than the stand biomass of the same age mangrove grown in Bali(27.90 kg/stand) (Table 9).

Mangroves grow best at light, medium and heavy texture soil with pH 6-8,5, relatively have high load of organic carbon, and optimal salinity 8-26 ppt (Duke, 2006.) The results of this study demonstrated that properties of soil cultivated by mangrove forest collected from four locations in Indonesia were different. If they were compared with soil characteristic variables for optimal requirement of mangrove growth, mangrove soil in Riau of Sumatera island might be comparatively was the most fertile, due to it had high pH, C-organic, total N and available P, Na content and SAR , and low salinity and exchangeable aluminum and H ion. Mangrove soil in Cilacap of Java was the least fertile due to it had low pH, low C-organic, total N and available P and Na content, and high salinity, exchangeable aluminum and hydrogen ion. While mangrove soil in East Lampung and Denpasar Bali were categorizes as had moderate soil fertility, since their parameter values were in between of these two locations with a slight variation.

Replanted mangroves in Sumatra Island developed faster than those grown in Jawa and Bali islands. It was indicated by higher value of all growth parameters, except stilt root height, of 4,5, and 6 year old replanted mangrove stands grown in Riau compared with those grown in Cilacap, and of 13-14 year old replanted mangrove stand grown in Lampung compared with that grown in Bali.

Mangrove physiology, growth and distribution were affected by many soil variables, including soil texture, salinity, soil pH, and available nutrient contents (Zhaomu,1987. Ukpong, 1994; Vanugopal, *et al.*, 2008;). The combined effect of the physical and chemical properties and salinity of the mangrove soil appears to be the major factors responsible for the difference in growth rate and biomass production between the same old replanted mangrove in Sumatra, Jawa and Bali islands. These three factors are

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reported become the main factors determining the high biomass production of mangrove species in the Apar Nature Reserve in East Kalimantan (Sukardjo, 1994). Soil properties also are the determining factors the tree height of mangrove, and 90% of non random variation of tree height was explained by taking into account of soil properties (Matsui *et al.,* 2008).

Mangrove soils in Riau and in Lampung had high clay percentage, because mangrove forest are located along the east coast of Sumatera island which receive much sediments of eroded soil from higher areas containing high finer soil particles transported down along many big rivers in Sumatera Island. It also might be caused by slow rate of inundation and low gradient which allows tidal water to remain in the swamp for long time (Effiong and Ayolagha. 2010). High percentage of clay might affect the nutrient and water availability. Clay soils is composed of fine particles and has low permeability, the soil hold more water and retain more nutrients in the soil, and therefore clay soils generally have higher nutrient content (Warrence and Bauder, 2003; Kathiresan, 2002; Sukardjo (1994). The results that soil texture in Riau was clay is in agreement with the previous result reported by Kusmana and Sabiham (1991), but that soil texture in Cilacap was sandy clay loam was different with result of Soerianegara (1971) which reported the soil texture in Cilacap was clay. The different in research locations might be responsible for this discrepancy. There are six classes of zonation of mangrove in Cilacap mangrove forest, the location of this study was in the outer zone, in which the sediment was dominated by hard and compact sediments sand and silt fractions (Brown, 2007)

Salinity in mangrove soil in Cilacap was relatively high (30 ppt), compared with that in Bali (22 ppt) Riau (20 ppt) and in Lampung (12 ppt). High salinity in Cilacap mangrove soil occurs because the mangrove forest was located in the outer zone area of the forest which close to the sea, receive inundation of sea water two times per day (Brown, 2007) While the mangrove forests in Riau and Lampung in riverbank locates in some distance from the estuary, although mangrove forest areas still influenced by daily tidal inundation. Higher salinity was probably one of many soil factors responsible for slow growth rate and low biomass production of mangrove in the replanted mangrove forest in Cilacap.

Many studies indicated that high salinity have negative effect on mangrove growth. Salinity has been long recognized as important factor regulating physiology, growth and zonation pattern of mangrove species. Although mangrove could growth at fresh water (Tomlinson, 1986), but the best growth of mangrove occurs where the plants live in sea water diluted by about 50% with fresh water (Sydenham and Thomas, 2003**). The highest growth of both seedling's height and the number of leaf for species of Rhizophora, Bruguirea and Avecennia occur on the sallinity ranged from 0.0 to 7.5 ppt.** In general, mangrove vegetation is more luxurious in lower salinity. Salinity of 15 ppt is optimal for the growth of Rizhophora apiculata seedling, while higher salinity level (35-40 ppt) could reduce the growth rate, and areas with lesser soil salinity showed higher growth rate (Kathiresan, K. 2002a.). Hyper salinity has been also shown to induce stunted growth of *Avecinea* sp. stands, and reduce biomass of Brugurea gymnorhiza (Vanugopal, *et al.*, 2008).

The pH of soil also affected the mangrove growth. Mangrove achieved the maximum root growth at acidic pH of 6. Soil pH lower than 6 retard the mangrove seedling growth is a cause of mangrove death. (Vanugopal, *et al.,* 2008).). The very acid soil pH in Cilacap (pH 3,7) and acid in Bali mangrove soil (pH 5,3) might be the factors responsible for the low growth rate and biomass production of mangrove stand in these locations. Although some nutrient contents of mangrove soil in Bali including C-organic, total N, exchangeable K and Ca, were quite high and were not so much different with those in mangrove soil in Lampung, but because of low soil pH as well as high soil salinity which hampered the growth, tree height and biomass production of mangrove in Bali were lower compared with those in Lampung.

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Nutrient availability is a great of important for mangrove growth. The younger mangrove stand need take up mor4e N, P and organic matter than those the older stands (Paibulkichakul, 2007). The high concentration of N, P and K nutrient in the soil probably stimulated the higher growth rate and biomass production of mangrove in Riau compared with those in Cilacap. Mangrove soil in Riau contains N, P and K nutrients respectively 2, 3, and 4 times higher than those contains in mangrove soil in Cilacap. Many studies revealed the importance the availability of these nutrients for growth and biomass production of mangroves. The growth of mangroves was limited if little N and P are available (Reef *et al*., 2010) . The presence of N and P greatly increases the number of shoot. Growth of mangrove was initially enhanced by N, then by P, with N enhancing the production of new leaves, P enhanced the number of leaves and the rate of shoot elongation (Vanugopal, *et al*., 2008).). Mangroves trees grow in Cilacap were shorter, and produced biomass less compared with mangroves that grow in Riau. Mangrove stands in Cilacap probably did not enough absorbing the nutrients P, due to soil P content in was low, high salinity and high aluminum concentration.

Biomass production of 4,5, and 6 year old mangrove in Cilacap was lower than in Riau, and Biomass production of 13-14 years old mangroves in Bali was lower than that in Lampung. The low P content in Cilacap and Bali mangrove soil probably was the cause of low biomass production mangrove stands in both locations. Under high salinity condition, P fertilization has positive effect on water status of mangrove leaves, it increase photosynthetic water use efficiency and hydraulic conductivity of the stem (Lovelock, *et al*., 2009). The results is in agreement with the research reported by Medina, *et al.,* (2010), which revealed that P availability in the soil regulate mangrove development. Under high P nutrient soil condition, photosynthetic tissue comprised approximately 50% of the total aboveground biomass, whereas under low soil P, only 12-13% of the total biomass was allocated to leaf tissues (Twilley,1996). Extractable P was positively correlated with aboveground biomass in Australian mangrove. The enrichment of P in *Rhizophora mangle* increased nearly 7 fold of stem elongation, and 3-fold of leaf areas (Kathiresan, K. 2002b).

K enrichment increases the growth of Rhizophora seedling. K could be replaced by Na if salinity increases (Yates, 2001; Reef, *et al.*, 2010). In this study Na and SAR (Sodium Adsorption Ratio) were high in Riau, Lampung and Bali mangroves soil, and was lowest in Cilacap mangrove soil. Growth and biomass production was higher in the mangrove stands planted in the soils had higher Na content and SAR value, such as in Riau and in Lampung. Therefore relatively high Na concentration in the mangrove soil and high value of SAR, probably is required for higher growth rate of mangrove stands.

Stilt root height is the only growth parameter which has value higher in Cilacap and Bali mangroves, while the value of other growth parameters were always lower in both places compared with those in Riau and Lampung. The less fertile and low nutrient availability conditions of mangrove soil, such as soil in Cilacap and Bali, might stimulate growth in favor of root relative to shoot. The same result was reported by (Lovelock *et al)* *(2*009)) in which the growth of mangrove is accelerated with the enhanced of nutrient availability, that enhancement favors growth of shoot relative to roots

This study indicated that *Rhizophora apiculata* BL stands grown at four mangrove ecosystems in Indonesia developed differently. Mangrove stands of 4, 5,and 6 year olds in Riau had higher three height, thicker stem diameter and more biomass production than the same old mangrove stands in Cilacap; as well as of 13-14 year olds mangrove grown in Lampung compared with those grown in Bali. Growth and biomass production of mangrove stands grown in Riau and in Lampung were high because their mangrove soils were more fertile, indicated by higher pH, lower salinity, and higher availability of essential nutrients; while growth and biomass production in Cilacap and Bali were low because of low soil fertility, indicated by lower pH, higher salinity, and low availability

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of essential nutrients.

Results of the studies indicated that soil in four locations of replanted *Rhizophora apiculata* BL mangroves forest in Indonesia has different characteristics.

Soil texture of mangrove soil in Riau and East Lampung of Sumatera Island were clay, while those in Cilacap and Bali were respectively sandy clay loam and loam. Mangrove soil in Riau had high pH, low salinity, and high availability of nutrients, in the contrary mangrove soil in Cilacap had low pH, high salinity, and low availability of nutrients, while the characteristics of mangrove soil in East Lampung and Denpasar Bali were in the range in between the values of mangrove soil in Cilacap and in Ria.

Growth indicated by parameters of root and plant height, stem diameter, crown volume and biomass production were higher in *Rhizophora apiculata* BL stands grown in Riau and Lampung of Sumatra Islands than those grown in Cilacap of Java and Denpasar of Bali Islands. Soil properties and salinity might be responsible for the discrepancy between mangrove growth in Sumatera and in Java and Bali. Mangroves grew in Sumatra Island developed higher than those grew in Cilacap of Jawa and in Denpasar of Bali, because soils of mangrove in Sumatera were more fertile than those in Jawa and Bali. Mangrove oil in Sumatera was fertile due to compared with the mangrove soil in Java and Bali due to they had high pH, C-organic, total N and available P, Na content and SAR , and low salinity and exchangeable aluminum and H ion; while mangrove soil in Jawa was less fertile due to it had low pH, low C-organic, total N and available P and Na content, and high salinity, exchangeable aluminum and hydrogen ion.

The studies showed that soil properties and salinity at four mangrove ecosystems located in Sumatera, Jawa and Bali Islands were different. The facts implies that other tracts of destroyed mangrove areas to be rehabilitated in Indonesia which locates not only in the above islands, but also in other islands such as in Kalimantan, Sulawesi, Lombok (Halimi, 2005) have different soil ecological characteristics. The study also reveals that growth of *Rhizophora apiculata* BL in Cilacap of Jawa was very slow compared with that in Riau of Sumatera. Mangrove species of *R.apicalata* might be not suitable to planted in Cilacap mangrove soil, which locates in the outer zone and close the seaward, with the sediment dominated by hard and compact sediments sand and silt fractions(Brown, 2007), that had low fertility and high salinity.

Sound management of mangrove rehabilitation program should be based on the knowledge on ecology of the mangrove forest (Sukardjo, 1994), and consider the site-specific requirement management (Matsui *et al*, 2008). As indicated in the study that the soil fertility, salinity and soil texture of the mangrove habitat appears to be primary factors controlling the growth of replanted mangroves, therefore ecological aspect of degraded mangrove is going to be rehabilitated should be taken in to consideration, particularly in developing methods of replanting techniques and selecting the species suitable for the selected sites. True mangrove species have different tolerance and adaptability to some ecological factors including to salinity and soil characteristics conditions. (Karthiresan, 2002c; Jayatissa and Wikramasinghe, 2006).

For mangrove species, capacity to invade intertidal habitat as well as position occupied in a species zonation, depend on their tolerance to salinity at early growth stage (Saures and Madina 2005). The site area preferred for plantation establishment of *R.apiculata* is in middleward areas, *Avicennia alba* and *Avicennia marina* are in seaward areas, *Sonneratia alba* is in seaward areas and *Bruguiera sp* are in landward and riverrine (Karthiresan, 2002c; DERN,2010). Many attempts to rehabilitate mangroves fail c completely, as they are poorly planned and managed. Planting the wrong species in the wrong place is one of the main reasons for much failure in Mangrove rehabilitation(Lewis, 2005).

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