VEGETATION SPECIES ABUNDANCE IN MANGROVE ECOSYSTEM OF PASIR MENDIT AT BOGOWONTO LAGOON, KULON PROGO, YOGYAKARTA

Maizer Said Nahdi and Ardyan Pramudya Kurniawan
Biology Department, Science and Technology Faculty, Islamic State University (UIN) Sunan Kalijaga
Jl. Adisucipto Yogyakarta, Indonesia. 55281
Corresponding Author email: maizersn@yahoo.co.id

ABSTRACT

This research was conducted on Pasir Mendit, Bogowonto Lagoon. Pasir Mendit, Bogowonto Lagoon is one of unique beaches in Indonesia, with sand dunes that protecting the beach from Indian Ocean's pounding waves. The purpose of this research is to shows the relation between the environmental factors and the abundance of vegetations in the mangrove's ecosystem. Quadrates method were used for collecting the data, by making several plots of the study of growth forms. Connonical Correspondence Analysis (CCA) were used to analyze the correspondential relationship between vegetation and the environmental factors. The result of this research shows that there are 19 species of mangroves and its associates and unity. All of the locations are colonized by ***Acanthus ilicifolius*** *bushes and* ***Derris heterophylla*** *woody climber, which is the r-strategy, with high level of density.* ***Sonneratia alba*** *and* ***Rhizophora mucronata*** *is the dominating species in all locations with varied abundance and importance value. This would be linked with the* relatively *high concentration of C organic, NO_3 and SO_4. The presence of* ***Acanthus ilifolius*** *and* ***Derris heterophylla*** *shows that the mangrove ecosystem of Mendit has suffered from destructions. With the existence of mangrove in Bogowonto Lagoon, the place is suggested to be a conservation location model for other lagoons in Yogyakarta and Central Java.*

Keywords: *conservation, growth form, r- strategy, sand dune, wood climber*

INTRODUCTION

Mangrove ecosystem is a transitional area between land and sea ecosystems, which is strongly influenced by the tidal conditions. It has important ecological and social economic functions which eventually have several benefits the mankind (Nybakken, 1993; Horne & Goldman, 1994; Noor *et al*., 2006; Iftekhar, 2008; Schaduw *et al*., 2011; Samad *et al*., 2013). This ecosystem has a role as nutrient provider for the ecosystem itself. The beach and ocean are the sources of the diversity of aquatic and non-aquatic biota. Besides it, mangrove ecosystem have several functions, includes 1) keep the beach stability, prevent abrasion and sea water intrusion, and trap the pollutants; 2) be nursery ground and protection for types of fish, shrimps, and crabs; 3) protect coastal and land areas from tsunamis (Blasco *et al*., 1996; Cole *et al*., 1999; Mitch & Gosselink, 2000; Kathiresan & Bingham, 2001; Muray *et al*., 2003; Harty & Cheng, 2003; Yanagisawa *et al*., 2009; Zhang *et al*., 2012).

Indonesia is an archipelago with more than 17. 000 small and big islands. The length of the coastal lines of Indonesia is 81.000 km^2. Bogowonto Lagoon is the ones of the unique beaches with the presence of sand dunes lays in the estuary of the southern beach of Yogyakarta. It is the one and only lagoon in Yogyakarta which is having mangrove forest (Djohan 2007; Suhardjono & Rugayah, 2007). The existence of mangroves alongside the Bogowonto Lagoon is being threatened due to the construction of shrimp ponds as a consequence of human population growth and improvement of living standards. The produce of the shrimp ponds are economically promising for the local habitats, since they are marketed widely in Yogyakarta and Central Java.

Bogowonto River in Central Java Province feeds its water into the Indian Ocean. The growth of mangrove in Bogowonto Lagoon is high supported by the availability of enabling environmental factors. The substrate is relatively fertile due to the sediment of nutrients from the streams along the location. Vegetations in this area adapts to anaerobic conditions using three rooting systems, namely breathing roots (*pneumatophor*), pop roots, and hanging roots. Generally, a mangrove tree has 30 meters of height with wide, tight, and closed canopy (Mitch & Gosselink, 2000). Kathiresan and Bingham, (2001), state that the presence of vegetation species in a particular place is influenced by environmental factors such as climate, edaphic, topographic, and biotic conditions.

The sustainability of mangrove ecosystem in Bogowonto Lagoon is a certainty and needs attention of all parts. However, the information on the mangrove ecosystem of Bogowonto Lagoon is not widely available, therefore it needs comprehensive research. The problems which discussed in this study are the abundance of mangrove, the quality of soil and water involving the physical-chemical factors, and how these environmental factors influencing the abundance of mangroves in the studied area. This study aimed to analyze how the environmental factors influencing the existence of mangrove in Pasir Mendit Bogowonto. The steps of this research are specifically by quantifying the density, important values, diversity index, and their relationships with the physical and chemical factors of the soil.

MATERIALS AND METHOD

This research were conducted from September to October 2013 in Bogowonto Lagoon of Pasir Mendit and Pasirkadilangu villages, Jangkaran, Kulon Progo, Yogjakarta. This place were located at the coordinate of S $07^0 53'44.4''$ and E$110^0 01'41.1''$. The location were divided into 3 stations. Station I (ST I) in the most western part of Pasir Mendit village, station II (ST II) directly located on the border between Pasir Mendit and Pasir Kadilangu, and station III (ST III) in Pasirkadilangu village near the Lagoon (Figure 1). The material objects are all species found and soil sample from Bogowonto mangrove area.

Figure 1. Research location in mangrove ecosystem of Pasir Mendit at Bogowonto Lagoon, Kulon Progo, Yogjakarta

Materials that used for data collection are quadrates and six replications. Plotting at each station were used stratified random sampling. This method were used three sizes of quadrats: 10 x 10 m, 5 x 5 m, and 1x1 to study tree, sapling, seedling and understories vegetation respectively. The number of individual species were counted, and the height and the trunk diameter of trees were measured. The data obtained were used to calculate the density, dominance, frequency of the species as well as the Important Value (IV) (Mueller-Dombois & Ellenberg, 1974). The soil sample were taken by using soil core modification as deep as 20 cm. The sample then were prepared for its chemical contents (nutrient content, nitrate, sulfate, and pH) in laboratory. In additions, physical factors such as humidity, light intensity, and soil temperature were measured. For the data analysis, the abundance of vegetations and the environmental data were presented in form of histogram. Connonical Corespondence Analysis (CCA) were applied to analyze the relation between a particular type of vegetation distributions and the soil physical chemical factors (Oksanen, 2011).

RESULTS

The total numbers of species found in the research area are 23 species consist of 7 species of tree, 5 spesies of sapling, 1 species of seedling, and 1 species each for bush, herbs, and liana, 7 spesies of grasses (Table 1). The result of the research shows that the contents of C_{Org} and other soil nutrients in the three stations varied noticeably, those were in ST I 5.4%, in ST II and ST III 3.6%, (Table 2). The high levels of C_{org}, $NH4^+$, NO_3, and Fe in ST I probably come from the leaf litter on topsoil which was decomposed and became humus. The relation between physicochemical parameters and the three studied *growthform* is divided into three groups with different compositions (Figure 2).

DISCUSSION

The highest presence of the species in ST I are 7 species of tree, 6 saplings and 4 grass, and one species each for bush, liana, and mangrove fern. There was no existence of seedling (Table 1). The species richness of ST I showed that the mangrove adapts well to the existing environmental factors. It could be linked with its high level of C organic, NH_4, NO_3 and Fe contents. These minerals probably derived from the leaf litter which tends to be humus on topsoil. The existence of NO_3 in the soil influences the photosynthesis process, and the high level of phosphate plays a prominent role in regulating how vegetations grow generatively (Fitter & Hay 1992; Nahdi *et al.*, 2014). In addition, this richness probably occurs due to propagule or mangrove seeds spreading from the surroundding area. These seeds replant location of Kulonprogo Regency (Anonymous, 2013). The number of species found in ST II and III was similar, that was three species of tree. The difference lies in the fact that ferns and herbs was not recorded in ST II, whereas in ST III, herbs was present, but fern was absent (Table 1).

The abundance of a species showed by its Important Value (IV) (Mueller-Dombois & Ellenberg, 1974). The highest abundance was observed in ST III with the score 2575 individuals/ha, followed by ST I with the score 1250 individuals/ha, and the lowest is in ST II with the score 1050 individuals/ha (Table 1). In terms of tree, two dominant species with varied IV were recorded: *Sonneratia alba* (IV= 50-105%) and *Rhizophora mucronata* (IV=18-119%). These two species is the major inhabitants that dominate the mangrove forest. In addition to the above species, *Avicennia* could also be found having varied IV. Besides, there is *Avicennia* sp with varied value of IV. Station I was dominated by *Avicenia alba* (IV 19%), and ST III was dominated by *Avicennia marina* (IV 26%). The abundance of *S. alba* or *S. apple* consistently showed that the area of Bogowonto Lagoon was historically proven as a mangrove forest ecosystem (Djohan, 2007). Other species found in the area have relatively low important value, but their existence is important to protect the diversity of the vegetations in the location (Table 1).

Table 1. The abundance of species in the seven growth form vegetations, including tree, sapling, seedling, shrub, herbas, climber, mangrove and grass in Station I, Station II, and l Station III in Mangrove Area of Bogowonto Lagoon.

Species	Station I			Station II			Station III		
	D total/ha	RF (%)	IV (%)	D total/ha	RF (%)	IV (%)	D total/ha	RF (%)	IV (%)
TREES									
Avicennia alba	150	14,29	37,36	50	14,29	19,05	-	-	-
Avicennia marina	25	14,29	18,13	-	-	-	-	-	-
Rhizophora mucronata	25	14,29	18,13	50	14,29	19,05	25	25	25,97
Sonneratia alba	225	28,57	63,19	800	28,57	104,76	1.675	50	115,05
Nypa fruticans	150	14,29	37,36	-	28,57	28,57	875	25	58,98
Acacia mangium	75	14,29	25,82	-	-	-	-	-	-
Cocus nucifera	-	-	-	150	14,29	28,57	-	-	-
SAPLING									
Avicennia alba	275	11,11	14,81	-	-	-	-	-	-
Avicennia marina	300	22,22	26,26	450	33,33	44,58	-	-	-
Rhizophora mucronata	5.950	44,44	124,58	2.000	33,33	83,33	-	-	-
Rhizophora apiculata	450	11,11	17,17	-	-	-	75	50	100
Sonneratia alba	450	11,11	17,17	1.550	33,33	72,08	-	-	-
SEEDLING									
Rhizophora apiculata	-	-	-	50	100	200	-	-	-
UNDERSTORIES (SHRUBS, GRASS, HERBS)									
Acanthus ilicifolius	64.050	100	200	21.050	100	200	-	-	-
Ipomoea pescaprae	525	100	200	-	-	-	-	-	-
Derris trifolia	4.425	100	200	1.750	100	100	-	-	-
Acrostichum aureum	1.425	100	200	-	-	-	-	-	-
Panicum repens	12.500	25	115,74	-	-	-	-	-	-
Penisetum purpureum	600	25	29,36	-	-	-	-	-	-
Cynodon dactylon	450	25	28,27	-	-	-	-	-	-
Achyranthes aspera	225	25	26,63	950	33,33	57,69	33.000	33,33	128,85
Imperata cylindrica	-	-	-	2.950	66,67	142,31	-	-	-
Ischaemum muticum	-	-	-	-	-	-	50,00	33,33	33,48

Table 2. Content of soil physical-chemical parameter in the research Stations I, II, and III.

Parameter Physic-chemical	Station I	Station II	Station III
C-Organic (%)	5,34 ± 0,23	3,56 ± 0,31	3,62 ± 0,18
Ammonium (NH_4)	0,16 ± 0,15	0,10 ± 0,23	0,11 ± 0,18
Nitrate (NO_3)	0,18 ± 0,32	0,15 ± 0,28	0,15 ± 0,20
Sulphate (SO_4)	10,30 ± 0,25	12,48 ± 0,26	6,78 ± 0,13
Iron (Fe)	11,46 ± 0,21	9,94 ± 0,18	11,39 ± 0,23
Soil humidity (%)	100 ± 0,00	100 ± 0,00	100 ± 0,00
Soil pH	5,40 ± 0,53	6,13 ± 0,23	6,90 ± 0,17
Light intensity (Lux)	805,67 ± 99,28	84,33 ± 25,11	34,33 ± 11,55
Soil temperature (^{0}C)	33,33 ± 2,08	29,67 ± 0,58	32,67 ± 3,06
Air temperature (^{0}C)	33,00 ± 0,00	30,67 ± 0,58	31,33 ± 1,53

The existence of the aforementioned three dominant tree species corresponds to the presence of their saplings, but not for the seedlings. Saplings and seedlings are normally grow not too far from their parental tree. Their existence has an important meaning for an ecosystem because they determine future species which will protect its sustainability (Barbour *et al.*, 1997). The species in the sapling stratum which has quite high important value was *R. mucronata* (in ST 1 = 124.6%; ST II = 88%) and *S. alba* in ST I and ST II (with the same IV = 72%). In station III, *R. mucronata* was not found, but *Nypha* sp. appeared with quite high important value (100%). At the level of seedling, in ST III, *R. mucronata* and *R. apiculata* (200%) gave the highest important value. They derived from the cultivation that carried out by the local forestry institutions, as they are a mangrove type generally used for reforestation along the line of southern beaches. Mangrove is difficult to grow in the steep coastal areas with big waves and strong tidal current because the conditions do not enable the mud sedimentation as the necessary substrate for its growth (Halidah, 2010). This type is mostly chosen for the mangrove reforestation because the seeds are easily obtained, sowed, and grown in the area with high or low level of tidal inundation (Djohan, 2007).

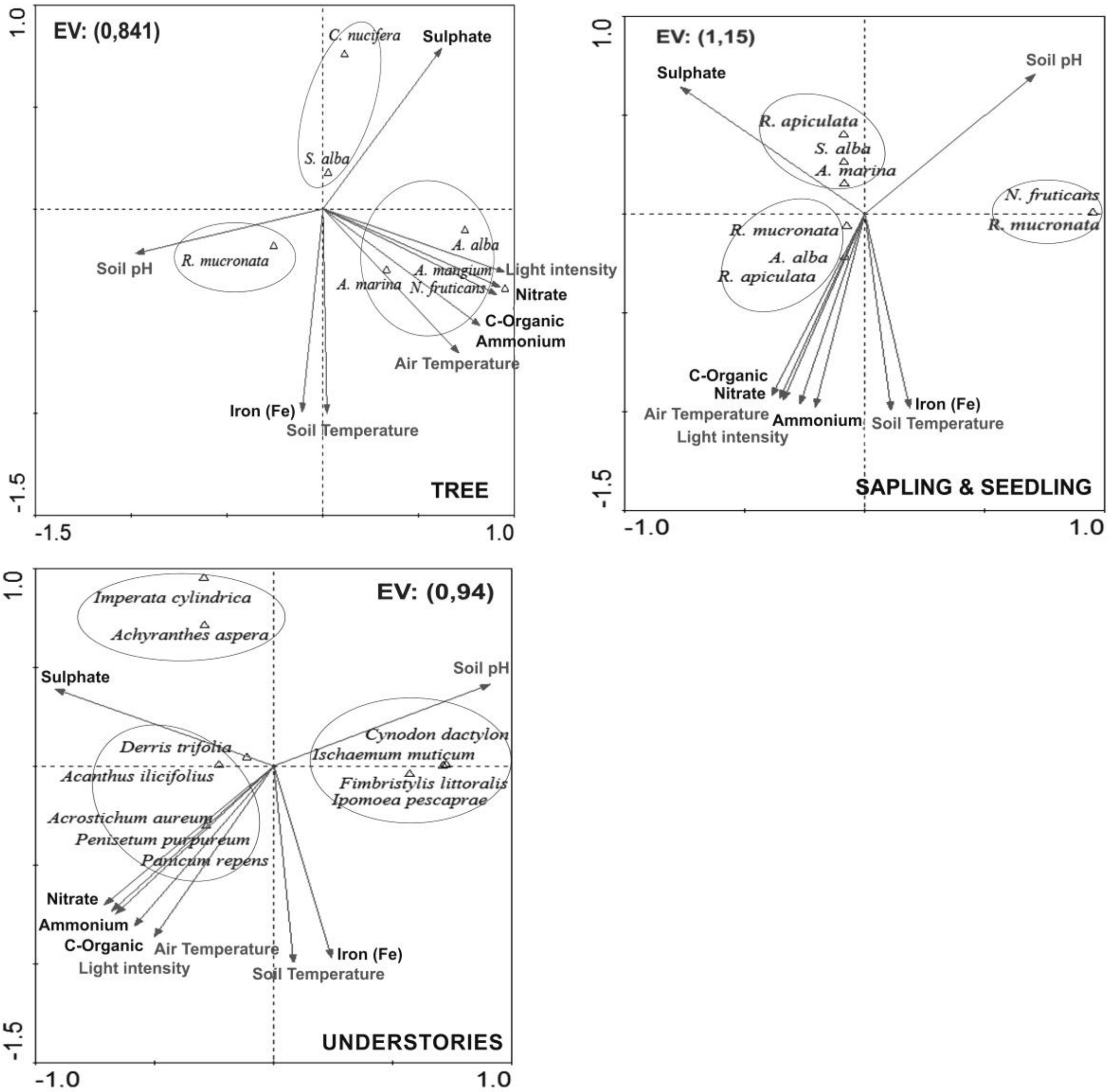

Figure 2. *Connonical Corespondence Analyses* (CCA) on the tree, sapling and seedling vegetation community and understories vegetation community using physical-chemical parameter in Bogowonto Lagoon of Pasir Mendit, Kulon Progo, Yogyakarta.

Acanthus ilifolius could be found with varied abundance. In station I, *A. ilifolius* was recorded to have the highest density (64050 individuals/ha), followed by ST II (21050 individuals/ha) and ST III (19600 individuals/ha). Nonetheless, it is also a species that was measured for a strong value r and k, and therefore showed great ability to adapt and compete with other species. In turn, however, this species tend to disturb other species' growth. The climber species, *Derris trifolia*, was present in the three stations with high level of abundance: in ST I (4425 individuals/ha), ST II (1750 individuals/ha) and ST III (1275 individuals/ha). As a parasite of mangrove, and disturbs the sustainability of its host life (Table 1). The presence of climber species in a large number might be causes of destruction or disappearance case of mangrove species in some area.

The absence of seedlings could be linked to the presence of *Acacia mangium's* canopy, which leads to competition for sunlights and such a determining factor for photosynthesis. Moreover, inability to adapt against the abrasion and tides inhibits the propagule and seedling in the canopy area to grow. The presence of a species is not only dictated by the high level of salinity and tidal patterns, but also is determined by the availability of propagule and seeds from the nearest mangrove and human activities. The tree of *Sonneratia alba* and *N. fruticans* was mostly present in ST I and II at a similar frequency rate (28.6%), and in ST III *R. mucronata* (50%). The calculated frequencies of the trees was not directly followed by those of the saplings and seedlings at each location. This was confimed by the fact that in ST I the frequency of *R. mucronata* sapling has the highest frequency rate (44%); *Sonneratia alba* was only 11%, and its seedlings was absent.

The frequency of the saplings of *Avicena marina, R. mucronata* and *S. alba* in ST II was relatively identical (33.3%). Similarly in ST III *Rizophora mucronata* and *Nypha fruticans* recorded a similar frequency, that was about 50 %. The presence of *Nypha fruticans* provides positive expectation for conservation of the mangrove forest since the species is an endemic species of Bogowonto Lagoon and performs low adaptibility, if compared to others. Seedlings could only be observed in ST II and ST III , with the two different species was recognized, i.e *R. apiculata* and *R. mucronata*. In terms of grass growthform, all three stations showed varied compositions. Four species in ST I appeared to have the same frequency, that was 25%. *Imperata cylindrica* (frequency=66,7%) was known to have the highest presence. In addition to this, ST III was dwelled by three species with the same frequency, that was 33.3% (Table 1). The similarily of recorded frequency shows that the grass species performed the same adaptation ability to the Bogowonto Lagoon. Except in ST II *Imperata cylindrica* species. It has slightly higher adaptation ability compared to other species. Based on the results, it can be concluded that in Bogowonto Lagoon there was only three important species which need conservation and more attention since they are categorized as scarce. The first two are *S. alba* and *Rhizophora* sp. with the status EN (A2 cd) and EN (A 2 bd) respectively based on the IUCN criteria, and the other one is *Avicennia officinalis* with the status EN (B1, 2b) (Anonymous, 2012; Noor *et al.*, 2006; Suhardjono & Rugayah, 2007).

Soil environment parameter.

The high content of nutrients influences the presence of mangrove species. It was proved by responses of mangrove species and its association in ST I compared to that in other locations. The high level of sulphate makes the soil acidic (Nahdi et al*.*, 2014). This condition allows only acid-tolerant vegetations to grow. The only species that strikingly grow well is *A. ilicifolius*, given that the presence of this species was almost 100% in all research stations (Table 2). Beside pyrite, the soil nutrients influencing the vegetations are NO3 and PO4. The measured level of NO3 was between 0.15 and 0.18 mg/l. Interestingly, a similar trend were measured in the three locations. The high levels of NO3 and PO4 in the soil are resulted from the response on the shoal formation, keeping the land slightly free from water during the low tides. The high contents of NO3 and PO4 increase the height and the number of branches and leaves of the trees. NO3 also speeds up the photosynthesis process. The conditions enable *A. ilicifolius'* seedlings grow and develop well (Djohan, 2007; Anonymous, 2012).

Environmental factor and vegetation.

From the *Cononical corespondence analysis* (CCA), the eigen values of tree, sapling, and under growth vegetation levels were calculated, those was 0.84, 1.15, and 0.94 respectively. These eigen values represent the real situation which explains the relation between the trees, sapling, seedling, and under growth vegetation community and the physico-chemical environmental parameter. The relation between physico-chemical parameters and the three studied *growth form* is divided into three groups with different compositions. At tree growthform, group I consisted of *A. alba, Acacia sp, A. marina,* and *N. fructicans.* Their presence was influenced by high intensity of light, NO_3, C org, ammonium and temperature. Group II consists of *Cocos nucifera* and *Soneratia alba* in which their presence was dictated by the content of SO_4 in the soil. Group III consisted of *R. mucronata* whose presence was affected by soil acidity (pH). In other words, *R. mucronata* tree adapts to acidic soil very well, hence this species can be used to improve soil conditions (Figure 2).

The analysis on physico-chemical parameters against the sapling and seedling community resulted in three groups of community, those was group I: *Nypa fruticans* sapling and *R. mucronata* seedling; group II; *S. alba, A. marina* sapling and *R. apiculata* seedling; and group III: *R. mucronata, R. apiculata*, and *A. alba* saplings). Moreover, it was also obtained three groups of understories vegetation community, those were group I: *Imperata cylindrica* and *A. aspera*; group II: *Cynodon dactylon*, *Ischaemum muticum*, *F. littoralis*, and *Ipomoea pescaprae*; and, group III: *D. heterophylla*, *A. ilicifolius*, *Achrostichum aureum*, *P. purpureum*, and *P. repens*. High levels of sulphate (SO_4) could be associated with the presence of forest-understories vegetations such as *Imperata cylindrica* and *A. aspera*. Similarly, the presence of understories vegetations *C. dactylon*, *Ischaemum muticum*, *F. littoralis* and *Ipomoea pescaprae* was mostly influenced by the high level of soil's pH which showed the acidic condition of soil. These conditions triggered the presence of the grass vegetation. Meanwhile, the presence of the understories vegetations *D. heterophylla*, *A. ilicifolius*, *A. aureum*, *P. purpureum*, and *P. repens* was driven by the high level of nitrate, ammonium, C-organic, light intensity, and temperature regime (Figure 2).

Based on the result can be concluded that in terms of biodiversity, the species of mangrove in Pasir Mendit has low level of diversity value. That was, 0.5 – 1.5 for tree; 0.4 – 1 for sapling, and 0.5 – 0.9 for understories. The environmental factors are pH, Fe, and temperature influence the growth of *Rhizophora mucronata*. The growth of *Sonneratia alba* influenced by pH and sulphate, and the growth of *Avicennia* sp was altered by light intensity, nitrate, C organic, ammonium, and temperature. The richness of mangrove species and its association as a result of high sedimentation and seasonal variety of salinity. In additions, the presence was also determined by human activities. The domination of bushes and climber-vegetations (lianas) endangers Pasir Mendit's mangrove forest and generally put mangrove trees in Bogowonto Lagoon at high risk.

REFERENCES

Anonymous. 2012. Know Kulonprogro Mangrove. *Mengenal Mangrove di Kulonprogo, Pokja Mangrove dan Sempadan Kabupaten Kulon Progo.* Badan Lingkungan Hidup Provinsi DIY

Barbour, M.G., J.H., Burk., and Wanna.D. P 1997. *Terrestrial Plant Ecology.* The Benjamin Cumming Publishing Company, Inc. United Stated of America.

Blasco, F., Saeger P., and Janodet E. 1996. Mangroves Indicators of Coastal Change. Institute for the International Map of The Vegetation. *Journal Catena* 27: 167 – 178

Cole, T.G, Ewel K.C, and Devoe N.N. 1999. Structure of Mangrove Trees and forests in Micronecia.Institute of pacific Islands Forestry. *Journal Forest Ecology and Management* 117: 95 – 109

Djohan, T.S, 2007. Distribusi Hutan Mangrove di Laguna Pantai Selatan Yogyakarta, jurnal Manusia dan Lingkungan Hidup. *Environment and Human Journal* 14 (1): 15-25

Fitter, A. H and R.K.M Hay. 1992. Fisiologi Lingkungan Tanaman. Gadjah Mada University Press. Yogyakarta

Halidah. 2010. Pertumbuhan Rhizophora mucronata Lamk Pada Berbagai Kondisi Substrat di Kawasan Rehabilitasi Mangrove Sinjai Timur Sulawesi Selatan. *Jurnal Penelitian Hutan dan Konservasi* 7 (4) : 399-412

Harty, C., and Cheng D. 2003. Ecological Assessment and Strategic for The Management of Mangroves in Brisbane Water – Gosford, New South Wales, Australia. *Journal landscape and urban planning* 62: 219 – 240

Horne, A. J. and Goldman C. R. 1994. *Limnology.* Mc Graw Hill Internasional Book Company. Department of Sanitary and Environmental Enginering University of California

Nahdi, M., Marsono, D., T. S. Djohan, M. Baequni. 2014. Struktur Komunitas Tumbuhan dan factor Lingkungan di Lahan Kritis Imogiri, Yogyakarta. *Jurnal Manusia dan Lingkungan Hidup* 21 (1): 67-74

Mueller-Dombois, D. & H. Ellenberg. 1974. *Aims and Methods of Vegetation Ecology.* John Wiley & Sons. New York

Muray, M.R., Zisman S.A., Furley P.A., Munro D.M., Gibson J., Ratter J., Bridgewater S., Minty C.D., and Place C. J. 2003. The mangrove of Belize: Part 1. distribution, composition, and classification. The university of Edinburgh. *Journal Forest Ecology and Management* 174: 265 – 279

Iftekhar, M. S. 2008. Functions and development of reforested mangrove areas: A review. *International Journal of Biodiversity Science and Management* 4: 1–14

Kathiresan, K and B. L. Bingham. 2001. *Biology of Mangrove and Mangrove Ecosystems.* Advances in Marine Biology 40: 58 – 67

Mitch, W. J. And J. G. Gosselink. 2000. *Wetland.* third edition. John Willey and sons.Inc. New York

Noor, Y.R., M. Khazali, I.N.N., and Suryadi P. 2006. *Panduan pengenalan Mangrove di Indonesia.* PHKA. Bogor, Indonesia

Nybakken, J. W. 1993. *Marine Biology.* Mc Graw Hill International Book Company. New York.

Oksanen, J. 2011. *Multivariate Analysis of Ecological communities in R: Vegan Tutorial.* University of Oulu, Departement of Biology. http://cc.oulu.fi/jarioksa/softhelp/vegan.html. Downloaded 3 Nov 2011

Samad, A., Bambang A. N., and Afiati N. 2013. Coastal People Activity on Mangrove Forest Rehabilitation in Mahakam Estuary. *International Journal of Waste Resources* 3 (1): 34-39.

Schaduw, J.N.W, Yulianda, F., and Setyobudiandi, I. 2011. Pengelolaan Ekosistem Mangrove Pulau Pulau Kecil Taman Nasional Bunaken Berbasis Kerentanan, *Agrosains* 12 (3): 173 -181.

Suhardjono and Rugayah. 2007. *Mangrove* plant diversity in Sepanjang Is-land, East Java. *Biodiversitas Journal* 8 (2): 130-134

Yanagisawa, H.,Koshimura S., Goto K., Miyagi T., Imamura F., Ruangrassame, A and Tanavud C. 2009. The Reduction Effect of Mangrove Forest on a Tsunami Based on Field Surveys at Pakarang Cape, Thailand and Numerical Analysis. *Journal: Estuarine. Coastal, and Shelf Science* 81: 27 – 37

Zhang, K., Liu H., *Yuepeng* L., Hongzhou X., Shen J., Rhome, J and Smith T. J. 2012. The role of mangroves in attenuating storm surges. *Journal El-sevier: Estuarine, Coastal and Shelf Science* 102-103:11-23