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Original Paper

THE EFFECTS OF ENVIRONMENTAL FACTORS ON THE DYNAMIC GROWTH PATTERN OF MANGROVE *Avicennia marina*

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ABSTRACT

Avicennia marina is a species of mangrove tree occurs in the intertidal zones of estuarine areas in Asia, including Indonesia. Mangrove within the genus member of Avicennia have long dominated many coastal areas along Semarang and Demak coasts. The aim of this research was to analyze the effect pattern of several environment parameters to Avicennia seedling growth rate. Observation was held by setting 8 stations with 3 transects, each including mangrove survey and environment parameter measurements. Mangrove survey including seedling and sapling stage occupying 1 x 1 m and 5 x 5 m transect plot respectively. While environmental factor measurements including on site measurement for temperature, salinity, pH and DO and laboratory analysis for organic matter, nutrient (N,P,K) and sediment structure. The results showed there were 2 effect pattern for environmental parameters observed including polynomial quadratic and logarithmic patterns. Parameters which had polynomial quadratic pattern including salinity, DO, P, sand and silt, while parameters which had logarithmic pattern were temperature, pH, organic matter and N.

Keywords: growth, pattern, avicennia, environment

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INTRODUCTION

Mangrove species *Avicennia marina* have been known to distribute along coastal ecosystem. Avicennia grow along the intertidal zone and estuaries (Ahmed dan Khedr, 2007). It is distributed along Africa's east coast, south-west, south and south-east Asia, and Australia. Avicennia tends to dominate most coastal mangrove ecosystems. Spatial distribution pattern caused by the change of water level and salinity are considered as the main factors (Ball, 1998). In addition, mangrove development vary susbstantially in their geomorphological characteristic (Semeniuk dan Semeniuk, 1995).

Mangrove ecosystem in Demak areas of Central Java rapidly change mainly caused by instability of its coastal conditions. Coastal development caused to the change of hydrooceanographic dynamic which led to coastal damage. Mangrove ecosystem as natural coastal ecosystem would not functioning optimaly with less extent and abundance. Since mangrove development dominantly affected by habitat change, a research concerning factors effecting mangrove growth rate is needed.

Seedling is key factor for mangrove distribution. Seedling establishment and growth would extend mangrove distribution and increase land establishment as well. Avicennia as the front line of mangrove development is vulnerable to establishment and growth failure caused by improper habitat condition. Environment factors including temperature,

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salinity, pH, DO, organic matter, nutrient (N,P,K), sediment structure including sand and silt composition were considered as factors effecting Avicennia seedling growth.

The aim of this research was to analyze the effect pattern of environment factors to Avicennia seedling growth that grow in the Semarang and Demak areas of Central Java.

Materials And Methods

Study sites

Research was held in mangrove ecosystem along Semarang and Demak coast including 8 sampling station with 3 observation transects in each station. Distribution of sampling location is shown in Figure 1. Sampling station including 8 observation plot, where 3 plot was located in location A, 1 plot was located in location B, 3 plot in location C and 1 plot in location D. Hence, 24 sampling plot was occupied for observation. Observation of physical and chemical parameters was occupied along the coast border to achieve the variation of the environment parameters as well as its mangrove abundance variation. Statistical analysis method was then conducted to observe the relation and effect pattern of environment parameters to the growth of *A. marina* seedling.

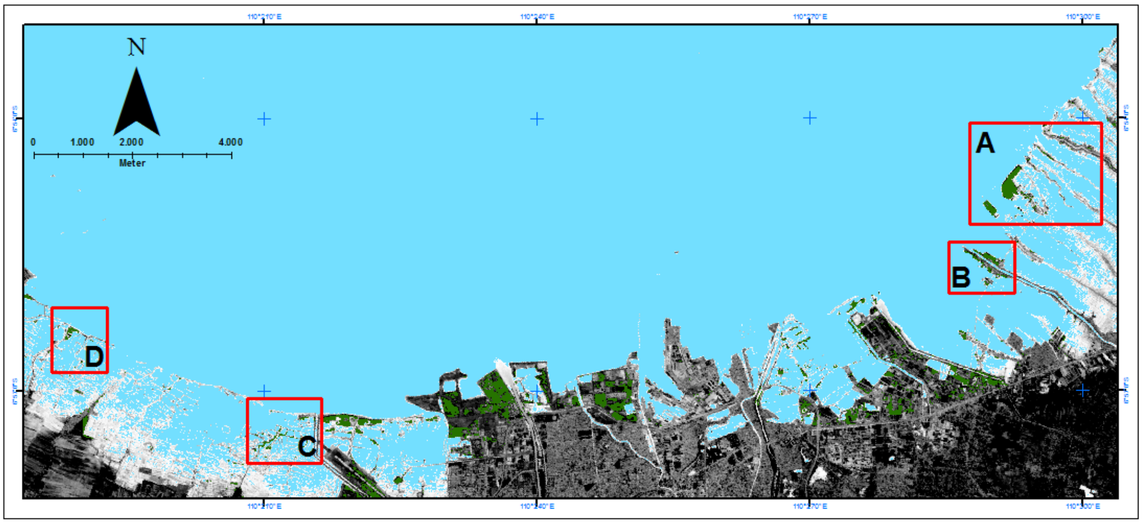

Figure 1. Distribution of Mangrove Vegetation Along the Research Location

Observation on mangrove abundance

Observation on mangrove abundance were including seedling and sapling. Plot transect method was used to observe mangrove abundance. Plot transect for each mangrove stage was differed where for seedling plot size of 1 x 1 m was occupied while for sapling plot size 5 x 5 was used.

Environmental parameter measurements

Environment parameters measurements namely temperature, salinity, pH and DO were measured directly on site. While organic matter, nutrient (N,P,K) and sediment structure were sampled and were analyzed in the laboratory.

Mangrove growth measurements

Mangrove growths were assumed by the ratio of sapling abundance and seedling abundance observed on each transect. The equation is described as:

$$Seedling\ Growth = \frac{Sapling\ Abundance}{Seedling\ Abundance} \times 100\%$$

Seedling growth resulted from the equation above was then along with environmental parameters were used for the next regression analysis between environmental parameters and seedling growth. Since analysis was done to observe the effect pattern of environmental parameters to Avicennia seedling growht rate, partial regression analysis including curve estimation was occupied. Curve estimations included including linear, polinomial quadratic and logarithmic pattern.

RESULT AND DISCUSSION

In order to achieve better understanding on the distribution of grey mangrove *A. marina* in the northern Java coasts, a study was carried out on the mangrove seedling growth patterns in Semarang and Demak coasts.

Mangrove seedling growth pattern caused by the observed parameters above including 2 effect pattern which are polynomial quadratic and logarithmic. Parameters which have polynomial quadratic pattern are salinity, DO, P, sand and silt, while temperature, pH, BO and N have logarithmic effect pattern. Each parameter have quiet strong to very strong effect on Avicennia seedling growth. Detailed information obtained from statistical analysis conducted is shown in Table 1.

Table 1
Interaction Pattern of Environment Parameters to the Growth of Avicennia Seedling

No.	Parameter	Pattern	Equation	Coef. Of Det (Sig.)
1.	Suhu	Logarithmic	$Y = 0{,}091 - 0{,}026.\ln(X)$	0.957 (0.004)
2.	Salinitas	Quadratic	$Y = -3{,}361e^{-2} + 4{,}281e^{-5} X^2$	0.542 (0.167)
3.	pH	Logarithmic	$Y = 0{,}140 - 0{,}072.\ln(X)$	0.928 (0.008)
4.	DO	Quadratic	$Y = 9{,}685e^{-3} - 2{,}680e^{-3} X + 2{,}194e^{-4} X^2$	0.927 (0.073)
5.	BO	Logarithmic	$Y = -0{,}024 + 0{,}010.\ln(X)$	0.790 (0.044)
6.	N sediment	Logarithmic	$Y = -2{,}189e^{-3} - 5{,}594e^{-3}.\ln(X)$	0.959 (0.004)
7.	P sediment	Quadratic	$Y = 9{,}378e^{-4} + 2{,}086e^{-5} X - 1{,}759e^{-8} X^2$	0.930 (0.070)
8.	Dissolved N	Quadratic	$Y = 3{,}947e^{-3} + 7{,}181e^{-3} X - 1{,}424e^{-3} X^2$	0.971 (0.029)
9.	Dissolved P	Logarithmic	$Y = -3{,}780e^{-3} - 3{,}319e^{-3}.\ln(X)$	0.415 (0.241)
10.	Dissolved K	Quadratic	$Y = 5{,}547e^{-3} - 9{,}152e^{-6} X + 4{,}863e^{-9} X^2$	0.541 (0.459)
11.	Sand	Quadratic	$Y = 6{,}494e^{-3} - 5{,}689e^{-4} X + 5{,}463e^{-6} X^2$	0.680 (0.320)
12.	Silt	Quadratic	$Y = 2{,}324e^{-3} - 1{,}545e^{-4} X + 2{,}312e^{-6} X^2$	0.669 (0.331)

Mangrove Avicennia seedling growth tends to be effected by temperature with logarithmic pattern. It means that temperature will reach its optimum effect on Avicennia seedling growth. When temperature rise above the optimum temperature for Avicennia seedling growth, its respond tends to decrease until it reaches the static point. Temperature is controlling factor for seedling growth. Lopez-Hoffman et al. (2006) mentioned that environmental temperature higly related to photosyntethic processes of mangrove vegetation. When temperature rise, utilization by Avicennia is not rising as well. Avicennia growth is inhibited in temperature of 37°C.

The most important factor in mangrove development is salinity. Salinity and Avicennia growth has possitive correlation where the increasing salinity would stimulate the growth of Avicennia (Ball, 2002). The best salinity range for Avicennia seeling growth is 5 - 30‰.

Effect of pH to Avicennia seedling growht is similar to temperature pattern. The logarithmic pattern showed that after reaching optimum point pH would not give further effect to the Avicennia growth. Joshi and Ghose (2003) mentioned that optimum pH for Avicennia is 7,5.

DO roles as limiting and directing factor for mangrove growth (Gerking, 1978). The pattern showed polynomial logarithmic to the growth of Avicennia seedling which means that the effect of the temperature is negative on low DO and positive on high DO. According to McKee (1996) Avicennia is vulderable to lack of DO where Avicennia would experience hypoxia which leads to decrease of respiration

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rate to the root system and decrease of root development.

Availability of organic matter roles in the growth of Avicennia seedling. Effect of organic matter availability to Avicennia seedling growth has a logarithmic pattern. It means that Avicennia seedling has limited capability on utilizing organic matter for growth. Organic matter compound in sediment roles in soil microbia availability and abundance and potential redox on mangrove soil which furthermore would effect the growth of Avicennia seedling (Gleason and Ewel, 2002).

N and P considered as nutrient for vegetation growth. As limiting factors, N and P effect on the seedling process (Lovelock et al., 2004). The pattern resulted in the analysis showed that N has consistent advantage on Avicennia growth while P tends to be more dynamic. Early development of mangroves are driven by N availability, while P roles in stimulating growth of leaves and branches (Kathirean and Bingham, 2001). Krauss et al (2008) also mentioned that mangrove is sensitive to nutrient variation.

Mangrove is vegetation with specific sediment characteristic. Park (2004) mentioned that there is correlation of mangrove and silt composition. Avicennia mostly established on coastal ecosystem with silt dominated sediment. Pattern effect showed polynomial quadratic which means effect of sediment composition above the appropriate would be reversed.

CONCLUSION

Avicennia mangrove seedling growth has dynamic pattern, depends on what parameters mainly effect. Several parameters have polynomial quadratic pattern such as salinity, DO, P, sand and silt while some other parameters have logarithmic pattern such as temperature, pH, organic matter and N. This result should be the key in maintaining mangrove development especially for Avicennia seedling. Since each mangrove species on each live stage has different factors affecting and different pattern, there should be more researches focusing the mangrove development to match the suitable management.

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