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ANALYSIS OF VEGETATION STRUCTURE IN THE MANGROVE ECOSYSTEM OF PENGARENGAN, PANGENAN, CIREBON REGENCY

Analisis Struktur Vegetasi Pada Ekosistem Mangrove Di Pengarengan, Pangenan, Kabupaten Cirebon

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ABSTRACT

Ekosistem mangrove berperan penting dalam menjaga keseimbangan biologis pesisir, melindungi daratan dari erosi, menyediakan habitat bagi berbagai biota, serta berfungsi sebagai penyerap karbon yang efektif. Indonesia memiliki kawasan mangrove terluas di dunia, yaitu sekitar 3,3 juta ha, namun ekosistem ini terus mengalami degradasi akibat alih fungsi lahan dengan laju kerusakan mencapai 530.000 ha/tahun. Degradasi tersebut menurunkan fungsi ekologis dan ekonomis mangrove, sehingga diperlukan analisis struktur vegetasi untuk menilai kondisi ekosistem. Penelitian ini bertujuan menganalisis struktur vegetasi mangrove di Desa Pengarengan, Kecamatan Pangenan, Kabupaten Cirebon, yang merupakan salah satu kawasan mangrove tertua di Cirebon. Pengambilan data dilakukan di tiga stasiun menggunakan metode *Transect Line Plot* dengan ukuran plot 10×10 m² untuk pohon, 5×5 m² untuk pancang, dan 1×1 m² untuk semai. Parameter yang diamati meliputi kerapatan, frekuensi, dan dominansi untuk kemudian dihitung Indeks Nilai Penting (INP). Hasil penelitian menunjukkan bahwa vegetasi mangrove di lokasi penelitian didominasi oleh spesies *Rhizophora mucronata* dan *Avicennia marina.* Kerapatan vegetasi tingkat pohon termasuk kategori sedang dan rapat dengan kerapatan tertinggi terdapat pada Stasiun II yaitu 2.433 ind/ha dan kerapatan terendah terdapat pada Stasiun I yaitu 1.200 ind/ha. Nilai INP mencapai masing-masing jenis pada semua stasiun adalah 300% pada tingkat pohon dan pancang, yang menandakan dominasi satu spesies pada tiap stasiun.

Kata Kunci: Dominansi, Frekuensi, Indeks Nilai Penting, Kerapatan Vegetasi

ABSTRACT

Mangrove ecosystems play an important role in maintaining coastal biological balance, protecting land from erosion, providing habitats for various biota, and functioning as effective carbon sinks. Indonesia has the largest mangrove area in the world, covering approximately 3.3 million hectares, but this ecosystem continues to experience degradation due to land

conversion, with a rate of destruction reaching 530,000 hectares per year. This degradation reduces the ecological and economic functions of mangroves, necessitating vegetation structure analysis to assess the condition of the ecosystem. This study aims to analyze the vegetation structure of mangroves in Pengarengan Village, Pangenan District, Cirebon Regency, which is one of the oldest mangrove areas in Cirebon. Data collection was carried out at three stations using the Transect Line Plot method with plot sizes of 10×10 m² for trees, 5×5 m² for stakes, and 1×1 m² for seedlings. The parameters observed included density, frequency, and dominance, which were then used to calculate the Importance Value Index (IVI). The results showed that the mangrove vegetation at the study site was dominated by the species Rhizophora mucronata and Avicennia marina. The density of tree-level vegetation was classified as moderate to dense, with the highest density found at Station II (2,433 ind/ha) and the lowest density found at Station I (1,200 ind/ha). The INP value reached 300% for each species at all stations at the tree and stump levels, indicating the dominance of one species at each station.

Keywords: dominance, frequency, importance index, vegetation density.

INTRODUCTION

Mangrove ecosystems are the connecting ecosystem between land and sea, so they play an important role in maintaining the biological balance of coastal areas (Winner) *et al.* 2023; Meidiana *et al.* 2020). Mangroves function as coastal protectors from damage to ocean waves and the threat of erosion through a root system that is able to dampen wave energy (Imburi *et al.* 2024; São Paulo *et al.* 2022). Mangrove ecosystems also provide important ecological functions as spawning grounds (*Spawning Ground*), a place to forage (*Feeding Ground*), and foster care (*Nursery Ground*) for a variety of biota, including benthic invertebrates such as crustaceans, bivalves and gastropods (Lewerissa *et al.* 2018; Ouyang & Guo 2021). In addition to ecological functions, mangroves also play a role in mitigating climate change. This ecosystem is known as *Carbon Sink* (carbon absorbers). Although mangrove forests are only about 1% of the world's total tropical forests, their ability to sequester carbon is recorded to be three times greater than that of other types of forests (Sulaiman, 2023).

Indonesia is a country with mangrove areas spread across 257 districts/cities with a total area of around 3.3 million hectares. Of these, 93% (3,121,239 ha) is categorized as dense mangroves, 5% (188,363 ha) medium mangroves, and 2% (54,474 ha) rare mangroves (Pahlevi et al., 2024). However, mangrove ecosystems in Indonesia continue to suffer degradation due to land conversion, with the rate of destruction reaching 530,000 ha/year (Eddy et al., 2015). This degradation has an impact on the decline of the ecological and economic functions of mangroves, such as the loss of biodiversity, the increased risk of disasters, the decrease in fisheries productivity, and the reduction of economic and social potential (Zega et al., 2024). To assess the condition of the mangrove ecosystem, the analysis of vegetation structure is an important step because it can describe the condition of the ecosystem and its carrying capacity. Vegetation analysis requires parameters in determining the Index of Important Values (INP), such as relative density and density, relative frequency and frequency, and relative dominance and dominance, in order to provide information about vegetation structure (Ndede et al., 2017).

Pengarengan Village in Pangenan District, Cirebon Regency, West Java is one of the coastal areas that has the oldest mangrove ecosystem in Cirebon Regency (Iqbal 2023)). This area is located along the Cipaluh River with a coastline of 4,931 km, of which about 4,731 km is a green strip overgrown with mangrove ecosystems (Purwanto *et al.* 2021). Although this area has a large area of mangroves, information about the vegetation structure is still limited. In fact, this information can be the basis for formulating strategies for managing and utilizing

mangrove forests to kill off their functions and benefits to remain sustainable. Based on this background, this study aims to analyze the structure of mangrove vegetation in the Pengarengan Mangrove Ecosystem, Pangenan, Cirebon Regency.

RESEARCH METHODS

Research Location

Data collection was carried out in July at the Pengarengan Mangrove Ecosystem, Pangenan, Cirebon Regency which consisted of 3 stations. The sampling transect is placed in a *purposive sampling* to find out the distribution of the type, diameter, and density of mangrove vegetation (Heriyanto & Subiandono, 2016). There are three stations to choose from, namely:

a. Station 1 (6°46'25.92"S, 108°38'47.45"E): It is an area located on the main course of the river
b. Station 2 (6°46'4.59"S, 108°38'39.38"E) : It is an area located in a tourist area.
c. Station 3 (6°45'46.85"S, 108°38'32.36"E) : It is an area located at the mouth of the river.

The location of the research station can be seen in **Figure 1.**

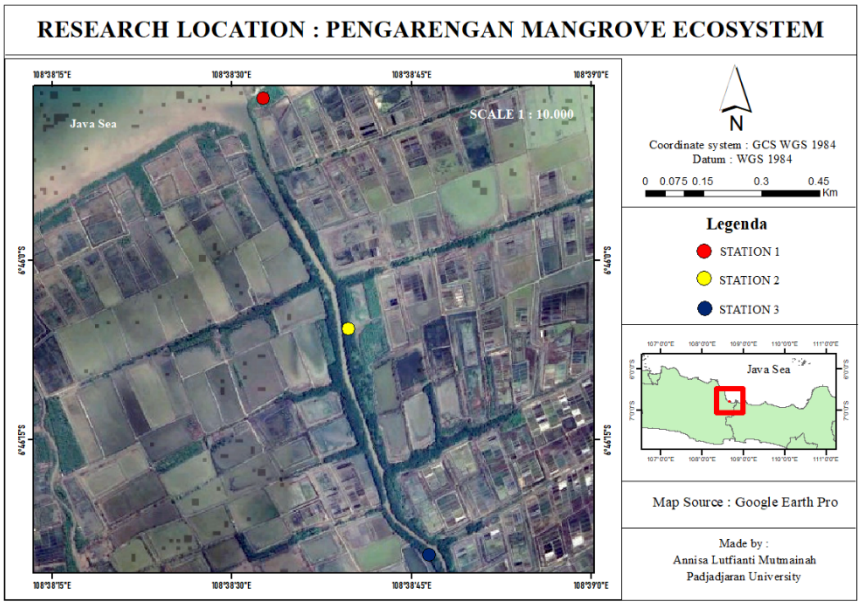

Figure 1. Research Location

Tools and Materials

The tools and materials used in the study are as follows,

Table 1. Tools used in the research

Yes	Name	Function
1	Roll Meter	To measure the length of the transect
2	Rabbi's Response	To create a sampling transect
3	Meter	To measure DBH (*Diamater of Breast Height*)
4	Life Form Mangrove Vegetation	As a guideline for identifying mangrove species
5	Life Form Field Data	For field data fill sheets
6	Stationery	To record field data

The materials used in the study are vegetation and its characteristics which are identified using pedogens *Life Form Mangrove Guide* (Sheue & Yong 2019), the number of types and their diameter values (DBH, *Breast Diameter and Height*).

Data Collection Method

Vegetation data collection was carried out using *the Transect Line Plot method.* This method is a combination of line and square transect methods. The data taken were the diameter (DBH), number, and individual types of mangroves. There are 3 data collection stations with 30×10 m each station consisting of 3 quadrant plots measuring 10×10 m2 for tree-level mangroves, 5×5 m2 subplots for stake level, and 1×1 m2 for seedling levels that are placed continuously along the transect rope.

Data Analysis

The vegetation structure was analyzed using vegetation analysis which summarized density, relative density, frequency, relative frequency, dominance, and relative dominance. Next, the importance value index (INP) will be calculated. The following is the calculation formula for each parameter (Odum, 1993):

a. Density and Relative Density

$$K_i = \frac{ni}{A}$$

Information:
Ki : Density of a type (Ind/m²)
Ni : Number of individuals
A : Plot area (m²)

$$\text{KR} = \frac{K_i}{K_{total}}$$

Information:
KR : Relative Density
Ki : Density of a type (Ind/m²)
Ktotal : Density of all kinds

The value of vegetation density (Ki) at the tree level is adjusted to the category of mangrove tree density in accordance with the Ministry of Living Environment No. 201 of 2004 concerning Standard Criteria and Guidelines for Determining Mangrove Damage presented in

Table 2. Standard Criteria for Mangrove Tree Density

No	Category	Density (Trees/ha)
1	Low	> 1,500
2	Medium	1,000 - 1,500
3	High	< 1,000

b. Frequency and Reactive Frequency

$$\text{Fi} = \frac{Jumlah\ petak\ penemuan\ suatu\ jenis}{Jumlah\ seluruh\ petak}$$

$$\text{FR} = \frac{F_i}{F_{total}}$$

Information:
Fi : Frequency of a kind
FR : Relative Frequency
Ftotal : Frequencies of all kinds

c. Dominance and Relative Dominance

$$D_i = \frac{LBD}{L_{plot}}$$

Information:
At : Dominance of a type

LBD : Base Field Area (LBD)= $\frac{1}{4} \times \pi \times d^2$
Lplot : Plot Area

$$DR = \frac{D_i}{D_{total}}$$

DR. : Relative Dominance
At : Dominance of a type
Dtotal : Dominance of all types

d. Vital Value Index (INP)

INP = KR + FR + DR

RESULT

Based on the results of the study, there are only two types of mangroves at the research site, namely *Rhizophora mucronata* and *Avicennia marina*. The formation of *R. mucronata* and *A. marina* mangroves at the research site is shown in **Figure 2,**

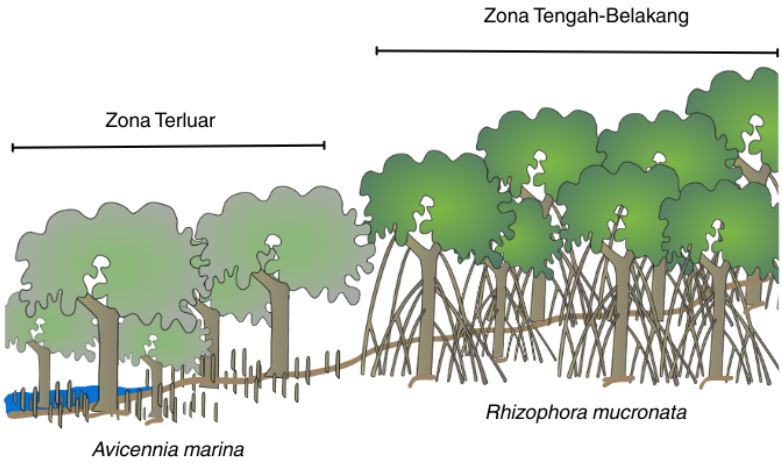

Figure 2. Mangrove Vegetation Formation at the Research Site

The highest density of tree-level mangrove vegetation is found at Station II with a value of 2,433 ind/ha, followed by Station III with a value of 1,233 ind/ha, and Station I with the lowest density of 1,200 ind/ha. The density value is lower than the results of research by Hapsari et al., (2022) in Karangsong, Indramayu, which recorded a density value ranging from 2,555-7,053 ind/ha. The difference in density in each region is influenced by various factors, including tree diameter, water conditions, substrate type, and anthropogenic activity around the mangrove area (Stuart et al., 2023). Meanwhile, the relative density, relative frequency, and relative dominance values of all stations were recorded at 100%, with the Critical Value Index (INP) reaching 300%. Details of the tree-level mangrove vegetation structure parameters of each station are presented in **Table 3.**

Table 3. Tree-Level Mangrove Vegetation Structure

Station	Species	K	KR (%)	F	FR (%)	D	DR (%)	INP (%)
I	*R. mucronata*	1.200	100	1	100	12.99	100	300
II	*R. mucronata*	2.433	100	1	100	23.48	100	300
III	*A. marina*	1.233	100	1	100	6.85	100	300

The highest pile level mangrove vegetation density is found at Station III with a value of 5,600 ind/ha, followed by Station II with a value of 1,467 ind/ha, and Station I with the lowest density value of 133 ind/ha. The relative density, relative frequency, and relative dominance values of all stations are 100%, with the Critical Value Index (INP) reaching 300%. Details of vegetation structure parameters of each station for stake-level mangroves are presented in **Table 4.**

Table 4. Pile-level mangrove vegetation structure

Station	Species	K	KR (%)	F	FR (%)	D	DR (%)	INP (%)
I	*R. mucronata*	133	100	1	100	0.01	100	300
II	*R. mucronata*	1.467	100	1	100	1.49	100	300
III	*A.marina*	5.600	100	1	100	6.08	100	300

The highest density of seedling-level mangrove vegetation is found at Station I with a value of 116,667 ind/ha, followed by Station II with a value of 23,333 ind/ha, while Station III shows the lowest density of 0 ind/ha. This density value is higher than the results of a study by Hapsari et al. (2022) in Karangsong, Indramayu, which reported a density range of 250-400 ind/ha. Meanwhile, the relative density and relative frequency values of all stations are 100%, with the Critical Value Index (INP) reaching 200%. Details of the vegetation structure parameters of each station for stake-level mangroves are presented in **Table 5.**

Table 5. Seedling-Level Mangrove Vegetation Structure

Station	Species	K	KR (%)	F	FR (%)	D	DR (%)	INP (%)
I	*R. mucronata*	116.667	100	1	100	-	-	200
II	*R. mucronata*	23.333	100	1	100	-	-	200
III	*A.marina*	0	-	-	-	-	-	-

DISCUSSION

The mangrove species found at the three stations are *Rhizophora mucronata* and *Avicennia marina*. Species *R. mucronata* found at Stations I and II, which are along the river flow, while *A. marina* found at Station III which dominates the mouth of the river and along the coastline. The zoning pattern at the research site is in line with the findings of Susanto et al. (2013), on the North Coast of Surabaya, which show that *A. marina* generally occupy the outermost zone or coastline, while *R. mucronata* more growing in the central zone to closer to the mainland (Susanto et al., 2013).

Vegetation density is calculated based on the number of individual species per square meter (transect area), so the more individuals in a transect, the higher the density. At the tree level, the highest density is found at Station II and the lowest value at Station I. Based on the Ministry of Environment No. 201 of 2004 concerning Standard Criteria and Guidelines for Determining Mangrove Damage, there are 3 categories of density, namely high, medium, and low (**Table 2).** The results of the study show that the density of tree-level mangroves at Station II is dominated by *Rhizophora mucronata* Included in the category of meetings. These findings are in line with the research of Pahlevi et al. (2024) on the North Coast of Mojo, Pemalang, where the species *R. mucronata* It also has the highest density. Meanwhile, the density of mangroves at Station I (*R. mucronata)* and III (*A. marina*) falls into the medium category. Mangrove forests with medium to dense/high categories generally show good and relatively well-maintained conditions (beautiful) (Prakoso et al., 2017).

At the seedling level, the density of vegetation can reflect the potential for mangrove regeneration. The results of the study showed that the seedling density at Stations I and II was

relatively good, in accordance with the criteria for natural rejuvenation of brackish forests which were considered good if they reached ≥2,500 stems/ha (Sahami, 2018). This condition is thought to be influenced by the suitability of the muddy substrate that supports growth *Rhizophora sp.* and *Avicennia sp*. (Fitzgerald, 2021). *Rhizophora mucronata* It is a species that is easily adaptable to substrates, so it grows widely in river mouths and tidal banks (Baskorowati et al., 2018; Arfan et al., 2023). Such substrate characteristics allow propagules *R. mucronata* thrives well, especially in flooded areas and soils rich in organic matter (Pahlevi et al., 2024). On the other hand, at Station III, which has a slightly sandy substrate, seedlings were not found, which shows that these conditions are not suitable for growth *A. marina*. This finding is similar to the research of Prakoso et al. 2027 in Demak, which states that the low density of mangroves in the substrate tends to be sandy and only flooded with seawater at high tide, causing mangrove roots to be difficult to penetrate the substrate and hinder successful growth (Prakoso et al., 2017).

The Index of Important Value (INP) of a type ranges from 0% - 300% and is used to describe the level of importance or role of a type in a community (Ismail et al., 2017; Rawana et al., 2023). A high INP value indicates a greater level of species dominance in the community, while a low value indicates the opposite. The high dominance of a species in a particular habitat indicates the ability of the species to make the most of the available resources (Ismaini et al., 2015). At the research site, the tree and stake level INP of all stations was 300%, while the seedling rate was 200%. The condition is caused by the dominance of one species at each station, so that the level of mastery is very tall. In addition, the high INP is also influenced by the carrying capacity of the environment, especially the type of mud substrate that is spread almost throughout the research station (Hapsari et al., 2022).

CONCLUSION

Mangroves in Pengarengan Village, Pangenan, Cirebon Regency are dominated by two species, namely *Rhizophora mucronata* and *Avicennia marina*. The highest tree-level mangrove density was found at Station II, which was 2,433 ind/ha and included in the meeting category, while the lowest density was found at Station I, which was 1,200 ind/ha which was included in the medium category. The Index of Important Value (INP) at the tree and pile levels at all stations is 300% for each type, while the seedling level is 200%.

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