

The Comprehensive Analysis of Mangrove Vegetation in Penunggul Village, Pasuruan Regency, Indonesia

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INDEXING	ABSTRACT
Keywords: Keyword 1; Community Keyword 2; Penunggul Keyword 3; Mangrove Keyword 4; Density Keyword 5; Dominance	This research aims to conceive the current condition of the mangrove vegetation community in Penunggul and proposes consideration of the attempt of maintaining the mangrove ecosystem in Penunggul. The primary data including species, density, dominance, and IVI (Important Value Index) are mined through a mangrove resource survey with vegetation analysis technique. Parameters for the study cover water quality including physics, chemical, tidal and soil quality parameters. Samples of the study are taken from three stations, Lawean river mouth, old fish ponds, and an area near the residential. The result of the study shows that <i>Rhizophora mucronata</i> dominates the growth in the research areas. The high scale of dominance and IVI indicates the important role of the species in the environment, such as producing organic materials and seedlings that contribute to the regeneration of mangrove habitats. Moreover, the parameter of water and soil quality shows an optimum scale for mangrove growth.

Article History

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INTRODUCTION

Several perilous issues are the impact of the downturn in the quality and quantity of mangrove swamps. These issues include abrasion, a decrease in coastal fisheries yield, seawater intrusion that has got farther inland, and an increase in the number of malaria cases (Onrizal and Kusmana, 2008; Mozumder *et al*, 2018; Wu *et al*, 2020 ; Shilla, 2021). Penunggul is one of the villages that have mangrove vegetation for reforestation. This conservation has brought significant benefits to the folk. According to Aye *et al* (2019), conservation helps fishermen increase the number of production and fisheries around the mangrove swamps ecosystem, as well as prevents tidal floods and storms.

Mangrove vegetation thrives over the estuary of the Lawean river (eastern part of Penunggul), old fish ponds, and near residential areas (western part of Penunggul). Hence, it is necessary to know the current condition of the mangrove vegetation community in Penunggul to consider suitable attempts in maintaining the mangrove swamps' sustainability.

This research aims to perceive the current condition of the mangrove vegetation community in Penunggul and provide considerations for the attempts to preserve the ecosystem. This research, hopefully, can increase public knowledge about mangrove vegetation for it has important ecological functions to the coastal areas, as to why it should

be preserved. So that efforts to maintain the mangrove ecosystem in Penunggul, Nguling, Pasuruan Regency, and East Java Province can be carried out more optimally.

LITERATURE REVIEW

One of the most important natural resources in coastal areas is mangroves. Based on Sofian *et al* (2019); Darma *et al* (2020) ; Sahputra *et al* (2022) ; Fisur *et al* (2020), the mangrove forest ecosystem is one of the natural resources of coastal areas which has an important role in terms of social, economic, and ecological. The success of mangrove forest conservation in Penunggul Village has brought significant benefits to the community around the forest, namely an increase in the number of production and fishermen fishing around the mangrove forest ecosystem and the protection of coastal areas from the dangers of tidal flooding and storm winds.

The Comprehensive Analysis of Mangrove Vegetation is to find out the current condition of the mangrove vegetation community and provide considerations to preserve the mangrove ecosystem. By analyzing mangrove vegetation through the Importance Value and Density Index, we can find out the direct benefit value or DUV (Direct Use Value) of the mangrove ecosystem and the strategy for preserving mangrove areas from an ecological perspective, so that they can support mangrove conservation activities. So, the writer is interested to understand the mangrove vegetation in Penunggul, Pasuruan Regency, East Java, Indonesia.

RESEARCH METHOD

Materials

The material in this research is mangrove vegetation, soil (substrate), water temperature, the pH of water, dissolved oxygen, salinity, and tides.

1. Samples

Samples of the study are taken from three stations, the Lawean river mouth, old fish ponds, and an area near the residential in Penunggul. In this research, there are 3 locations of sampling. These are below:

- a. Station I: the mangrove vegetation on the edge of the mouth of the Lawean River which is the boundary between Penunggul Village and Tambakrejo Village, Tongas District, Probolinggo Regency.
- b. Station II: the mangrove vegetation in the middle of a mangrove tourism site that used to be a fishpond.
- c. Station III : the mangrove vegetation to the west of Penunggul Village which is close to residential areas.

2. Site and Time

This research was done in Penunggul, Nguling, Pasuruan Regency, East Java Province, by Soil Physics Laboratory, Faculty of Agriculture, Brawijaya University Malang and Chemistry Laboratory, the University of Muhammadiyah Malang from March to May 2022.

3. Procedures

Survey

The method used in this research is Survey Method for Mangrove Forest Resources using Vegetation Analysis Techniques (Baloloy *et al*, 2020; Rhyma *et al*, 2020). Based on Anand *et al* (2020); Thakur *et al* (2020), it is for knowing the wealth contained in a forest area, both qualitatively and quantitatively. Considering that the forest that is used as the object covers a large area, data collection in the field is generally carried out with a sampling unit.

These primary data include salinity, water temperature, pH, DO parameter, mangrove substrate, mangrove vegetation, trunk circumference and diameter, field documentation, and community interviews. The secondary data includes tidal data from relevant agencies, books, and scientific journals about mangroves, and the coastal area of Penunggul. The Parameters for this research are water quality, soil quality, tidal, and mangrove vegetation parameters.

Sampling

The method used in determining the observation station for sampling is Stratified Random Sampling. According to Marzuki (1977) ; Baderan *et al* (2019), Stratified Random Sampling is that before the sample is taken, the population is divided into sub-populations called strata / layers / smaller groups. This is done because the population is heterogeneous, so that by grouping it into several strata, it is expected that each stratum will be relatively homogeneous.

Measurement

1. Water and Soil Quality Parameters

Water quality parameters measured in this research include temperature, salinity, pH, and DO (Dissolved Oxygen). The soil quality parameters measured in this research include soil texture, soil pH, and soil organic matter.

2. Mangrove Vegetation Parameters

Line Transect and Plot Sampling are used to observe and measure mangrove vegetation. Lapolo *et al* (2018) ; Asadi *et al* (2019) ; Indarjo *et al* (2020) ; Japa *et al* (2021) stated that the 10 m × 10 m square-shaped plots are used to observe the tree level. In the 10 m × 10 m plot, a smaller 5 m × 5 m plot is made for monitoring mangroves at the shrub level. In the 5 m × 5 m plots, a plot measuring 2 m × 2 m is made to observe mangroves at the seedling level.

There are three plots of 10 m × 10 m are placed at each observation station. On each station, these plots are vertically and horizontally patterned. Hence, each plot can represent the state of mangrove vegetation for the whole station (Vincentius *et al*, 2019 ; Irwanto *et al*, 2020). These 10 m × 10 m plots are two hundred meters away from each other. The observation of mangrove vegetation takes place after these plots are built. The characteristics of mangrove vegetation are then classified according to each class. Kartawinata *et al*. (1976) in Heriyanto and Subiandono (2012); Otero *et al* (2019), classify the level of mangrove regeneration as follows:

- a. Trees are woody plants with a diameter of more than 10 cm at chest height (1.3 m).
- b. The Shrub is a woody plant with a diameter of 2 cm to less than 10 cm at chest height (1.3 m).

- c. Seedling is cultivated from sprouts to a height of less than 1.5 m. Explanation of how measurements were made and calculations performed.

Data Analysis

The method used in this research is a survey of mangrove forest resources with vegetation analysis techniques (Isoni *et al*, 2019 ; Pototan *et al*, 2021), including Density of Mangrove Species, Relative Density, Species Frequency, Relative Frequency and IVI (Important Value Index).

1. Density of Mangrove Species or Di (ind/ha)

The Density of Mangrove Species is the stands trunk type-i in a unit area. Determination of density by using the formula below:

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

Di : Density of Mangrove Species (ind/hectares)
 ni : The amount of the stands trunk (ind)
 A : Total area of the sampling area (hectares)

2. Relative Density or RDi (%)

Relative Density is the ratio between the number of stands trunk of certain mangroves with the total stands trunk of all species. Determination of relative density (RDi) using the formula:

$$RDi = \frac{ni}{\sum n} \times 100 \%$$

RDi : Relative Density (%)
 ni : The amount of the stands trunk of certain mangrove (ind)
 $\sum n$: The amount of the stands trunk in all species (ind)

3. Species Frequency or Fi

Species Frequency states the probability of finding an i-th type in all sample plots compared to the total number of sample plots created. To calculate the Specific Frequency (Fi) used the formula:

$$Fi = \frac{pi}{\sum F}$$

Fi : Species Frequency
 pi : Number of sample plots where certain mangrove species are found
 $\sum F$: Total number of sample plots created

4. Relative Frequency or RFi (%)

The relative frequency is the ratio between the frequency of the i-th Type with the total frequency of all types, which is calculated by the formula:

RFi : Relative Frequency (%)
 Fi : frequency of certain mangrove species

$\sum F$: Total number of sample plots created

$$RFi = \frac{Fi}{\sum F} \times 100 \%$$

5. IVI (Important Value Index) or INP.

According to Onrizal (2008), useful for determining the dominance of a species over other species in an area, and also determining how big the role or influence of a species is on the surrounding environment. Determining the important value index using the following formula :

$$\text{IVI (Important Value Index) or INP} = \text{Relative Density} + \text{Relative Frequency}$$

RESULT AND DISCUSSION

Location

This research is done at Penunggul Beach which has 150 hectares of mangrove vegetation as reforestation by the community led by Mukarim. Penunggul is a coastal village that has an area of 57 hectares. Penunggul area is divided into two hamlets, Pesisir and Sawahan.

Sampling Station Description

Station 1 is located on the eastern part of Penunggul, on the edge of the Lawean River mouth. The Lawean River is the border of Penunggul to Tambakrejo, Tongas, Probolinggo. Station 1 is located at the coordinates of 7°42'10.47" South Latitude – 7°42'13.91" South Latitude and 113°5'56.82" East Longitude – 113°5'53.98" East Longitude.

Station 2 is located in the middle of a mangrove tourism area which was once a freshwater or brackish aquaculture pond. Station 2 is located at the coordinates 7°42'11.94" South Latitude – 7°42'13.84" South Latitude and 113°5'28.43" East Longitude – 113°5'34.96" East Longitude. This station is close to residential areas and overgrown by shrubs. The station is accessible by foot, boat, or other vehicles.

Station 3 is located in the western part of Penunggul, close to the residential areas. Station 3 is on the border of Penunggul to Mlaten. This station is located at the coordinates 7°42'10.34" South Latitude – 7°42'11.81" South Latitude and 113°5'19.09" East Longitude – 113°5'20.88" East.



Figure 1: Station 1 (left) ; Figure 2 : Station 2 (middle) ; Figure 3 : Station 3 (right)

Water Quality Parameters

The data from the measurement of water quality parameters can be seen in the table below:

Table 1. Water Quality Analysis Data

No.	Station	Temp- (°C)	Salinity (‰)	pH	DO (mg/l)
1.	Station 1	33.7	30	7.62	6.4
2.	Station 2	33.5	30	8.34	6.2
3.	Station 3	34.5	34.8	7.10	7.0

The temperature at the observation site is range from 30°C to 34°C. At this range of temperature, these three types of mangroves, *Avicennia alba*, *Avicennia marina*, and *Rhizophora mucronata*, can grow well. According to Cuenca *et al* (2015), the maximum temperature for *Rhizophora stylosa* and *Ceriops* to grow is from 26°C to 28°C, and *Bruguiera spp.* is at 27°C. Meanwhile, the water temperature of 27.8°C to 31.7°C is the optimum temperature for *Rhizophoraceae* to grow.

At the observation site, the salinity is range from 30 to 34.8 ppt. This range is within the tolerance limit for mangrove growth. According to Checon *et al* (2016) ; Barik *et al* (2018), mangrove vegetation can thrive in intertidal areas with a 10–30 ppt range of salinity.

The pH scale at the observation site ranges between 7.10 to 8.34. This range is good for mangrove growth. According to Priosambodo *et al* (2019), *Rhizophora mucronata* can grow well on relatively thick mud substrate, with water/soil pH between 6.6 and 8.2. The range of dissolved oxygen at the observation site is between 6–7 mg/l. This range is the general value of dissolved oxygen in the ocean. This is per the statement of Gebresilasie *et al.* (2021), that the oxygen in seawaters generally ranges between 5.7 to 8.5 mg/l.

Substrate Parameters

The data from soil quality parameters can be seen in the table below

Table 2. Soil Quality Analysis Data

No.	Station	Soil (Substrate) Quality			Soil Texture
		pH	SOM (%)	SOC (%)	
1.	Station 1	7.28	2.96	2.28	Dusty Loam
2.	Station 2	7.58	3.352	2.58	Sandy Loam
3.	Station 3	7.56	3.084	2.37	Loamy sand

Types of soil texture at the observation site include dusty loam, sandy loam, and loamy sand. The range of soil organic carbon and soil organic matter is between 2–3%. This percentage is suitable for the three types of mangroves at the observation site, as the soil organic matter plays an important role in fertility. According to Xu *et al* (2016), soil organic matter can affect the physical and chemical properties of the soil. The content of organic matter in the soil is relatively small (2–6%) compared to mineral matter (94–98%).

The Identification of Mangroves in Penunggul Village

The data of Mangrove species parameters can be seen in the table below.

Table 3. Species of Mangrove Founded in Penunggul Village

No.	Photo	Species of Mangrove	Characteristic
1.		<i>Avicennia alba</i>	The respiratory roots are usually thin. Living in protected coastal locations and their roots can help bind sediment and accelerate the process of land formation. (Noor <i>et al.</i> ,1999).
2.		<i>Avicennia marina</i>	The respiratory root is erect with several lenticels. The most common plant species found in tidal habitats. The tip of the leaf is tapered to rounded with a leaf size of 9 x 4.5 cm (Noor <i>et al.</i> ,1999) .
3.		<i>Rhizophora mucronata</i>	Support roots and aerial roots that grow from the lower branches. The shape of the leaves is elliptical widening to elongated round, with a tapered leaf tip. Tolerant to harder substrates and sand. It generally grows in groups, near river mouths. (Noor <i>et al.</i> ,1999).

The Analysis of Mangrove Vegetation

The results of the analysis of mangrove vegetation at the location of the research can be seen in the following table:

Table 4. The Analysis of Mangrove Vegetation in Penunggul Village

Station	Species of Mangrove	Total	Di (ind/ha)	RDi (%)	Fi	RFi (%)	INP (%)
1	<i>Avicennia marina</i>	Σ Am	1166	4,4	1,6	34,81	39,21
	<i>Rhizophora mucronata</i>	Σ Rm	24932	95,6	3	65,19	160,79
		Σ Total	26098	100	4,6	100	200
2	<i>Avicennia marina</i>	Σ Am	7665	46,7	0,99	37,35	84,05
	<i>Rhizophora mucronata</i>	Σ Rm	8767	53,3	1,66	62,65	115,95
		Σ Total	16432	100	2,65	100	200
3	<i>Avicennia alba</i>	Σ Aa	600	1,47	0,33	14,29	15,76
	<i>Avicennia marina</i>	Σ Am	500	1,23	0,66	28,57	29,8
	<i>Rhizophora mucronata</i>	Σ Rm	39500	97,3	1,32	57,14	154,44
		Σ Total	40600	100	2,31	100	200

Based on the standard criteria for mangrove damage according to Nurfitriani *et al* (2019) ; Pasaribu *et al* (2020) ; Yoswaty *et al* (2021), mangroves are in good criteria (very dense) if the tree density is more than 1500 ind/ha, mangroves are in good criteria (moderate) if the tree density is more than 1000 to less than 1500 ind/ha, and mangroves are categorized as damaged or distant if the tree density is less than 1000 ind/ha.

Referring to the regulation, at Station 1, *Rhizophora mucronata* is in good category (very dense) with a density value (Di) of 24932 ind/ha, while *Avicennia marina* is in the moderate category with 1166 ind/ha. At Station 2, *Rhizophora mucronata* is in good criteria with a density of 8767 ind/ha and *Avicennia marina* is also in a good criteria with 7665 ind/ha. At Station 3, *Rhizophora mucronata* is in the good criteria (very dense) with a density value of 39500 ind/ha, while *Avicennia alba* and *Avicennia marina* are in the distant category (damaged) with tree-level densities of 600 ind/ha and 500 ind, respectively.

The Important Value Index (IVI) of Mangrove Vegetation

Based on the observation of mangrove vegetation at the site, there found two types of mangroves at Station 1, *Avicennia marina* and *Rhizophora mucronata*. *Rhizophora mucronata* dominates the environment with a higher value than *Avicennia marina*. Besides, *Rhizophora mucronata* contributes an important role to the environment as it has the highest IVI value of all species with 160,79%, while *Avicennia marina* records 39.21%. This is indicated by a large number of *Rhizophora mucronata* seedlings, while there is no seedling record of *Avicennia marina*. The substrate contains organic matter that allows the seedlings to thrive. This organic matter is contributed by the sludge in the substrate. The presence of *Rhizophora mucronata* and *Avicennia marina* will produce a lot of organic matter.

Avicennia marina and *Rhizophora mucronata* are also found at Station 2. *Rhizophora mucronata* dominates the environment with a higher dominance value than *Avicennia marina*. *Rhizophora mucronata* holds a more important part of the environment for its highest IVI records of all the tree species with 115,95%, while *Avicennia marina* records

84,05% of all species. The existence of *Avicennia marina* and *Rhizophora mucronata* will produce organic matter at Station 2. Therefore, *Avicennia marina* and *Rhizophora mucronata* seedlings can sprout well. Seedlings have an important role in the habitat or regeneration as they will grow into trees to replace snag mangroves.

At Station 3, there are three types of mangroves, *Avicennia alba*, *Avicennia marina*, and *Rhizophora mucronata*. *Rhizophora mucronata* dominates the growth value at the station with a higher dominance value than *Avicennia alba* and *Avicennia marina*. *Rhizophora mucronata* also records the highest IVI value at the tree level with 154.44%, while the IVI value of *Avicennia alba* and *Avicennia marina* is 29,8% and 15,76%, respectively. *Rhizophora mucronata*, *Avicennia alba*, and *Avicennia marina* can vegetate well as the substrate is sandy and located right by the sea. According to Ragavan *et al.* (2019) ; Ramachandra *et al* (2022), the area closest to the sea has a slightly sandy substrate and is often overgrown by *Avicennia spp.* The mangrove vegetation of *Avicenniaceae*, *Rhizophoraceae*, and *Sonneratiaceae*, is characterized by loamy sand, sandy loam, and sandy clay textures.

Mangrove litter at the observation site is useful for soil fertility. According to Alongi (2018), one component of mangrove swamps that plays a role in soil fertility in coastal areas comes from its litter. Decomposed litter contributes organic matter which is a source of food for various types of fish and organisms. The nutrients contained in *Avicennia marina* leaf litter are carbon, nitrogen, and phosphorus.

CONCLUSION

The conclusions that can be drawn from this research are:

- a. The water quality according to physics parameters (temperature), including temperature, pH, DO, and salinity is in optimum conditions for mangrove growth. The results of soil quality (substrate) show that soil pH, organic matter, and organic carbon are suitable for mangrove growth as they are in the optimum range.
- b. *Rhizophora mucronata* dominates the environment and plays an important role in all observation sites (Station I until Station III), this is indicated by the high value of dominance and IVI of this species over the others. The role of these species is either in the form of trees as a contributor to soil organic matter for the substrate, seedlings as a contributor to habitat, or a new generation of mangroves that will replace dead mangroves.
- c. *Rhizophora mucronata* is in the good criteria (very dense), while *Avicennia marina* and *Avicennia alba* have it in the distant criteria or damaged.

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