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STRUCTURE OF MANGROVE VEGETATION IN MANGKANG WETAN VILLAGE, TUGU DISTRICT, SEMARANG CITY

Struktur Vegetasi Mangrove di Kelurahan Mangkang Wetan Kecamatan Tugu Kota Semaran

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ABSTRACT

Mangroves are coastal vegetation characterized by distinctive root morphology and adapted to tidal environments. They play a vital role as providers of organic matter and represent a natural resource utilizable by local communities. The objective of this study was to determine the mangrove community structure in Mangkang Wetan Village, Tugu District, Semarang City. The research was conducted from July to September 2024 across three observation stations within Mangkang Wetan Village. Analysis of mangrove community structure employed the purposive sampling method using a line transect with 10 m x 10 m plots, replicated three times. The results of the mangrove community structure analysis in Mangkang Wetan Village identified only one mangrove species: Avicennia marina, present at the tree vegetation level. This species was selected as it is readily available in the surrounding natural mangrove forest, easily cultivated, and its stands provide significant resistance to coastal abrasion. Consequently, the study location constitutes a monospecific (homogeneous) mangrove forest. The Importance Value Index (IVI) for mangroves at stations 1, 2, and 3 was consistently 300. The mangrove species diversity level in Mangkang Wetan Village was recorded with a Shannon-Wiener Diversity Index (H') value of 0, indicating relatively low species diversity. The species evenness index values at stations 1, 2, and 3 were also 0, reflecting low species evenness. The dominance index (C) value was 1, signifying the dominance of a single species. The low diversity and evenness values are attributed to the relatively uniform or homogeneous condition of the mangrove forest.

Keywords: Vegetation, mangrove, Diversity Index

ABSTRAK

Mangrove merupakan komonitas vegetasi pantai tropis yang didominasi oleh spesies pohon bakau yang mampu tumbuh dan berkembang pada daerah pasang surut pantai berlumpur. Komunitas vegetasi ini umumnya tumbuh pada daerah intertidal dan supratidal yang cukup mendapat aliran air dan terlindung dari gelombang dan arus pasang surut yang kuat. Mangrove memiliki peranan sebagai penyedia bahan organik serta sangat potensial bagi kesejahteraan masyarakat baik dari segi ekonomi, sosial, dan lingkungan Penelitian ini bertujuan untuk

mengetahui struktur komunitas mangrove yang ada di Wilayah Kelurahan Mangkang Wetan, yang masuk administrasi Kecamatan Tugu, Kota Semarang. Penelitian ini dilaksanakan pada bulan Juli sampai dengan bulan September 2024 pada tiga stasiun di Kelurahan Mangkang Wetan. Analisis struktur komunitas mangrove dilaksanakan dengan metode purposive sampling melalui transek garis yang dilengkapi plot berukuran 10 m x 10 m, dengan tiga kali ulangan pada setiap plotHasil penelitian pada struktur komunitas mangrove di Kelurahan Mangkang Wetan, mangrove yang teridentifikasi sebanyak 1 jenis yaitu *Avicennia marina* dalam vegetasi tingkat pohon, karena spesies tersebut mudah diperoleh dari ekosistem hutan mangrove alami yang ada di sekitar dan spesies tersebut mudah untuk dibudidayakan serta tegakannya mampu menahan abrasi laut yang cukup besar. Lokasi penelitian ini termasuk dalam hutan mangrove yang bersifat homogen. Indeks Nilai Penting (INP) mangrove pada stasiun 1, 2, dan 3 masing-masing adalah 300. Tingkat keanekaragaman jenis mangrove di Kelurahan Mangkang Wetan tercatat dengan nilai H = 0, menunjukkan tingkat keanekaragaman spesies mangrove yang relatif rendah. Indeks keseragaman pada stasiun 1, 2, dan 3 bernilai 0, yang menandakan tingkat keseragaman jenisnya rendah. Nilai indeks dominansi (C) yaitu 1 , menunjukkan bahwa ada individu spesies yang mendominasi. Rendahnya nilai keanekaragaman dan keseragaman dipengaruhi oleh kondisi hutan mangrove relatif sama atau homogen.

Kata Kunci: Vegetasi, Mangrove, Nilai Indeks Keseragaman

INTRODUCTION

Mangroves constitute one of the distinctive ecosystems in coastal and tidal areas that possess highly important ecological and economic functions. Ecologically, mangrove forests function as natural coastal protectors against abrasion, waste filters, barriers to seawater intrusion, and controllers of erosion. This ecosystem also serves as an important habitat for various marine biota such as fish, shrimp, crabs, and birds, thereby supporting the balance of food chains in coastal areas. In addition, from an economic perspective, mangroves provide timber resources, raw materials for charcoal, as well as non-timber products such as honey and medicinal materials, which can be utilized by communities in a sustainable manner.

In Indonesia, mangrove ecosystems are widely distributed along the coastline and constitute one of the important assets in maintaining environmental resilience and the socio-economic sustainability of coastal communities. However, in recent decades, mangrove forests have faced various serious threats due to land-use conversion, excessive logging, coastal abrasion, and pollution. These conditions have resulted in a reduction in the extent and quality of mangrove ecosystems, thereby threatening the sustainability of both their ecological and economic functions. This situation demands special attention through scientifically based conservation and rehabilitation efforts.

One of the areas that possesses mangrove forests under relatively high environmental pressure is Mangkang Wetan Subdistrict, Tugu District, Semarang City. This area is located on the northern coast of Java and frequently experiences abrasion, tidal flooding, and pressure resulting from human activities such as sand mining, land conversion, and infrastructure development. Along with the increasing pressure, the quality of mangrove forests has declined, thus requiring serious efforts to maintain their sustainability.

Various conservation and rehabilitation programs have been implemented in this area, including mangrove replanting involving the government, universities, and community organizations. One of the communities that plays an active role in these activities is the Mangrove Ecosystem Study Group of Teluk Awur (KeSEMaT), which focuses on conservation, education, and community empowerment through mangrove forest management. These efforts have been quite successful in increasing the awareness of coastal communities

regarding the importance of maintaining mangrove ecosystems, although environmental challenges continue to occur.

Nevertheless, monitoring results indicate that the mangrove community structure in Mangkang Wetan Subdistrict is still dominated by a single species, namely *Avicennia marina*. This single dominance indicates a low level of species diversity, which may have implications for low ecosystem stability in facing changes in surrounding conditions. Thus, the implementation of this research is important to examine the mangrove community structure through the analysis of density, frequency, dominance parameters, as well as diversity, evenness, and dominance indices. The results of the study are expected to provide a comprehensive overview of the condition of the local mangrove ecosystem, while also serving as a basis for the formulation of more effective conservation and rehabilitation strategies.

In addition to environmental pressure factors, low mangrove diversity is also often caused by replanting patterns that do not consider aspects of species diversity. Many rehabilitation activities only plant one or two mangrove species because they are considered easier to grow and adapt. In fact, this approach can exacerbate ecosystem homogeneity. Species diversity is highly required because each species has different ecological roles, both in maintaining substrate structure, attenuating waves, and providing habitats for aquatic fauna.

Mangrove forests with high species diversity have been proven to be more resistant to external disturbances, such as climate change, sea-level rise, as well as pest and disease attacks. Conversely, homogeneous ecosystems are more vulnerable to damage when facing environmental pressures. Therefore, studies that examine mangrove community structure, including levels of diversity and evenness, have high significance in supporting sustainable management strategies.

In addition to ecological aspects, mangroves also possess social values that are closely related to the lives of coastal communities. In Mangkang Wetan, many residents depend on coastal resources for their livelihoods, either through direct utilization of mangrove forest products or indirectly through fisheries activities. The decline in mangrove quality has the potential to reduce the income of fishermen and local communities, as well as increase the risk of environmental disasters. Therefore, this research is not only academically beneficial but also has socio-economic implications for the local community.

Thus, research on the structure of mangrove communities in Mangkang Wetan Subdistrict is highly relevant to be conducted. Through the analysis of density, frequency, dominance, as well as diversity, evenness, and dominance indices, it is expected that the actual condition of the mangrove ecosystem in the area can be identified. This information will serve as an important basis for formulating conservation and rehabilitation strategies that not only focus on replanting but also consider the principles of species diversity and community empowerment.

Ultimately, the results of this research are expected to contribute to supporting policies for the management of mangrove ecosystems in Semarang City, particularly in Mangkang Wetan Subdistrict. Furthermore, this study is also expected to serve as a reference for the development of mangrove conservation programs in other coastal areas in Indonesia that face similar problems. Through efforts based on scientific data, mangrove conservation can be more targeted, sustainable, and provide long-term benefits for both the environment and society.

METHODS

Research Procedure

This study began with reviewing several literature studies, followed by the determination of sampling location points, continued with the establishment of line transects, and concluded with data analysis.

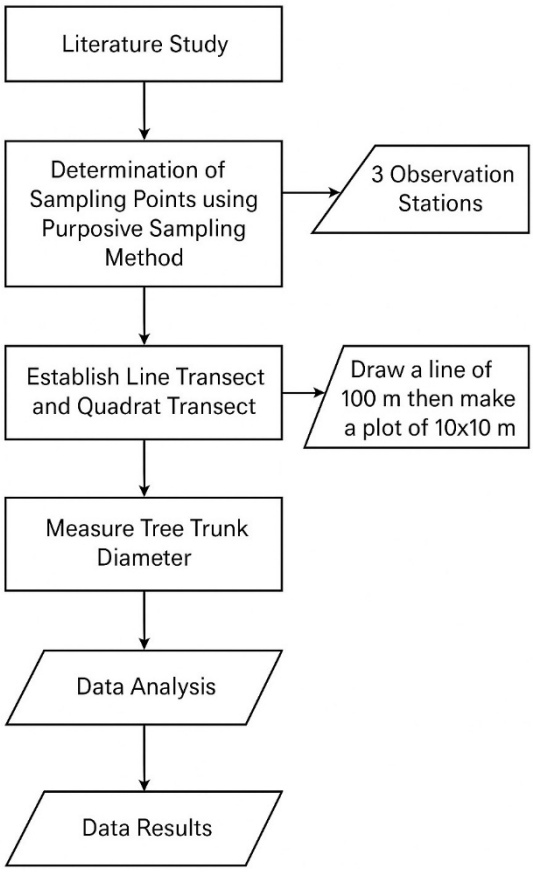

Figure 1. Flowchart of research implementation procedures

Data Analysis

Data related to tree species, number of stands, and diameter were then further processed to obtain information on Density, Relative Density, Frequency, Relative Frequency, Dominance, Relative Dominance, Importance Value Index, and Species Diversity using the formula from Mahu (2021).

a. Community structure

$$\text{Type Dominance} = \frac{Dominate\ all\ types}{dominance\ of\ each\ type}\ x\ 100\%$$

Based on the results of these calculations, the Importance Value Index (INP) value is then determined using the following formula (Mahu, 2021):

$$INP = KR + FR + DR$$

b. Diversity index

Based on community characteristics, the level of diversity is determined by the number of species and the evenness of individuals of each species found. The higher the diversity value, the more diverse the types of organisms present, where this value is greatly influenced by the total number of individuals of each species. The abundance of individuals of each

species obtained (Febrian, 2022) is used to calculate the diversity index according to Odum (1996) in Latuconsina *et al*. (2012) with the following formula:

$$H' = \sum_{i=1}^{s} Pi\ lnPi$$

Description:
H' = Shannon-Wiener species diversity index;
Pi = ni / N;
ni = number of individuals of the i-th species;
N = total number of individuals of all species; and
S = number of species recorded.
The results obtained can then be categorized into three categories:
- If $\hat{H} < 1$, the diversity index is categorized as Low.
- If $\hat{H}$ 1 < $\hat{H} < 3$, the diversity index is categorized as Medium.
- If $\hat{H} > 3$, the diversity index is categorized as High.

c. Diversity Index

Mangrove diversity can be determined using the diversity index. The lower the index value, the more uneven the distribution of individuals of each species (Febrian, 2022) and the more likely it is to be dominated by certain species (Odum, 1993 in Latuconsina *et al*., 2012).

$$E = \frac{H'}{H_{max}}$$

Description:
E = Diversity index;
Hmax = 2 log S;
S = Number of species.
There are three criteria for the diversity index:
e > 0.4 indicates low population diversity; 0.4 > e > 0.6 indicates moderate population diversity;
e < 0.6 indicates high population diversity

d. Dominance Index

The dominance index (C) is used to measure the extent to which one group of organisms dominates another. High levels of dominance can indicate an unstable or stressed community (Febrian, 2022). The dominance index is calculated using Simpson's dominance formula (Odum, 1993 in Latuconsina *et al*., 2012).

$$D = \sum \left(\frac{n_i}{N}\right) 2$$

Description:
C = Simpson's dominance index;
ni = Number of individuals per species; and
N = Number of individuals of all species.

According to Odum (1993) in Latuconsina *et al*. (2012), the dominance criteria are as follows:
- If the C value approaches 0 (<0.5), then no species dominates.
- If the C value approaches 1 (>0.5), then a species dominates.

RESULTS

Mangrove Species Composition

The results show that the mangrove vegetation in Mangkang Wetan Village consists of only one species, Avicennia marina, which was found at all observation stations. This finding indicates that the mangrove ecosystem at the study site is homogeneous.

Mangrove Community Structure

1. Density and Frequency

The density of Avicennia marina ranged from 64–86 individuals per plot (10 m × 10 m). A relative frequency of 100% indicates that this species is present at all observation points.

2. Dominance

The dominance value (D) for Avicennia marina was 1 (100%) at each station, as shown in Table 1.

Table 1. Dominance Level

Station	Domination (D)	Description
1	1	High Dominance
2	1	High Dominance
3	1	High Dominance

3. Importance Value Index (IVI)

The Importance Value Index (IVI) for Avicennia marina at all stations was 300, indicating the maximum value for a single species.

4. Diversity Index (H')

The Shannon-Wiener diversity index (H') was 0 at all stations. The data are shown in Table 3.

Table 3. Diversity Index

Station	H'	Information
1	0	Low
2	0	Low
3	0	Low

5. Dominance Index (C)

The dominance index (C) was 1 at all stations, as shown in Table 5.

Table 5. Dominance Index

Station	C	Description
1	1	High Dominance
2	1	High Dominance
3	1	High Dominance

6. Environmental Parameters

Table 2. Environmental Parameters of the Research Location

Parameter	Unit	St. 1	St. 2	St. 3
Water temperature	°C	24	25	26
Air temperature	°C	29	30	32
Salinity	ppt	30	30	30
pH	-	7	7	7
Substrate	-	Muddy	Muddy	Muddy

1. Interpretation of the Diversity Index (H') = 0

The Shannon–Wiener index (H') value of 0 at all three stations indicates the absence of taxonomic variation in the samples (monospecific). Conceptually, H' = 0 occurs when all recorded individuals originate from a single species, such that the relative proportion of each species (Pi) for all species other than one equals zero. This condition may arise due to several interrelated mechanisms:

1.1. Successional stage or homogeneous rehabilitation outcome.

Areas that have been recently rehabilitated or are in the early phase of ecological succession are often dominated by pioneer species that are tolerant of extreme conditions. Avicennia marina is known as a species that is tolerant of salinity variation and muddy substrates, and therefore tends to dominate during early stages or at disturbed sites.

1.2. Selective environmental pressure.

Measured environmental parameters—salinity of 30 ppt, neutral pH (7), muddy substrate, and water temperature of 24–26°C—represent conditions that support the growth of *Avicennia marina*. These physico-chemical conditions appear to be less conducive for several other species that require different substrate or salinity conditions (e.g., some *Rhizophora* species that require stronger rooting substrates and specific sedimentation).

1.3. Conservation practices and seedling provision.

If local rehabilitation activities tend to plant a single species due to seedling availability, cost considerations, or ease of adaptation, such planting patterns will reinforce the homogeneity of vegetation structure.

The ecological impacts of H' = 0 include a reduction in community complexity and a decrease in certain ecosystem functions associated with species diversity (e.g., variation in root structures and habitat heterogeneity for fauna). Functionally, processes such as sediment retention, wave attenuation, and the provision of juvenile habitats for marine biota may still occur, but their service potential may be narrower compared to more diverse communities.

2. Evenness Index (E) = 0 and Dominance Index (C) = 1: Ecological Meaning

An E value of 0 confirms the imbalance in individual distribution among species (all individuals belonging to a single species), while C = 1 confirms the absolute dominance of *Avicennia marina*. The combination of these two indices has the following implications:

2.1. Ecosystem vulnerability to concentrated disturbances.

Single-species dominance increases the risk of ecosystem function failure if the dominant species is affected by disease, pests, or environmental changes (e.g., rapid salinity shifts or increased storm frequency). This risk also affects species-specific ecosystem services (e.g., fauna species that exclusively utilize particular vegetation types).

2.2. Reduced long-term stability

Homogeneous communities generally exhibit lower functional variability; recovery processes following disturbances tend to be slower in the absence of species reserves with different environmental tolerances.

2.3. Potential competitive advantage and spread

Dominance may result from the competitive advantages of *A. marina* under local conditions (e.g., seed dispersal capability and physiological tolerance), such that reducing dominance requires approaches that consider natural competition as well as habitat conditions.

3. Relationship between Environmental Parameters and Community Structure

The environmental parameter results (water temperature 24–26°C; air temperature 29–32°C; salinity 30 ppt; pH 7; muddy substrate) provide strong context for the dominance of *A. marina*:

3.1. Salinity and substrate:

A salinity of 30 ppt falls within the tolerance range of *A. marina* and may limit species that are less tolerant of high salinity. Muddy substrates with high clay content affect root aeration and physical stability; *A. marina* often performs well under such conditions.

3.2. Temperature and pH:

The recorded temperature and pH values generally support the growth of tropical mangroves; no clearly extreme conditions were identified that would inhibit *A. marina*. However, this multi-parameter combination creates a specific niche that favors one or a few pioneer species.

4. Implications for Fauna and Ecosystem Services

4.1. Faunal habitat:

Root structure, canopy, and spatial configuration of mangroves influence habitat availability for juvenile fish, crustaceans, and gastropods. Monospecificity reduces microhabitat variation (e.g., prop-root zones versus branching zones), such that faunal communities dependent on specific structures may decline.

4.2. Ecosystem services:

Coastal protection functions (wave attenuation and wave energy absorption) and basic economic services (raw materials and food sources) remain present, but species diversification often enhances functional redundancy—namely, multiple species can perform similar functions if one fails. The presence of a single species reduces this redundancy.

5. Possible Root Causes and Data Limitations

Based on the results, several causes of homogeneity can be identified without altering the data:

- Restoration/rehabilitation practices that select a single species.
- Local environmental conditions that are more favorable to *A. marina*.
- Anthropogenic pressures (land conversion, logging, abrasion) that alter natural composition.

Limitations that should be noted for further interpretation include that this study presents snapshot data (July–September 2024) from three stations; temporal analyses (seasonal/annual) and studies of natural regeneration/seedlings are not available in the current data, such that long-term community dynamics have not been fully revealed.

6. Operational and Measurable Management Recommendations

Based on the conditions identified, the following recommendations are designed to be implementable and monitorable:

6.1. Planned Species Diversification

- Initial phase: testing local tolerance and adaptation of several candidates (e.g., *Rhizophora mucronata*, *Bruguiera gymnorrhiza*, *Sonneratia alba*) in limited experimental plots.
- Early success indicators: survival percentage > 70% at 6 months, biomass increase, and increased root structure heterogeneity within 12 months.

6.2. Gradual Rehabilitation Strategy

- Apply mosaic planting (small blocks with mixed species) rather than homogeneous distribution.
- Substrate improvement if required (controlled sediment addition or stabilization) to support species requiring stronger rooting substrates.

6.3. Quantitative Monitoring Program

- Minimum parameters: density, Important Value Index (IVI), H', E, C, salinity, pH, temperature, and indicator faunal data (juvenile fish/shrimp abundance).
- Monitoring frequency: baseline, 6 months, 12 months, and subsequently annually. Use consistent protocols to enable trend analysis.

6.4. Community Empowerment and Collaboration

- Involve local groups (e.g., Srikandi Pantura) in planting planning, supervision, and education to foster social ownership of rehabilitation programs.
- Simple incentive schemes (e.g., marketing of non-timber products or community-based ecotourism) can enhance program sustainability.

6.5. Further Research

- Studies on natural regeneration and natural seed sources to understand spontaneous regeneration capacity.
- Faunal surveys to assess the effects of vegetation structure on faunal biodiversity and ecosystem services.

CONCLUSION

Based on the research results, the mangrove community in Mangkang Wetan Subdistrict exhibits a homogeneous structure with dominance of *Avicennia marina*. This condition is characterized by low diversity and evenness, as well as very high dominance. Environmental conditions such as temperature, salinity, pH, and substrate type indeed support the growth of this species but are less supportive of species diversity. Therefore, strategic efforts are required to enrich diversity and strengthen the resilience of mangrove ecosystems in this area.

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