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Assessing the Structure and Environmental Impact of Mangrove Forests in Segara Anakan, Cilacap, Central Java

Wintah[1,2], Kiswanto[2*]
[1]Master of Fisheries Science Study Program, Teuku Umar University, Meulaboh, Indonesia
[2]Public Health Sciences, Faculty of Public Health, Teuku Umar University, Meulaboh, Indonesia

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*Corresponding author:
E-mail: kiswanto@utu.ac.id

ABSTRACT

The mangrove ecosystem in Segara Anakan has experienced significant habitat changes, with nearly half of the area damaged, thereby impacting the mangrove vegetation structure. This study determines the structure of mangrove forest communities using a survey method and a random sampling technique. Quadrants of varying sizes were used to measure tree, sapling, and seedling vegetation. The study identified 10 mangrove species from 4 families: Rhizophoraceae (5 species), Meliaceae (1 species), Lythraceae (2 species), and Acanthaceae (2 species). Tree-level mangrove density was highest at station 3 (0.28 ind/m²), followed by stations 2 (0.27 ind/m²) and 1 (0.16 ind/m²). Sapling density was also highest at station 3 (13.08 ind/m²), followed by stations 2 (12.48 ind/m²) and 1 (9.84 ind/m²). These findings provide valuable insights into the current state of mangrove ecosystems in Segara Anakan, emphasizing the need for conservation and management efforts to mitigate further habitat degradation and loss of biodiversity..

INTRODUCTION

Mangroves are woody plants that grow in areas between land and sea so that they are in an environment that has high salinity, extreme tidal areas with very strong winds and high temperatures, is muddy, and has anaerobic soil. Mangroves are equipped with special tissues and organs that can be used to meet primary needs, such as water and air, because they are in areas with extreme environmental conditions. In general, mangrove trees have glandula and root systems that are very supportive of air intake (Kathiresan and Bingham, 2001).

Forming mangrove vegetation groups are various species of mangrove plants that can adapt physiologically to a typical environment, namely high, medium, or low salinity, soil types dominated by mud, sand, or sandy mud, and affected by tides so that zoning is formed. Each mangrove location has a different variety of vegetation (Gunarto, 2004).

The mangrove forest vegetation in Indonesia has a high species diversity. However, there are only about 47 species of plants specific to mangrove forests. In mangrove forests, there are several important or dominant true plants that fall into four families: Rhizophoraceae (*Rhizophora* sp.,

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Bruguiera sp. and *Ceriops* sp.), Sonneratiaceae (*Sonneratia* sp.), Avicenniaceae (*Avicennia* sp.), and Meliaceae (*Xylocarpus* sp.) (Bengen, 2001; Kathiresan and Bingham, 2001)

Mangrove ecosystems play a variety of ecological, social, and economic roles (Wintah et al., 2023). Socially, mangrove ecosystems have a role as a place of interaction for various species in the mangrove ecosystem and a place to stop for migratory birds. Economically, mangrove ecosystems produce various benefits that can increase the economic value of the surrounding community, such as the use of mangrove fruit that can be processed into various food and beverage ingredients.The ecological function of mangroves is as a source of feed for fish, crabs, shrimp, and other associated biota (Nordhaus et al., 2009; Kauffman et al., 2011). Mangroves also play a role as habitats for the biota of mangrove associations (Wintah et al., 2021).

The dominant mangrove vegetation in Segara Anakan Cilacap is *Rhizophora apiculata*, *Rhizophora mucronata*, *Avicennia marina*, and *Avicennia alba* (Wintah et al., 2022a). However, the mangrove ecosystem in Segara Anakan, Cilacap, Central Java, has experienced considerable habitat degradation, with almost half of the mangrove area damaged. This degradation has had a major impact on the structure of mangrove vegetation in the region, and this requires urgent research efforts to assess and understand the dynamics of mangrove communities in Segara Anakan. Such research is essential to understand environmental impacts on mangrove community structures as a basis for management aimed at maintaining the ecological integrity and biodiversity of mangrove ecosystems in the region. Therefore, the objective of this study was to assess mangrove community structure and environmental impacts in Segara Anakan, Cilacap, Central Java, Indonesia, focusing on the structure of mangrove vegetation.

MATERIALS AND METHOD

The research was conducted using a survey method with a random sampling technique. The main parameter of the study was the mangrove vegetation community, and the parameters measured were the number of species and the number of individuals of each species. The data obtained by measuring these parameters is used to calculate species density and richness.

Mangrove vegetation measurements at the study site consisted of 3 stations covering each plot covering an area of 10 x 10 m for the tree category, 5 x 5 m for the sapling category, and 1 x 1 m for the seedling category. The distance between sampling plots was 50 m. From each plot, mangrove vegetation data were collected by counting the number of species and the number of individuals per species (Latifah, 2005). Each type of mangrove vegetation identified in the laboratory was based on Kitamura et al. (1997) and Giesen et al. (2006)

An analysis of mangrove species richness based on references from Santoso et al. (2008) was conducted by calculating the number of species in an area. Meanwhile, mangrove density based on Krebs (2009) defines the density as the number of individuals per unit area (hectares and m^2). Therefore, the equation for calculating mangrove density is:

$$Di = \sum \frac{ni}{L}$$

Where Di, ni, and L were species density / population density, number of individuals in species I, and plot area, respectively.

RESULTS AND DISCUSSION

Mangrove Species Richness

The species richness of mangroves in Segara Anakan identified 10 species from 4 families, namely the families Rhizophoraceae (5 species), Meliaceae (1 species), Lythraceae (2 species), and Acanthaceae (2 species) (Table 1).

The results indicate variation in species richness across stations. Station 1 (SA1) exhibited three families with a richness of 5 species, while Station 2 (SA2) and Station 3 (SA3) displayed 5 five families with richnesses of 9 and 10 species, respectively. The study site is a natural mangrove forest, and the mangrove species in the study site have high environmental tolerance. Tolerance to environmental factors affects the growth and development of mangroves. Lose et al. (2015) stated that many factors can affect the growth and development of mangrove forests. Khairunnisa et al. (2020) stated that mangroves can grow well and be traversed by tides and muddy soil, and can tolerate high water salinity and wave heaving.

The prevalence of species within families varied, with Rhizophoraceae being the most diverse, comprising five species, including *Ceriops tagal, Bruguiera gymnorhiza, Bruguiera sexangula, Rhizophora mucronata*, and *Rhizophora apiculata.* In contrast, Meliaceae displayed the lowest diversity with only Xylocarpus *granatum* (Table 1).

The species richness observed in Segara Anakan exceeds that of other locations, such as West Aceh (Wintah et al., 2023), Papua (Rambu et al., 2019), and Pemalang (Poedjirahajoe et al., 2017). West Aceh Mangroves found 6 species, and high species richness is influenced by organic matter. Differences in organic content can also be caused by litter produced by mangrove forests because it is the main source of organic matter (Wintah et al., 2023). Papua found 7 species, and the presence of species is influenced by temperature, salinity, and pH (Rambu et a., 2019). Pemalang found 6 species, and the presence of species is influenced by temperature, salinity, and substrate factors (Poedjirahajoe et al., 2017). This discrepancy can be attributed to the natural growth of mangroves in Segara Anakan, which fosters higher diversity than planted mangroves in other regions. Rhizophora and Bruguiera species were prominently observed across stations, reflecting their adaptability and resilience to environmental fluctuations, which was supported by Agustini (2016).

Table 1. The richness of mangrove species at each station

No	Family/Species	Station		
		SA1	SA2	SA3
1.	Rhizophoraceae			
	– *Ceriops tagal*	2.0	2.0	2.0
	– *Bruguiera gymnorhiza*	0.0	2.0	1.0
	– *Bruguiera sexangula*	0.0	3.0	3.0
	– *Rhizophora mucronata*	5.0	6.0	6.0
	– *Rhizophora apiculata*	4.0	5.0	5.0
2.	Meliaceae			
	– *Xylocarpus granatum*	2.0	2.0	2.0
3.	Lythraceae			
	– *Sonneratia caseolaris*	0.0	2.0	2.0
	– *Sonneratia alba*	3.0	3.0	3.0
4.	Acanthaceae			
	– *Avicennia marina*	0.0	2.0	2.0
	– *Avicenia alba*	0.0	0.0	2.0
Sum		16.0	27.0	28.0

Mangrove Species Density

The densities of mangroves were assessed at different stations in Segara Anakan. At the tree level, Station 3 (SA3) exhibited the highest density of 0.28 ind/m², followed by Station 2 (SA2) with 0.27 ind/m², and Station 1 (SA1) with 0.16 ind/m² (Figure 1). Similarly, sapling density was highest at Station 3 (SA3), at 13.08 ind/m², followed by Station 2 (SA2) at 12.48 ind/m², and Station 1 (SA1) at 9.84 ind/m² (Figure 2).

The predominance of Rhizophoraceae species contributed to the higher sapling density due to the greater number of individuals. These species, known for their adaptability to muddy substrates, thrive in the sediment-rich environment of Segara Anakan, as corroborated by Rambu et al. (2019) and Darmadi (2012), who stated that the Rhizophoraceae family, consisting of *Rhizophora mucronata, Rhizophora apiculata, and Bruguiera cylindrica,* favor dusty clay loam substrates.

Despite the observed richness, the overall mangrove density in Segara Anakan has been categorized as degraded by government standards (Kepmen LH No.201 Year 2004). This damage has the potential to disrupt the integrity of habitats and ecosystem services, as evidenced by previous studies (Sari et al.,, 2016; Hilmi et al., 2018; Wintah et al., 2022b). Factors contributing to the destruction of mangrove ecosystems due to changes in environmental functions will affect the availability of goods and services, which will affect the benefits caused by problems in the ecological system such that it will affect the value of resources (Sari et al., 2016), sparse vegetation (Hilmi et al., 2018), sedimentation and anthropogenic, and an overall decrease in mangrove cover (Wintah et al., 2022b).

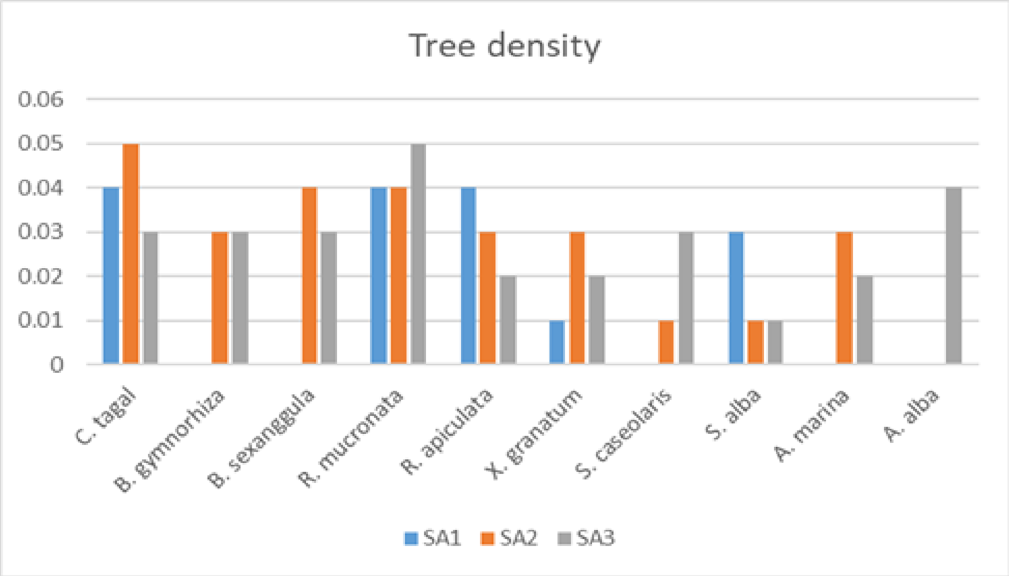

Figure 1. Mangrove species density (Ind/m^2) at each station

Damage to mangrove ecosystems is caused by excessive use by humans over a long period of time, which will damage mangrove forests and their ecosystems and reduce the quality of the carrying capacity of mangrove forests for life around them. This is supported by the statement that mangrove ecosystem damage is influenced by changes in environmental quality, global warming, and natural disasters (Akram and Hasnidar, 2022), destructive utilization activities around mangrove ecosystems, anthropogenic activities (Wintah et al., 2022b), and mangrove forest degradation (Hilmi et al., 2021). To mitigate damage to the mangrove ecosystem, it is necessary to restore the mangrove ecosystem and preserve it.

CONCLUSION

This study identified 10 mangrove species across 4 families in Segara Anakan, with the highest species richness and density observed at station 3. The dominance of adaptable species like Rhizophora mucronata suggests their potential role in mangrove restoration efforts. These findings underscore the need for targeted conservation strategies to mitigate habitat degradation in the region of Segara Anakan. Future research should focus on identifying the specific factors influencing mangrove distribution and health in this region to inform effective management practices.

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