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Mangrove vegetation structure in the Marine Science Techno Park (MSTP) Area, Teluk Awur, Jepara Regency, Central Java

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A B S T R A C T

Marine Science Techno Park (MSTP) is an area located in the Teluk Awur Beach region, Jepara Regency, Central Java. This area features a rehabilitated mangrove ecosystem that has been established for approximately 20 years. This research aims to study the mangrove vegetation structure, including diversity, composition, evenness index, Importance Value Index (IVI), and assess the regeneration of true mangroves in the Marine Science Techno Park (MSTP) area in Teluk Awur, Jepara, Central Java. The study was conducted at 3 stations: the mangrove track area (Station 1), riverbank area (Station 2), and coastal area (Station 3). The research identified 20 mangrove species (5 major mangroves, 4 minor mangroves, and 11 associated mangroves) belonging to 15 families. The species diversity index (H') ranged from 1.51 to 1.68, indicating a moderate category, while the evenness index indicates relatively even evenness ranging between (0.63 – 0.69), indicating relatively even communities and stable populations. The highest INP at station 1 (mangrove track) is *Rhizophora mucronata* Lamk (INP 163.58%), at station 2 (riverbank) is *Bruguiera cylindrica* (L) BI (INP 150.52%). At station 3 (coastline) the highest INP is *Rhizophora mucronata* Lamk (161.07%). The regeneration status of true mangroves in the MSTP area, categorized as good, includes *Xylocarpus granatum* Koen, *Bruguiera cylindrica* (L) BI, *Ceriops tagal* (Perr.) C.B. Rob, *Rhizophora apiculata* BI, and *Rhizophora mucronata* Lamk, while poor regeneration was observed in *Nypa fruticans* Wurmb, *Lumnitzera racemosa* Willd, *Excoecaria agallocha* L, and *Aegiceras corniculatum* (L.) Blanco.

Keywords: Diversity Index, Importance Value, Marine Science, Mangrove Regeneration, Vegetation.

1. INTRODUCTION

Mangroves are a type of plant that play an important role in supporting life in coastal areas. Mangroves function to protect coastlines, prevent erosion, and support the life of various organisms along tropical coastal zones (Rangkuti *et al*., 2022). The loss of mangrove ecosystems can lead to coastal erosion, which in turn results in the narrowing of land areas. The sustainability of biological resources around mangroves is highly dependent on the availability of mangrove ecosystems. The loss of various flora and fauna species associated with mangrove ecosystems will disrupt the stability of both mangrove and coastal environments (Akbar *et al*., 2015).

Indonesia's mangrove ecosystems are among the largest in the world. This area covers 30,000 km², or nearly 21% of the total global mangrove area (Spalding, 2010). Jepara Regency is one of the areas in Indonesia that has an extensive mangrove zone. The mangrove area in Jepara Regency, particularly in the Karimunjawa region, was 473.94 hectares in 1992, increased to 600.75 hectares in 2003, and decreased to 391.57 hectares in 2017. The main causes of the decline in mangrove area include illegal logging, natural factors, and land conversion for aquaculture and hospitality development (Latifah *et al*., 2018).

Mangrove regeneration indicates the future sustainability of the ecosystem, which can be observed through the growth of mangrove seedlings (Putro *et al*., 2018). Natural seedling regeneration is a crucial stage in the recovery process of damaged vegetation (Mukhlisi & Gunawan, 2016). The presence of more mangrove seedlings compared to saplings and mature trees may indicate that mangrove regeneration is proceeding well (Shankar, 2001; Abrar *et al*., 2018; Rahmania *et al*., 2019).

Jepara Regency has mangrove areas, one of which is located in Teluk Awur Village, Tahunan District, Jepara Regency, Central Java Province. This area is being developed into the Marine Science Techno Park (MSTP) of Jepara. MSTP is an expansion of the Science and Techno Park (STP) developed by Diponegoro University on Teluk Awur Beach. MSTP aims to manage knowledge and technology in its environment (Sasmito *et al*., 2018).

The mangrove area in Teluk Awur is managed by Diponegoro University in collaboration with the Jepara government, working to restore and enrich the plant diversity in the Teluk Awur coastal zone. Around the early

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2000s, the MSTP area was originally open land, partly abandoned former fish ponds, with remnants of mangrove plants and shrubs. This condition sparked concern among Marine Science students who were residing in Teluk Awur at the time. Since 2002, efforts have been made to rehabilitate the area by planting various types of mangroves. The mangrove rehabilitation activities in the MSTP area, including the planting of diverse mangrove species, represent efforts to restore the threatened functions and benefits of mangroves. The rehabilitation of the MSTP mangrove area has been conducted in stages, involving the local community and various mangrove conservation organizations (Faisal et al., 2021).

After being rehabilitated with the planting of various mangrove species, the condition of the mangroves in the MSTP area has transformed into a relatively healthy mangrove ecosystem. Various mangrove and non-mangrove species can now be found in the area. The presence of these mangroves also provides critical habitats for a variety of animal species. Therefore, mangrove plants and their regeneration status serve as important information in determining policies related to coastal ecosystem conservation. The area is now being developed into a mangrove conservation zone managed specifically by Diponegoro University and the *Mangrove Education Center of KeSEMaT* (MECoK).

After two decades, the MSTP area has undergone significant transformation, now more organized and rich in vegetation diversity. However, there is still limited information regarding mangrove species diversity, tree, sapling, and seedling strata descriptions, importance value index, and true mangrove regeneration, which are all relevant to the ecosystem stability in the MSTP area. Therefore, this research aims to assess the mangrove vegetation structure, including diversity, composition, evenness index, Importance Value Index (IVI), and to examine the true mangrove regeneration in the Marine Science Techno Park (MSTP), Teluk Awur, Jepara, Central Java.

2. MATERIAL DAN METHODS

2.1 Study area

The research was conducted in the *Marine Science Techno Park* (MSTP) area from October 2022 to June 2023. Mangrove sampling was carried out in the wetland (mangrove area) of the *Marine Science Techno Park* (MSTP) in Jepara, Central Java. Research stations were determined based on area conditions and divided into three coordinate points: the mangrove track area (Station 1), riverbank area (Station 2), and coastal edge area (Station 3) (Figure 1).

2.2 Material

The tools and materials used in this study included: stationery, camera, measuring tape, GPS (Global Positioning System), Leutron NM 8000 A, stakes, soil tester, scissors, *Mangrove Identification Guidebook in Indonesia* (Noor et al., 2006), *Species Composition of Mangroves at the Mangrove Education Center of KeSEMaT (MECoK)* (Bahari et al., 2018), plastic bags, labels, and raffia string.

2.3 Sampling method

At each station, a 200-meter transect line was laid from the coastal mangroves toward the inland area. Four quadrat plots were established systematically at each station, with a 50-meter distance between plots. Plot sizes were based on vegetation strata of tree stratum (diameter >4 cm): 10 m x 10 m, sapling stratum (diameter <4 cm, height >1 m): 5 m x 5 m and seedling stratum (height <1 m): 1 m x 1 m (Bengen, 2002). In each quadrat, the species name, number of individuals per species, and diameter at breast height (DBH) were recorded for trees and saplings. For seedlings, the species name and number of individuals were recorded. Data on mangrove regeneration were collected by calculating the total density of seedlings, saplings, and trees at each station, expressed as individuals per 3 hectares (ind/3 Ha). The data were then compared to assess the regeneration condition of mangroves at the study site. Environmental parameters measured included air temperature, air humidity, soil moisture, light intensity, and soil pH.

2.4 Data analysis

The data on mangrove vegetation composition were tabulated by local name, scientific name, family, number of individuals per species, and type (true mangrove - major/minor or associate). The Shannon-Wiener Diversity Index was used to calculate species diversity (Indriyanto, 2006):

Shannon-Wiener Index: $H' = -\sum pi \ln pi$ (1)

where H' is Shannon-Wiener Diversity Index, p_i is Proportion of individuals of species, shannon-Wiener Index categories (Ismaini et al., 2015) are $H' < 1$ for low species diversity, $1 \leq H' \leq 3$ for Moderate species diversity, $H' > 3$ for High species diversity. The Shannon-Wiener Diversity Index was used to calculate species diversity (Indriyanto, 2006).

Evenness Index (E) = $\frac{H'}{\ln(S)}$ (2)

The Evenness Index was calculated by dividing the Shannon-Wiener Index (H') by the number of species (S), to assess community balance, where E is Species evenness index**,** H' is Shannon-Wiener Diversity Index, S is total number of species, with evenness Index categories $E < 0.3$ for low population evenness**,** $0.3 < E < 0.6$ for moderate population evenness, and $E > 0.6$ for high population evenness (Magurran, 1988).

Density

Absolute Density (AD) = $\frac{Number\ of\ individuals\ in\ each\ species\ type}{Snippet\ plot\ area}$ (3)

Relative Density (RD) = $\frac{Density\ of\ a\ species}{Total\ density} x100\%$ (4)

Frequency

Absolute frequency (AF) = $\frac{Number\ of\ occupied\ plots\ in\ each\ species\ type}{Total\ of\ all\ observation\ plot}$ (5)

Relative Frequency (RF): $\frac{Absolute\ frequency\ type}{Total\ of\ frequency} x100\%$ (6)

Domination

Absolute Dominance (DM): $\frac{Total\ area\ of\ the\ basic\ field\ type}{Total\ observation\ plot\ area}$ (7)

Relative Dominance (RD): $\frac{Absolute\ dominance\ of\ type}{Total\ dominance} x100\%$ (8)

Importance Value Index (IVI)

For trees and saplings: IVI = RD + RF + RDo (9)

For seedlings: IVI = RD + RF (10)

Importance Value Index (IVI) was used to determine the dominance level of species in a community and was calculated based on density, frequency, dominance, and importance value index, where RD is relative density, RF is relative frequency, RDo is relative dominance and IVI is Importance Value Index (Indriyanto, 2006).

Mangrove regeneration assessment

Mangrove regeneration status was determined by analyzing the density levels of seedlings, saplings, and trees. According to Putri & Kurniawan (2021), adequate availability of the seedling stage is a key prerequisite for successful ecosystem regeneration. Shankar (2001) notes that poor regeneration is indicated by the absence of seedling (Seedling growth) stages.

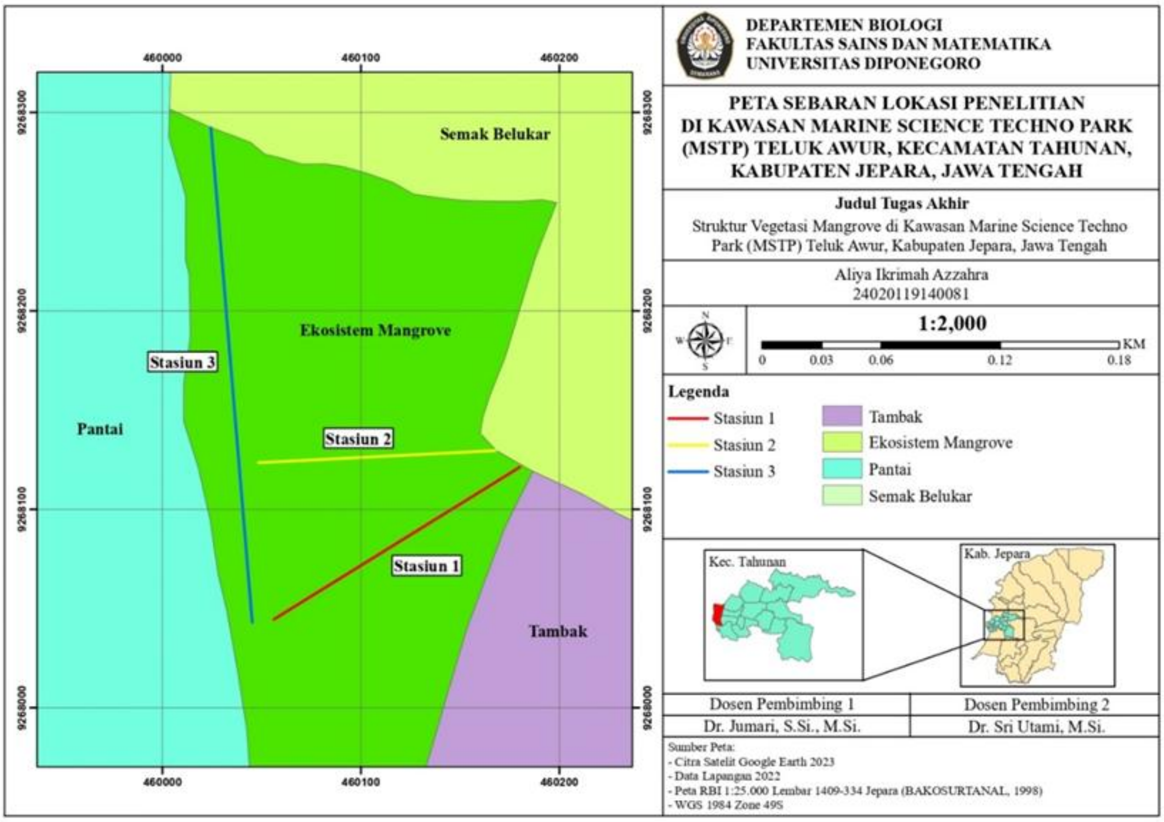


Figure 1. Research Location Map at the Three Stations in the MSTP Mangrove Area, Teluk Awur, Jepara.

3. RESULTS DAN DISCUSSION

3.1 Mangrove species identification and classification

Example of a subsection: here you would describe the specific results related to yield. A total of 20 mangrove species were identified in the *Marine Science Techno Park* (MSTP) area, comprising 5 major mangrove species, 4 minor mangrove species, and 11 associated species, which belong to 15 families (Table 1). These species were found across various growth stages, including tree, sapling, and seedling strata. Station 3 recorded the highest species richness with 13 species, followed by Station 2 with 11 species, and Station 1 with the lowest, at 10 species. The most dominant family observed was Rhizophoraceae, represented by four species: *Bruguiera cylindrica* (L.) Bl., *Ceriops tagal* (Perr.) C.B. Rob., *Rhizophora apiculata* Bl., and *Rhizophora mucronata* Lamk.

Mangroves are classified into three categories—true mangroves (major and minor) and mangrove associates (Tomlinson, 1986). Major mangroves typically inhabit coastal zones and exhibit specialized morphological and physiological adaptations to survive in such environments. Minor mangroves are generally not found as dominant stands but rather coexist with other species, often in transitional areas affected by adjacent ecosystems. Associated mangroves also function in transitional zones between terrestrial and marine environments and often interact with both major and minor mangrove types.

Reforestation efforts within MSTP serve as a practical example of mangrove ecosystem rehabilitation. Mangroves are crucial for coastal protection, as highlighted by Sumar (2021), who noted their ability to reduce shoreline erosion by buffering wave energy and stabilizing coastal sediments.

Table 1. Types of mangrove species in the MSTP Area, Jepara.

No	Family	Local Name	Scientific Name	Description
A. True Mangrove				
1.	Arecaceae	Nipah	*Nypa fruticans* Wurmb.	Mayor
2.	Combretaceae	Truntun	*Lumnitzera racemosa* Willd.	Minor
3.	Euphorbiaceae	Buta-buta	*Excoecaria agallocha* L.	Minor
4.	Meliaceae	Nyiri	*Xylocarpus granatum* Koen.	Minor
5.	Myrsinaceae	Teruntung	*Aegiceras corniculatum* (L.) Blanco.	Minor
6.	Rhizophoraceae	Tanjang	*Bruguiera cylindria* (L) BI.	Mayor
7.	Rhizophoraceae	Tagar	*Ceriops tagal* (Perr.) C.B. Rob.	Mayor
8.	Rhizophoraceae	Bakau merah	*Rhizophora apiculata* BI.	Mayor
9.	Rhizophoraceae	Bakau hitam	*Rhizophora mucronata* Lamk.	Mayor
B. Mangrove Association				
1.	Acanthaceae	Jeruju	*Acanthus ilicifolius* L.	Association
2.	Aizoaceae	Gelang laut	*Sesuvium portulacastrum* (L.) L.	Association
3.	Aizoaceae	Krokot	*Triathema portulacastrum* L.	Association
4.	Casuarinaceae	Cemara laut	*Casuarina equisetifolia* L.	Association
5.	Celastraceae	Duri-duri	*Maytenus emarginata* (Willd.) Ding Hou.	Association
6.	Combretaceae	Ketapang	*Terminalia catappa* L.	Association
7.	Convolvulaceae	Katang-katang	*Ipomoea pes-caprae* (L) Sweet.	Association
8.	Malvaceae	Waru laut	*Thespesia populnea* (L.) Sol. ex Corrêa.	Association
9.	Primulaceae	Lampeni	*Ardisia elliptica* Thunberg	Association
10.	Rubiaceae	Mengkudu	*Morinda citrifolia* L.	Association
11.	Verbenaceae	Lamburung meit	*Clerodendrum inerme* (L.) Gaertn.	Association

3.2 Mangrove density analysis

The results of the density analysis for each stratum at the three research stations show that the highest tree stratum density in the mangrove track area was recorded for the species *Rhizophora mucronata* Lamk, with a density of 2,350 individuals/ha (Table 2). In the riverside area, the highest density was *Excoecaria agallocha* L, with 1,600 individuals/ha (Table 3), while in the coastal edge area, the highest density was again *Rhizophora mucronata*, with 1,050 individuals/ha (Table 4). This high density is due to both rehabilitation efforts and natural regeneration from fallen seeds that successfully grew in the study location. According to Usman & Hamzah (2013), high mangrove density indicates a large number of mangrove stands growing in the area. This condition suggests that *Rhizophora mucronata* has high tolerance to environmental conditions. *Rhizophora mucronata* is known for its high tolerance to muddy substrates and its wide seed dispersal capability. In addition, environmental factors such as soil pH also influence mangrove growth in the area. At Station I, the soil pH was 6.3 (Table 5).

Onrizal and Kusmana (2008) stated that a soil pH between 6 and 7 is an ideal range for mangrove growth. Soil moisture measurements using a soil tester indicated that the substrate moisture in each research quadrat was uniform, with no significant differences. The average moisture level across all plots ranged from 60–75%, which falls within the category of favorable conditions for mangrove growth. According to Tolangara *et al*. (2022), soil moisture levels between 50% and 70% are considered moist and suitable for mangrove development. In the seedling stratum, the mangrove species with the highest density at Station I (mangrove track area) was *Rhizophora mucronata* Lamk with 3,700 individuals/ha (Table 2). At Station II (riverside area), the highest density was *Bruguiera cylindrica* (L.) Blume with 3,300 individuals/ha (Table 3), while at Station III (coastal edge), the highest density was again *Rhizophora mucronata* Lamk with 1,900 individuals/ha (Table 4). This high density is attributed to the suitability of muddy substrates for the growth of *Rhizophora mucronata*. According to Noor *et al*. (2012), *Rhizophora* species are generally well-adapted to environments with muddy to muddy-sandy substrates, as are other members of the Rhizophoraceae family.

Table 2. Station 1 and INP analysis data DI Marine *Science Techno Park* (MSTP) Area

No	Local Name	Scientific Name	K	F	D	INP
	Tree					
1	Bidara	*Maytenus emarginata* (Willd.) Ding Hou	375.00	0.5	0.01	24.13
2	Truntun	*Lumnitzera racemosa* Willd	700.00	0.5	0.01	28.08
3	Buta-buta	*Excoecaria agallocha* L.	550.00	0.5	0.01	26.11
4	Nyiri	*Xylocarpus granatum* Koen	50.00	0.5	0.00	13.53
5	Tanjang	*Bruguiera cylindria* (L) Bl	125.00	0.25	0.00	8.83
6	Bakau Merah	*Rhizophora apiculata* Bl	900.00	1	0.03	51.13
7	Bakau Hitam	*Rhizophora mucronata* Lamk	2350.00	0.75	0.27	148.18
	Tree Saplings					
1	Truntun	*Lumnitzera racemosa* Willd	2100.00	0.25	0.25	69.39
2	Ketapang	*Terminalia catappa* L.	100.00	0.25	0.00	15.81
3	Tanjang	*Bruguiera cylindria* (L) Bl	1100.00	0.5	0.07	51.22
4	Bakau Hitam	*Rhizophora mucronata* Lamk	3700.00	0.75	0.68	163.58
	Seedling					
1	Jeruju	*Acanthus ilicifolius* L.	50000	0.25	35.50	
2	Nyiri	*Xylocarpus granatum* Koen	7500	0.25	14.77	
3	Lampeni	*Ardisia elliptica* Thunberg	5000	0.25	13.55	
4	Tanjang	*Bruguiera cylindria* (L) Bl	25000	0.25	23.31	
5	Bakau Merah	*Rhizophora apiculata* Bl	5000	0.25	13.55	
6	Bakau Hitam	*Rhizophora mucronata* Lamk	87500	0.75	76.02	
7	Dadap Laut	*Clerodendrum inerme* (L.) Gaertn	25000	0.25	23.31	

Description: K: Density, F: Frequency, D: Dominance, INP: Index of Important Values.

Table 3. Station 2 and INP analysis data DI Marine *Science Techno Park* (MSTP) Area

No	Local Name	Scientific Name	K	F	D	INP
	Tree					
1	Nipah	*Nypa fruticans* Wurmb	100.00	0.25	0.02	11.98
2	Truntun	*Lumnitzera racemosa* Willd	25.00	0.25	0.00	7.82
3	Buta-buta	*Excoecaria agallocha* L.	1600.00	1	0.34	104.45
4	Lampeni	*Ardisia elliptica* Thunberg	25.00	0.25	0.00	7.82
5	Tanjang	*Bruguiera cylindria* (L) Bl	625.00	1	0.05	49.60
6	Bakau Merah	*Rhizophora apiculata* Bl	1425.00	0.75	0.59	118.33
	Tree Saplings					
1	Truntun	*Lumnitzera racemosa* Willd	900.00	0.5	0.05	37.98
2	Buta-buta	*Excoecaria agallocha* L.	1500.00	0.5	0.19	61.08
3	Teruntum	*Aegiceras corniculatum* (L.) Blanco	100.00	0.25	0.00	11.55
4	Lampeni	*Ardisia elliptica* Thunberg	100.00	0.25	0.00	11.62
5	Tanjang	*Bruguiera cylindria* (L) Bl	3300.00	0.75	0.71	150.52
6	Bakau Merah	*Rhizophora apiculata* Bl	800.00	0.25	0.05	27.27
	Seedling					
1	Jeruju	*Acanthus ilicifolius* L.	65000.00	0.5	36.36	
2	Waru	*Hibiscus tiliaceus* L.	5000.00	0.25	9.85	
3	Lampeni	*Ardisia elliptica* Thunberg	125000.00	0.5	54.55	
4	Tanjang	*Bruguiera cylindria* (L) Bl	75000.00	0.25	31.06	
5	Tengah	*Ceriops tagal* (Perr.) C.B. Rob.	5000.00	0.25	9.85	

6	Bakau Merah	*Rhizophora apiculata* Bl	50000.00	1	48.48
7	Dadap Laut	*Clerodendrum inerme* (L.) Gaertn	5000.00	0.25	9.85

Description: K: Density, F: Frequency, D: Dominance, INP: Index of Important Values.

Table 4. Station 3 and INP analysis data DI Marine *Science Techno Park* (MSTP) Area

No	Family	Local Name	Scientific Name	K	F	D	INP
	Tree						
1	Casuarinaceae	Cemara Laut	*Casuarina equisetifolia* L.	25.00	0.25	0.00	8.29
2	Combretaceae	Truntun	*Lumnitzera racemosa* Willd	125.00	0.5	0.00	19.98
3	Euphorbiaceae	Buta-buta	*Excoecaria agallocha* L.	650.00	0.75	0.04	58.26
4	Malvaceae	Waru	*Hibiscus tiliaceus* L.	75.00	0.25	0.00	10.47
5	Rhizophoraceae	Tanjang	*Bruguiera cylindria* (L) Bl	75.00	0.25	0.00	10.38
6	Rhizophoraceae	Bakau Merah	*Rhizophora apiculata* Bl	325.00	0.25	0.01	23.34
7	Rhizophoraceae	Bakau Hitam	*Rhizophora mucronata* Lamk	1050.00	1	0.37	161.07
8	Rubiaceae	Mengkudu	*Morinda citrifolia* L.	25.00	0.25	2E-05	8.21
	Tree Saplings						
1	Combretaceae	Ketapang	*Terminalia catappa* L.	200.00	0.25	0.00	14.74
2	Euphorbiaceae	Buta-buta	*Excoecaria agallocha* L.	300.00	0.25	0.01	17.80
3	Malvaceae	Waru	*Hibiscus tiliaceus* L.	200.00	0.25	0.00	14.41
4	Rhizophoraceae	Tanjang	*Bruguiera cylindria* (L) Bl	400.00	0.25	0.01	19.59
5	Rhizophoraceae	Bakau Merah	*Rhizophora apiculata* Bl	1700.00	0.5	0.32	88.63
6	Rhizophoraceae	Bakau Hitam	*Rhizophora mucronata* Lamk	1900.00	1	0.64	144.83
No	**Family**	**Local Name**	**Scientific Name**	**K**	**F**	**INP**	
1	Aizoaceae	Krokot (Gelang laut)	*Sesuvium portulacastrum* (L.)L.	25000.00	0.25	21.21	
2	Aizoaceae	Krokot (Telekan)	*Triathema portulacastrum* L.	12500.00	0.25	16.16	
3	Convolvulaceae	Tapal Kuda	*Ipomoea pes-caprae* (L) Sweet.	62500.00	0.25	36.36	
4	Malvaceae	Waru	*Hibiscus tiliaceus* L.	17500.00	0.5	29.29	
5	Myrsinaceae	Lampeni	*Ardisia elliptica* Thunberg	55000.00	0.5	44.44	
6	Rhizophoraceae	Bakau Hitam	*Rhizophora mucronata* Lamk	75000.00	0.5	52.53	

Description: K: Density, F: Frequency, D: Dominance, INP: Index of Important Values.

Table 5. Environmental factors of mangrove ecosystems in the MSTP Area

No	Environmental Factors	Station 1	Station 2	Station 3
1	Air Temperature (ºC)	27,68	29,18	31,53
2	Air Humidity (%RH)	72,325	68,2	62,175
3	Light Intensity (lux)	546.35	529,85	597.95
4	Soil pH	6,3	6,5	6,6
5	Soil Moisture (%RH)	60	62	75

Description: Station 1 (Mangrove Track Area), Station 2 (Riverbank Area), Station 3 (Beachside Area).

Air temperature is another important environmental factor influencing mangrove growth in the area, with recorded temperatures at the research site ranging from 27.68°C to 31.53°C (Table 5). This is supported by Haya et al. (2015), who stated that the optimal temperature for mangrove growth and photosynthesis lies between 25°C and 35°C.

In the sapling stratum, the highest density in the mangrove track area was *Rhizophora mucronata* Lamk with 87,500 individuals/ha (Table 2). In the riverside area, the highest density was *Ardisia elliptica* Thunberg with 125,000 individuals/ha (Table 3), while in the coastal edge area, *Rhizophora mucronata* Lamk had the highest density again with 75,000 individuals/ha (Table 4). This is due to the species' ability to adapt and grow well in mangrove ecosystems.

Based on environmental factor measurements, the highest light intensity was recorded at Station III (coastal edge), at 597.95 lux (Table 5). According to Rahmadhani *et al*. (2021), mangrove plants generally require high sunlight intensity for optimal growth.

3.3 Mangrove diversity index value

The diversity index value is calculated based on the number of species and the number of individuals of each species within a community (Indriyanto, 2006). Based on the analysis of the mangrove diversity index in the *Marine Science Techno Park* (MSTP) area, the H' value ranged from 1.59 to 1.68, which falls into the moderate category. Detailed data can be seen in Figure 2.

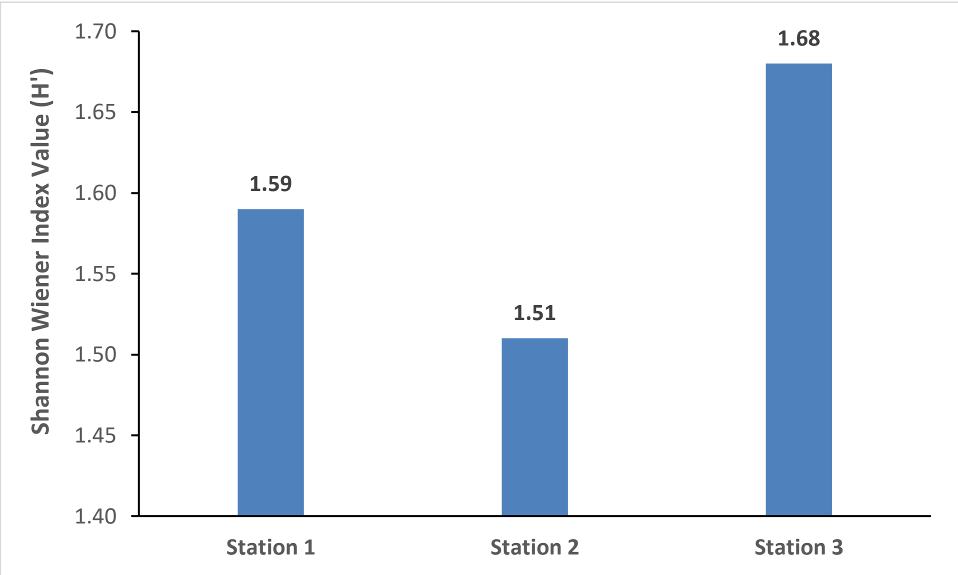


Figure 2. Shannon *Wienner Diversity Index Value* in the Mangrove *Marine Science Techno Park* (MSTP) Area.

Based on the Shannon-Wiener Diversity Index (H') analysis (Figure 2), the highest diversity value was found at Station III (coastal edge area), with an H' value of 1.68. The Shannon-Wiener diversity index at Station II (riverside area) was 1.51, while Station I (mangrove track area) had an H' value of 1.59. These values indicate that the species diversity in the MSTP mangrove area falls within the moderate category.

This is consistent with Magurran (1998), who stated that an H' value of less than 1.5 indicates low diversity, a value between 1.5 and 3.5 indicates moderate diversity, and a value above 3.5 indicates high diversity. According to Fachrul (2007), a higher diversity index indicates a more stable community. Moreover, the level of species diversity is also influenced by environmental factors, as plant species that adapt well to the environment tend to survive better than those that do not.

3.4 Mangrove eveness index

The evenness index is used to determine the distribution of plant species within a community. The results of the evenness index calculation are presented in Table 6. The evenness index (E) describes the distribution of plant species within a community. The analysis results show that Station I (mangrove track area) had an evenness value of 0.69, Station II (riverside area) 0.63, and Station III (coastal edge area) 0.66. These values indicate that population distribution at all three stations falls into the category of moderately even.

Table 6. Mangrove Evenness Index

Research location	Evennes Indeks (E)
Station 1	0.69
Station 2	0.63
Station 3	0.66

According to Sari *et al*. (2023), an evenness index of 0.84 in the tree stratum indicates an almost even distribution, while values of 0.73 for saplings and 0.7 for seedlings are categorized as moderately even. On the other hand, according to Ernawati et al. (2019), an evenness value ranging from 0.30 to 0.32 represents a stressed community with low evenness, indicating an uneven species distribution. Kusmana & Azizah (2021) also note that the evenness index reflects the level of individual distribution across species, and it is closely related to species diversity—higher evenness values generally indicate a more stable diversity index.

The Importance Value Index (IVI) can be defined as an index calculated based on abundance to determine the dominance level of a species within a plant community. Based on the IVI analysis, at station I (mangrove track area), *Rhizophora mucronata* Lamk was found to have the highest IVI across all strata. The tree stratum recorded an IVI of 148.18%, the sapling stratum 163.58%, and the seedling stratum 76.02% (Table 2). This indicates that *Rhizophora mucronata* Lamk plays a major role in the mangrove ecosystem community, significantly affecting ecosystem stability in the MSTP Jepara area. According to Momo *et al*. (2018), the role of a species in a community is reflected in its high importance value index.

The black mangrove (*Rhizophora mucronata* Lamk) is known as a major mangrove species that functions to protect coastal areas from abrasion, where its strong root system can bind the soil and help prevent wave action caused by tidal currents. According to Saswini *et al*. (2023), black mangrove (*Rhizophora mucronata*) is one of the mangrove species with the ability to serve as a natural coastal barrier against abrasion.

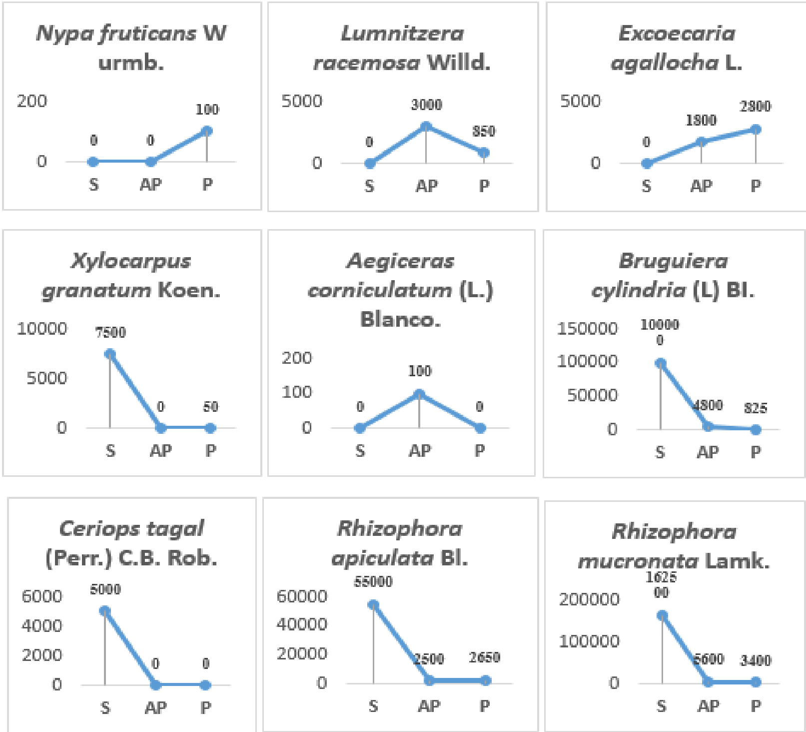
At station II, *Rhizophora apiculata* Blume dominated the tree stratum with a value of 118.33%, *Bruguiera cylindrica* (L.) Blume dominated the sapling stratum with 150.52%, while in the seedling stratum, *Ardisia elliptica* Thunberg had the highest importance value at 54.55% (Table 3). According to Sidiyasa (2007), a mangrove species with a high IVI means it plays a significant role in the mangrove ecosystem, while a species with a low IVI does not have much ecological impact on the mangrove environment.

At station III, *Rhizophora mucronata* Lamk again dominated all strata with an IVI of 161.07% for the tree stratum, 144.83% for saplings, and 52.53% for seedlings (Table 4). This shows that the species plays the most dominant role in the community. This is in accordance with the opinion of Utami & Anggoro (2017) which states that species with a high importance value index are dominant species with high ecological value in the area.

3.5 True mangrove regeneration in the MSTP Area

The analysis of true mangrove density was conducted by calculating the total number of individual mangrove plants in each stratum across all stations (3 hectares) to assess the regeneration status in the MSTP mangrove area. A total of nine true mangrove species were identified in the area (Figure 3). Species with good regeneration status include *Xylocarpus granatum* Koen, *Bruguiera cylindrica* (L.) Blume, *Ceriops tagal* (Perr.) C.B. Rob, *Rhizophora apiculata* Blume, and *Rhizophora mucronata* Lamk. These species were characterized by a greater number of individuals in the seedling stratum compared to saplings and mature trees.

Conversely, species with poor regeneration status include *Nypa fruticans* Wurmb, *Lumnitzera racemosa* Willd, *Excoecaria agallocha* L., and *Aegiceras corniculatum* (L.) Blanco. These species showed no presence of individuals in the seedling stage within the research area. According to Shankar (2001), regeneration status is considered good when the number of seedlings exceeds the number of saplings and trees, while poor regeneration is indicated by the absence of the seedling growth stage.



Description: S (Seedling), AP (Sapling), P (Tree).

Figure 3. True mangrove regeneration density graph in the Jepara MSTP area.

Based on the analysis of true mangrove regeneration density (Figure 3), the mangrove ecosystem in the MSTP area generally exhibits an inverted-J shaped stand structure for the species *Bruguiera cylindrica* (L.) Bl., *Ceriops tagal* (Perr.) C.B. Rob., and *Rhizophora mucronata* Lamk, indicating that the regeneration process in this location is relatively good. Species that do not form an inverted-J curve are influenced by several factors that contribute to regeneration failure, including poor growth capability and unsuitable growing conditions. This is consistent with Wicaksono (2014), who states that species unable to form an inverted-J curve are affected by failed regeneration activities and habitat unsuitability.

4. CONCLUSION

The species composition of mangroves in the *Marine Science Techno Park* (MSTP) area comprises 20 species (5 major mangroves, 4 minor mangroves, and 11 associated mangroves) belonging to 15 families. The species diversity index is categorized as moderate, ranging from 1.51 to 1.68, and the evenness index is considered fairly even, ranging from 0.63 to 0.69. In Station I, *Rhizophora mucronata* Lamk had the highest Importance Value Index (IVI) across all strata: tree stratum (148.18%), sapling stratum (163.58%), and seedling stratum (76.02%). In Station II, the highest IVI values were found in *Rhizophora apiculata* BI for the tree stratum (118.33%), *Bruguiera cylindrica* (L.) BI for the sapling stratum (150.52%), and *Ardisia elliptica* Thunberg for the seedling stratum (54.55%). In Station III, *Rhizophora mucronata* Lamk also had the highest IVI across all strata: tree stratum (161.07%), sapling stratum (144.83%), and seedling stratum (52.53%). The regeneration of true mangroves in the MSTP Jepara area was categorized as good for species such as *Xylocarpus granatum* Koen, *Bruguiera cylindrica* (L.) BI, *Ceriops tagal* (Perr.) C.B. Rob, *Rhizophora apiculata* BI, and *Rhizophora mucronata* Lamk, whereas regeneration was considered poor for *Nypa fruticans* Wurmb, *Lumnitzera racemosa* Willd, *Excoecaria agallocha* L, and *Aegiceras corniculatum* (L.) Blanco.

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