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Mangrove Plant Community Structure of Kwala Indah Village, Batu Bara Regency

Ricky Tommy Fransiskus Purba[1], Welmar Olfan Basten Barat[1]*, Daniel Tony E Siburian[1]

[1]HKBP Nommensen Pematangsiantar University, Jln. Sangnaualu no 4, Indonesia.
*Corresponding author e-mail: purba080501@gmail.com, olfan_basten_barat@yahoo.com

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Abstract

Coastal areas are transitional areas between land and marine ecosystems that have high biological productivity. Mangroves are a type of plant that grows in coastal areas or river estuaries and has an ecological function by acting as the last defense against sea waves after coral reef and seagrass ecosystems, as sediment traps, as a place to find fish food, as a fish spawning ground, as a shelter, and as a place for fish farming. Mangrove Plant Community Structure Research in the Kwala Indah Village Area was conducted in August–October 2023 with the aim of knowing the types of mangroves, mangrove diversity and uniformity, dominance, Important Value Index (INP), and mangrove crown cover in Kwala Indah Village. The method used in the observation of mangrove plant community structure is to use the quadrant transect method by analyzing species density, relative density, species frequency, relative frequency, species dominance, relative dominance, and important value index at the tree, sapling, and seedling levels, as well as crown cover. Based on the results of the study, 7 species were found, namely *Xylocarpus granatum*, *Xylocarpus mekongensis*, *Rhizophora apiculata*, *Rhizophora mucronata*, *Soneratia alba*, *Bruguiera parviflora*, and *Excoecaria agallocha*. *Xylocarpus and Rhizopora* have the highest INP, diversity, uniformity, and dominance. Canopy cover is in the medium category; coastal areas are transitional areas between terrestrial and marine ecosystems that have high biodiversity values.

Keywords: Mangrove, INP, Diversity, Uniformity, Canopy

1. Introduction

1.1 Background

The coastal area is a transitional area between land and ocean ecosystems that have high biological productivity. The supply of nutrients from the land through river flow and surface water flow when it rains causes the growth and development of various natural ecosystems such as mangrove forests, coral reefs, seagrass beds, and estuaries, causing coastal areas to be very fertile. Coastal forest areas in various regions in Indonesia, especially on the north coast of Java, Sumatra, South Sulawesi, Bali, and East Kalimantan, have been degraded due to forest destruction and conversion to other uses as settlements, ponds, agricultural land, plantation land, or industry. It is recorded that the rate of mangrove degradation reaches 160–200 thousand ha/year (Utomo *et al.,* 2018).

Mangroves are one of the rare ecosystems because they only cover about 2% of the earth's surface. According to the Ministry of Environment and Forestry, Directorate General of Watershed Control and Protected Forests, Directorate of Soil and Water Conservation, Indonesia is the country with the largest mangrove ecosystem in the world, which reaches 3.5 hectares, and Indonesia also has a large and varied biodiversity (Wijayanto *et al.,* 2022).

This ecosystem has an important ecological, socio-economic, and socio-cultural role in maintaining coastal stability from abrasion and other biodiversity, is a source of firewood and building wood, and has a function in conservation, education, ecotourism, and cultural identity. Mangrove areas also have various ecological functions, such as being a place to live for various flora and fauna typical of mangrove ecosystems, wave breakers, mitigation of rising sea levels, and CO2 absorption from the air (Nurfitriani *et al.,* 2022).

Part of the mangrove canopy is also a habitat for various types of land animals, such as monkeys, insects, birds, and bats. Mangrove tree wood can be used as firewood, charcoal, building materials, and pulp. Mangrove density contributes to accretion rates, sediment distribution, and surface elevation (Salim *et al.,* 2017).

Judging from the magnitude of the role of mangroves for life, especially in coastal areas, it is important to maintain this ecosystem, but even so, there are several main activities that contribute most to the decline of mangroves in Indonesia, including the conversion of mangrove forests into ponds, plantations, and settlements, as well as the habit of people taking wood from mangrove forests for firewood or building materials, causing a decrease in mangrove species diversity (Akram and Hasnidar, 2022).

The highest distribution of mangroves with sparse cover conditions is in North Sumatra Province, covering an area of 8,877 ha, and the lowest distribution of sparse mangroves is in Bali Province, covering an area of 75 ha. The area of mangrove forests in Batubara Regency is 3,424.53 ha (Ministry of Environment and Forestry, 2021).

From these various things, it is necessary to conduct research to determine the diversity and uniformity of mangrove forests in the coastal area of Batubara as a reference for future mangrove forest improvement, especially in the coastal areas of North Sumatra, especially the Batubara Region, as a form of anticipation of increasing mangrove forest degradation.

2. Research Methods

This research was conducted in Kwala Indah Village, Batubara Regency, in September 2023. The method used is quadrant transect, where there are 3 stations and each station has 3 substations. The plot area used was 20 m x 20 m. Determination of points using the purposive sampling method. The data taken in each plot is the type of mangrove and stem circumference of the tree. Tools used in data collection can be seen in Table 1.

2.1 Identification

Mangrove identification is done by paying attention to every aspect, such as leaves, roots, and fruit, of the trunk of mangrove trees in the mangrove identification guidebook that has been prepared. Then the identification results are written on the data sheet that has been prepared previously using the book (Rusilla *et al.,* 1999).

2.2 Data Analysis

Diversity is determined using the diversity formula according to Shannon-Wiener (1984) in Bengen (2004) as follows:

$$H' = -\sum_{i=1}^{n} \text{pi Ln pi}$$

Information:
H’ = Diversity Index
Pi = ∑ni/N
ni = number of individuals of Type i
N = total number of individuals

The diversity index (H') consists of some 3 Shannon-Wiener criteria (Martuti, 2013), namely:

H ' > 3.0 = indicates high diversity, low ecological stress
1 ≤ H ' ≥ 3 = indicates moderate diversity, low ecological stress
H ' < 1 = indicates low security, low ecological stress

Uniformity index (E) type can use the formula. Evennex index of Shannon index of Diversity as follows:

$$E = \frac{H'}{LnS}$$

Description:
E = Uniformity Index
H' = Diversity Index
S = number of species

Uniformity index values are grouped in three criteria, namely:

E < 0.4 = small population uniformity rate
0.4<E< 0.6 = medium degree of poppulation uniformity
E > 0.6 = large population uniformity rate

Type density (Di) is the number of i-type stands in a unit area (Bengen, 2004). Determination of density types through the formula:

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

Information :
Di = Density of type i
Ni =Total number of i-th individuals
A =Total sampling area (m2

Relative density (RDi) is the number of comparisons between the number of stands of the 1st type with the total stands of all types (Bengen, 2004). Determination of relative density (RDi) using the formula:

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

Information :
RDi = Relative Density
N = Number Of Individuals
∑n = Total stands of all types

Type frequency (Fi) is the chance of finding a type i in all sample plots compared to the total number of sample plots made (Bengen, 2004), to calculate the type frequency (Fi) used the formula:

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

Information :
Fi = frequency of the i-th type
Pi = number of sample plots where Type I is found
∑p = total number of sample plots created.

Relative frequency (RFi) is a comparison between the frequency of the type i with the number of frequencies of all types (Bengen, 2004). To calculate the relative frequency using the formula:

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

Information :
RFi = relative frequency
Fi = frequency of the i-th type
∑F = number of frequencies of all types

The dominance of a Type (D) (m2 /Ha) shows the amount of control of space in an ecosystem. D is only calculated for the category tree formula as follows:

$$D = \frac{Area\ of\ Base\ Field\ of\ a\ type\ (\frac{1}{4}\pi d^2)}{Tile\ Area\ example}$$

Relative dominance (DR) (%).

$$DR = \frac{Dominance\ of\ a\ Breed}{Dominance\ of\ All\ Types} \times 100\%$$

Important Value Index (INP) mangrove vegetation description was analyzed by calculating the influence value (K), relative influence (KR), frequency (F), relative frequency (FR), dominance (D), relative dominance (DR), and influence Value Index (INP) (Odum, 1993).

INP = RDi + RFi + DR (tree)

Canopy cover, data collection was carried out using a front-facing cell phone camera directed perpendicular to the sky. The number of photos taken is determined based on the condition of the mangrove forest. The shooting point should be between the trees. Things to avoid are shooting next to the tree trunk, taking multiple photos, and avoiding photos from sunlight. The point and number of photos taken are based on the condition of the mangrove forest using the ImageJ application. The concept of this analysis is the separation of sky pixel color (white) and mangrove vegetation pixel color (black). According to the Decree of the Minister of Environment No. 201 Year 2004 the value of mangrove canopy cover is categorized into 3, namely; rare (<50%), moderate (50-75%), and dense (≥75%). Canopy cover analysis is done by calculating the percentage of the number of mangrove vegetation cover pixels in binner image analysis with the formula (Dharmawan and Pramudji, 2014), and study location can be seen on Fig 1.

$$\%\ Kanopi = \frac{p255}{\sum P}\ X\ 100\%$$

Information :
P255 = the number of pixels that are worth 255 as interpretation of mangrove canopy cover
P = number of pixels

Table 1. Percentage of mangrove species

No	Tools	SUM
1	GPS	1 Unit
2	Stationery	1 Set
3	Raffia strap	1 Rolls
4	Camera	1 Unit
5	Roll Meter	1 Unit
6	Peg	4 Unit
7	Identification Book	1 Unit

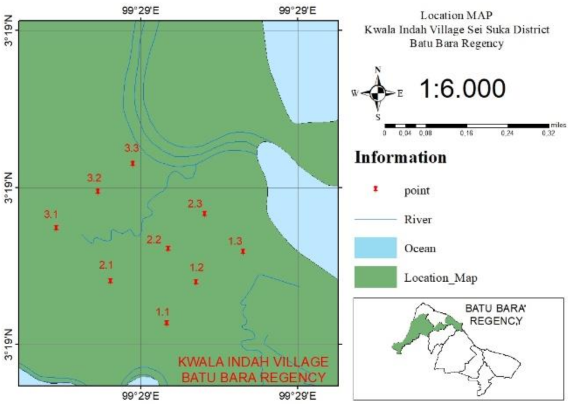


Figure. 1. Map of the study area

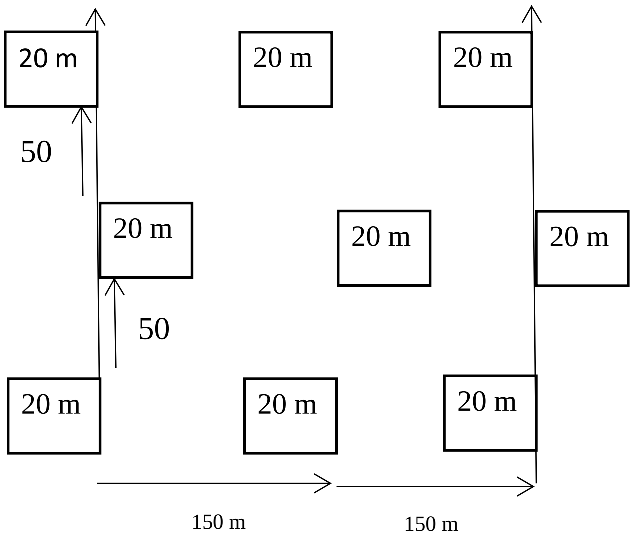


Figure 2. Mangrove Sampling Plot

In (Fig. 2) above, it is explained that each sub-station is 50 m apart and stations are 150 m apart. However, this may change if the terrain of the study site does not allow it.

3. Results and Discussion

3.1 Identification of Mangroves

Based on observations in Kwala Indah Village, Seisuka District, Batu Bara Regency. The number of mangroves found in this village there are 7 species that dominate namely *Rhizophora apiculata, Rhizophora mucronata, Xylocarpus granatum, Xylocarpus mekongensis, Soneratia alba, Bruguiera parviflora, Excoecaria agallocha*. The percentage of mangroves from the samples taken is in Table 2, in the table it can be seen that the largest percentage is 24.8276%, namely *Rhizophora apiculata* where the lowest percentage is the type of *Bruguiera parviflora* which is 5.51724%. The substrate found in this location is dominated by mud, especially at stations 1 and 2. According to Kustanti (2011) in Sarifudin (2021), *R. apiculata* is one of the dominant mangrove species in mangrove forest areas because it is able to adapt well to its environment when compared to other species, especially in muddy conditions. The taproot type in *Rhizophora apiculata* also helps the adaptation of *Rhizopora* to a flooded environment.

From Table 3, it can be seen that there are some similarities between the images found in the field and also the sketches in the identification book, coupled with some of the characteristics below taken from the mangrove identification book by (Yusrila *et al.,* 1999).

3.2 Mangrove diversity and uniformity index

Based on the results of data processing from the level of mangrove trees obtained in Kwala Indah Village in accordance with Table 4, the diversity value (H') is 1.81916 which indicates a moderate level of diversity. The value of uniformity (E) 0.93486 shows that at a large level of uniformity, this diversity value consists of 7 species found.

According to Ewusie (1990), diversity means a state that is different or has various differences in form or nature. The idea of species diversity is based on the assumption that populations of species that together form, interact with each other and with the environment in various ways, indicating the number of species present and their relative abundance. According to Supriadi et al (2015), a high diversity index indicates that environmental conditions are more mature and stable, and indicates the level of pressure by ecology. This medium diversity value consists of 7 species found. According to Indriyanto (2006) in Sarifudin (2021), species diversity can indicate that a community has high complexity because the species interactions that occur in the community are very high. A community is said to have high species diversity if it is composed of many species. Supriadi et al. (2015) stated that the lower the uniformity index value of a community means the more unstable the environmental conditions. A low uniformity value indicates that the community is under stress. Therefore, the high diversity and uniformity in an ecosystem can be interpreted from how the environmental conditions are stable or not either naturally or due to human factors.

3.3 Tree Dominance and INP

From the results of observations and data processing obtained at the research site, it was found that the species that dominated the entire research site were from Table 5 it can be seen that the highest overall dominance value was *Xylocarpus granatum* which amounted to 26.39%, slightly different from *Rhizophora apiculata* which amounted to. The lowest value is *Bruguiera parviflora* which is 4.44%. This is due to differences in the number and size of the stem circumference of the type of Xylocarpus granatum, where dominance is influenced by the overall value of stem circumference that dominates the space of a plot or ecosystem area in accordance with the opinion of Hotden *et al.,* (2014) which states that the greater the size of the mangrove tree trunk, the greater the dominance and will be able to compete well for nutrients from other types of mangroves. As for the low dominance of a species due to the inability of the species to adapt to its environment, this is stated by Nasution (2005) in Hotden *et al.,* (2014) that the species that has a relatively low dominance value means that it reflects its inability to tolerate environmental conditions, even though the research location is in a muddy and flooded area where the area is a good location for X. granatum and *Rhizopora apicualata*.

The Index of Important Value (INP) on Mangrove trees in Kwala Indah Village as a whole location according to Table 3 the highest value is *Xylocarpus granatum* which is 75.37%. The lowest value is *Bruguiera parviflora* which is 13.80%. This shows that the type of *Xylocarpus granatum* has an important role in the coastal mangrove ecosystem of Kwala indah Village.

The importance value index above can be seen as an illustration of how important mangrove species that dominate in an ecosystem location. INP (Important Value Index) is a quantitative parameter that can be used to state the level of dominance of species in mangrove communities. In addition, the Important Value Index reflects the existence of the role (dominance) and structure of mangrove vegetation in a location (Supriadi *et al.,* 2015).

In the research location of Kwala Indah Village, *Xylocarpus and Rhizophora* became the most instrumental species because of the resilience of the two species in muddy environmental locations so that they dominate over other species, the high INP factor of a species is caused by how high the species is able to adapt to its environmental habitat. The environmental conditions of the study site is on the banks of a small river whose substrate is muddy and affected by tides, this is in accordance with the original habitat of *Rhizophora* and *Xylocarpus* proposed by Yusrila *et al.,* 1999, the original habitat of *Rhizopora* and *Xylocarpus* is in the environment of the forest edge adjacent to the tidal waters and at the edge of the land in the mangrove area. The growing substrate consists of sand and mud. They favor areas with fresh water.

3.4 Canopy Cover

In accordance with Table 6, the highest overall canopy cover was at Station 3, valued at 65.759%. The lowest value is Station 1, which is 51.344%. In the overall research area obtained an average of 56.331%, these results are much lower than the percentage of mangrove canopy cover at the Betah walang Village research site, the average mangrove canopy cover at all research stations is 81.07% and has a solid status (Muksin *et al.,* 2020).

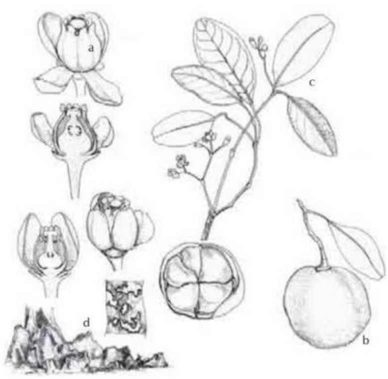
As for the factors that make crown cover in a moderate position because in some locations it is damaged both bare areas and bare leaf cover, it should be noted that environmental conditions adjacent to the sand mine resulted in the erosion of mangrove forests so that there are several points where the forest area has been lost, this affects the size of the crown cover. According to Nurdiansah & Dharmawan (2018); Tinambunan *et al.,* 2021 that the percentage of mangrove crown cover is influenced by tree category density and environmental suitability characteristics.

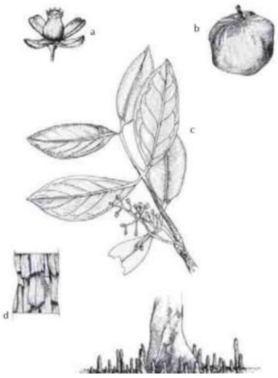
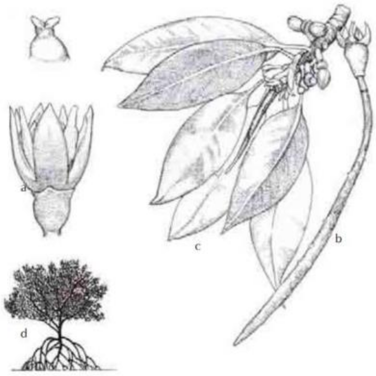
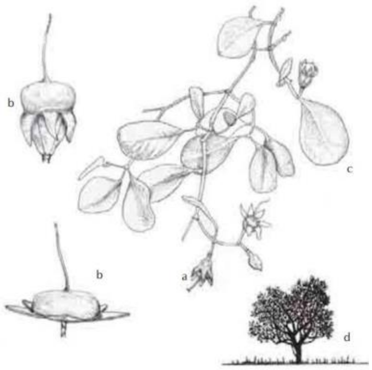
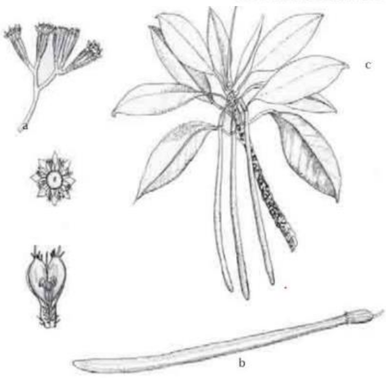
While the condition of the width and size of the leaves also affects because at that location the leaves are still small and not dense, this opinion is in accordance with Pretzsch (2015) the greater the leaf overlap area, the denser the crown cover, this causes differences in species will also have differences in the area of overlap.

Table 2. Percentage of mangrove species

No	Species	Total	Percentage (%)
1	*R. apiculata*	36	24,8276
2	*R. mucronata*	13	8,96552
3	*X. granatum*	32	22,069
4	*X. mekongensis*	27	18,6207
5	*S. alba*	19	13,1034
6	*E. agallocha*	10	6,89655
7	*B. parviflora*	8	5,51724
	Total	145	100

Table 3. Mangrove identification

Species	Sample Image Found	Species Image
Xylocarpus granatum		

Xylocarpus mekongensis		
Rhizophora Apiculata		
Rhizophora Mucronata		
Soneratia Alba		
Bruguiera Parviflora		

Excoecaria agalloca

Table 4. The results of data processing H', and E overall tree

No	Species	Sum	Numbers Of Plots	H'	E'
1	*R. apiculata*	36	5		
2	*R. mucronata*	13	2		
3	*X. granatum*	32	7		
4	*X. mekongensis*	27	6	1,81916	0,93486
5	*S. alba*	19	4		
6	*E. agallocha*	10	1		
7	*B. parviflora*	8	1		
	Total	145	9		

Table 5. Dominance Value and INP

Mangrove Species	Number of Species	Number of Plots	Di (ind/m²)	Rdi (%)	Di (Ind/ha)	Fi	Rfi (%)	D	DR (%)	INP (%)
R. apiculata	36	5	0,01	24,83		0,56	19,23	10,48	20,18	64,23
R. mucronata	13	2	0,00	8,97		0,22	7,69	3,23	6,22	22,87
X. granatum	32	7	0,01	22,07		0,78	26,92	13,70	26,38	75,37
X. mekongen	27	6	0,01	18,62	402,78	0,67	23,08	13,65	26,28	67,97
S. alba	19	4	0,01	13,10		0,44	15,38	6,13	11,79	40,28
E. agallocha	10	1	0,00	6,90		0,11	3,85	2,45	4,72	15,46
B. parviflora	8	1	0,00	5,52		0,11	3,85	2,30	4,44	13,80
SUM	145	9	0,04	100,00		2,89	100,00	51,94	100,00	300,00

Table 6. Overall Canopy Cover Data Processing Results

Station	Pixel Canopy	Pixels Total	Cover Percentage (%)	Avarage
1	6460580,333	12582912	51,34407944	
2	6529350	12582912	51,89061165	56,3313
3	8274432,667	12582912	65,75928264	

4. Conclusion

Based on the study, the conclusion is that mangrove species, namely *Xylocarpus granatum, Xylocarpus mekongensis, Rhizophora apiculata, Rhizopora mucronata, Soneratia alba, Bruguiera parvifora, and Excoecaria agallocha, Rhizophora apiculata* species has the highest number. The value of diversity and uniformity of mangroves in Kwala Indah Village is as follows: the diversity value is 1.81916, which shows the level of medium diversity. While the uniformity value (E) of 0.93486 shows a level of great uniformity, The saplings are 1.825, which shows a moderate level of diversity. The uniformity value (E) of 0.9378 shows a large level of uniformity. While the seedling diversity value (H') is 1.832, which shows a medium level of diversity, The uniformity value (E) of 0.941 shows a large level of uniformity. The tree with the highest overall Index of Importance (INP) in Kwala Indah village is *Xylocarpus granatum*, worth 75.37%. The lowest value is *Bruguiera parvifora*, worth 13.80%. The plant with the highest dominance index is X. granatum, with a value of 26.39%. The lowest value is *Bruguiera parviflora*, worth 4.44%.

The canopy cover, with an average of 56.331%, is in the medium category. From the above conditions, the community structure in Kwala Indah Village is formed by several species. In this study, 7 species were found, with *Xylocarpus* and *Rhizophora* being the most important species in the ecosystem. The location of the environment is close to the river flow, which makes the substrate dominantly muddy, namely at stations 1 and 2, while station 3 is sandy mud.

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