Vegetation Characteristic and Micro Environment of Mangrove Rehabilitation Forest at Coastal Areas of East Sinjai, South Sulawesi

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Abstract. This study aims to determine vegetation characteristics and micro-climate of rehabilitation mangrove forests at East Sinjai District, Sinjai Regency. The results showed that mangrove forest rehabilitation had a complete vegetation structure, consisting of seedlings, saplings, and trees, with the level of vegetation diversity included in the "low" category. Overall, there are 18 types of mangroves at the rehabilitation mangrove forest, consisting of 12 major mangroves and 6 minor mangroves. The dominant mangrove vegetation is Rhizophoramucronata with an Important Value Index on the tree class is 263.183. Substrate texture under mangrove vegetation is dominated by “sandy clays” with pH level between “acid” to “neutral” and soil fertility levels based on C-Organic content, categorized in “high levels”. Water quality is included in the "good" category with an average pH level of 7.03 (neutral) and an average dissolved oxygen content (DO) of 5.12. The level of macrozoobenthic diversity categorized in the "medium" level, with the diversity index value (H) of 1.365 and the dominant species, namely Littorinascabra. The level of plankton diversity is "medium" category with a diversity index value of 1.711 with the dominant species Coscinodiscus sp.

1. Introduction

Indonesia is an archipelago consisting of 17,504 islands [1] with a stretch of coastline of 81,000 km [2]. With a long coastline, the potential of mangrove ecosystems in Indonesia is very high. According to Jones et al.[3], mangrove vegetation is spread in 120 countries in the world between latitudes 30°N and latitude 30°S. The location of Indonesia which is in the equator also supports the development of mangrove ecosystems. Mangrove forests are spread in almost all coastal areas in Indonesia, ranging from Sumatra, Java, Kalimantan, and Sulawesi to Papua, with an area varies depending on physical conditions, substrate composition, hydrological conditions, and climate types on each island. The area of mangrove forests in Indonesia is the largest in the world with an area of 3,112,989 Ha with a percentage of 22.6% of the total mangrove area in the world [4]. So far, in Indonesia, there are at least 202 species of mangrove plants, covering 89 species of trees, 5 species of palm, 19 species of climbers, 44 types of soil herbs, 44 types of epiphytes and 1 type of ferns [5].

Coastal communities who interact with mangroves daily depend on this ecosystem to support their needs. The increasing population in coastal areas, resulting in more intensive utilization of mangrove ecosystems so the pressure on these ecosystems is greater, even more than their carrying capacity. As
a result, there is damage to mangrove ecosystems in various places. The data shows that over the past 40 years, mangrove land cover in the world has decreased by more than half [6]. The deforestation rate that occurs in mangrove forests is four times greater than the rate of deforestation in terrestrial tropical rainforests [7]. Mangrove damage also occurred in the coastal areas of South Sulawesi Province. Based on data from the South Sulawesi Provincial Forestry Service in 2014, the mangrove area in South Sulawesi Province reached 28,954.3 ha, but only 5,238 ha were in a good category, while the rest were in damaged condition. In order to restore the mangrove function, both in terms of economy and ecology, there are two main steps that are needed, the rehabilitation of mangrove ecosystems and regulation of utilization to formulate mangrove ecosystem management strategies to ensure the realization of mangrove ecosystems that are able to provide sustainable benefits.

Mangrove rehabilitation continues to be carried out, both by government agencies, non-governmental organizations, and the community independently. One area that has succeeded in rehabilitating mangroves is East Sinjai Sub District, Sinjai Regency, South Sulawesi Province. The success of mangrove rehabilitation activities in East Sinjai is not always measured by the percentage of plant growth but also measured by microenvironment aspects, which include physical and chemical aspects of water, physical and chemical aspects of substrate, abundance, and diversity of plankton and abundance and diversity of macrozoobenthic. Therefore, the research activities on the characteristics of vegetation and the microenvironment of mangrove ecosystem rehabilitation in Sinjai District, South Sulawesi are very important to be done in order to know that the success of mangrove rehabilitation activities also has an impact on the ecology of the microenvironment around mangrove rehabilitation forests.

2. Research method
2.1 Time and location
This research activity was conducted in August 2017. The location of the study was conducted in the mangrove forest area of East Sinjai District, Sinjai Regency. Data collection was carried out in mangrove rehabilitation areas in four villages, namely Samataring Village, Tongke Tongke, Panaikang, and Sanjai.

2.2 Materials and equipment
The material used as the object of study was mangrove forest rehabilitation in the District of East Sinjai, Sinjai Regency. The other supporting materials were maps of research locations and regional statistical data. The tools used in this research include pH meter, portable refractometer, thermometer, plankton net, benthos filter, sample bottle, formalin, scale pole, digital camera, Global Positioning System (GPS), compass, keep meter, phi band, tally sheet, roll meters, raffia, kit herbarium, callipers, plastic bags, drop pipettes, plastic buckets, label paper, stationery and other supporting tools.

2.3 Data collection method
Primary data collection was carried out using field observation methods and direct measurements. The field observation method is used to describe the biophysical conditions of the research location, for example, to describe the use of land around the mangrove rehabilitation area. Direct measurement techniques are carried out on the measurement of several vegetation parameters, namely identification of species, measurement of plant height and diameter and measurement of water quality and microclimate. Determination of the location of the observation plot was carried out by purposive sampling with consideration of species diversity, vegetation density, and differences in biophysical conditions. Thus, it was expected that the vegetation used as a sample can represent the composition of the mangrove species at the research location.

Some steps taken in collecting vegetation data include: (a) Determining blocks / observation stations; (b) Making observation plots using a 10 x 10 m crater (square) method for tree growth classes in which there are 5 x 5 m plots for sapling growth classes, and 2 x 2 m for seedling growth classes; (c) identification of the type of vegetation; (d) dimension measurement of vegetation, including height,
diameter of the stem. Water sampling was carried out using 600 ml of water sampler in each research plot with three repetitions. Then the sample bottles are labeled and put into a cool box with ice preservatives. Measurement of water physical and chemical properties carried out in two ways, namely direct field measurements and laboratory measurements. The measurement results are analyzed by the Decree of the Minister of Environment No. 51 of 2004 concerning Sea Water Quality Standards. Soil samples were taken using a 2.5-inch iron pipe designed to take soil samples on a muddy substrate. The iron pipe is then plugged into the ground perpendicular to a depth of ± 60 cm. Then the soil sample was put into a plastic bag ± 2 kg. Furthermore, soil samples are taken to the laboratory to analyze their physical and chemical properties. Data obtained from the laboratory were then analyzed descriptively.

Plankton samples were taken by taking 100 liters of water then filtering 100 ml of water using plankton net. Filtered water samples were put in a sample bottle and then given 4% formalin preservative. Then the sample was brought to the laboratory to identify the species and its abundance was calculated. The macrozoobenthic sampling was carried out using a 1 x 1 m2 squared method, while the determination of sampling points was determined by purposive sampling method. Sampling is done by placing the square at the sampling point, and then the macrozoobenthic in the square are taken and recorded. Furthermore, the macrozoobenthic that have been taken are put in bottles and given alcohol preservatives and labeled. The sample is then taken to the laboratory to identify the species and its abundance is calculated.

2.4 Data analysis
Data were obtained from measurement results in the field were analyzed using two methods, qualitative descriptive analysis, and vegetation analysis. Quantitative descriptive analysis was used to describe the condition of physical and chemical properties of water and substrate. Vegetation analysis was carried out to find out the importance index of each species. This analysis used field measurement data which includes the number of individuals, stem diameter, type of vegetation and area of sample plot. In addition, an analysis of the Shanon-Wiener (H’) diversity index was also used to determine the level of diversity of vegetation types and also to know the sustainability of succession or stability in a vegetation community.

3. Results and discussion
3.1 Vegetation composition
The composition of vegetation type is the composition of vegetation from each level of growth from the smallest or can also be said to be floristic wealth in certain environments [8]. The composition of vegetation type is one of the factors that can be used to determine the succession process that is taking place in an area. If the composition of the stand is restored then it can be said that the environment can recover to its initial condition when damage or disturbance occurs [9]. Based on observations, mangrove vegetation in East Sinjai District was dominated by 3 (three) types of mangroves, namely Rhizophoramucronata, Avicennia marina, and Sonataalba. Other types of mangrove vegetation with small levels of abundance include Bruguiergymnorhiza and Rhizophoraapiculata. This type of mangrove is classified in the major (true) mangrove type. Major mangroves are plants that live entirely in tidal mangrove ecosystems and do not grow in other ecosystems and adapt morphologically and physiologically to live in mangrove environments [10]. In addition to major mangroves, minor (associated) mangroves are also found in the research location, namely plants that live on the banks of mangrove ecosystems and are unable to form the main components of striking vegetation. Some of the vegetation included in the associated mangroves found in the research location, includes Calophylluminophyllum (nyamplung), Hibiscus tiliaceus (waru), Terminaliacatappa (ketapang) and Pandanustectorius(pandan). Based on data from the Forestry and Plantation Service of Sinjai District, there were 15 major and minor mangrove species that grow in SinjaiRegency.

Species diversity is a very useful parameter to determine the ecological characteristics of mangrove forest stands in an area and also to determine the level of succession or stability of a community.
Mangrove forests with a high level of diversity tend to have a higher level of community stability compared to mangrove forests that have a low level of diversity. According to Insafitri [11], diversity indices (H) with value <1 indicates a low level of diversity, the value between 1 to 3 can be classified into the medium category and H value > 3 is categorized into a high level of diversity. Species diversity index at all growth levels includes seedlings, saplings, and trees, respectively, 0.363; 0.196; 0.055 so that all growth levels have a "Low" diversity level. *Rhizophoramucronata* is the dominant type at all growth rates. The dominant species is the species that can utilize the environment occupied efficiently than others in the same place. While the codominant is *Avicennia marina* and *Sonneratiaalba*. *Rhizophoramucronata* as the dominant species has the highest Important Value Index at each growth level, namely for a seedling level of 162.485, sapling and trees of 279.045 and 263.183. The second type of codominant at the seedling level is *Sonneratiaalba* with an Important Value Index 19.164, while at the sapling level is *Avicennia marina* with an Important Value Index 20.955.

### 3.2 Vegetation structure

Vegetation structure is an organization of individuals in space that form a stand [8]. The structure of mangrove forest stands shows the number of trees that are decreasing from small diameter classes to large diameter classes. In seedling level growth class (diameter less than 2 cm) shows individual density level 23,382 individuals/ha, the density at sapling level (diameter less than 10 cm) is 4,824 individuals/ha and tree level density (diameter more than equal to 10 cm) is 706 individuals/ha (Figure 1a).

In general, the structure of forest stands in the research location shows the characteristics resembling the inverted "J" letter, so that it can be said that the forest is still normal. This result is the same as the research conducted by [9] which states that the structure of mangrove stands in PasarBanggi Village, Rembang Regency also resembles the reverse "J" letter. The same results were also obtained [12], which stated that the structure of mangrove stands in Alas Purwo National Park resembled the reverse "J". The correlation value (R) between the diameter class and tree density is 1 (Figure 1b). This correlation value indicates there is a correlation with the degree of "Very Strong" between the diameter class variable and the level of tree density. The structure of mangrove stands in the mangrove rehabilitation area produced by the community, seen from the pattern of the relationship between the growth class and the density level can be used as an indicator of the success of the regeneration of mangrove stands. Based on the pattern depicted in the graph (Figure 1b), shows the level of regeneration of mangrove stands in the mangrove rehabilitation area of self-supporting communities following the normal line, starting from the seedling level which ranked highest, then the sapling level and the lowest tree level.

![Figure 1](image1.png)  
(a) The level of vegetation density at each growth level, (b) The level of correlation between density and diameter
Results of the assessment of the level of health of mangrove forests based on the parameters of vegetation density according to the standard criteria for mangrove damage by the government show that, the level of health of mangrove forests in the East Sinjai Sub District of is at a good level (high). In total at all levels of growth, the individual density of mangrove vegetation reached 2,207 trees/ha. Based on the Decree of the Minister of Environment No. 201 of 2004 concerning standard criteria and guidelines for determining mangrove damage, mangrove forest areas with tree density levels above 1,500 trees/ha are categorized as good (very tight). Mangrove regeneration in this area is still very good which can be seen from the composition of seedling density that is higher than saplings and trees. In the aspect of density and regeneration, mangrove forests in East Sinjai Sub District are better than mangrove forests on the east coast of North Sumatra which regenerates mangrove forests is not perfect because there is no tree growth class [13]. This result is also better than the condition of mangrove vegetation on the coast of Sungai Raya Kepulauan Subdistrict, Bengkayang Regency, West Kalimantan, which is categorized as heavily damaged [14].

3.3 Water quality and substrate
Physical properties of soil are factors that are responsible for transporting air, heat, water and dissolved materials in the soil [15]. Information regarding the physical and chemical properties of the soil under the mangrove stand is expected to be a reference in the efforts to protect, preserve and use mangrove forests in general. The results of soil texture analysis under mangrove stands in East Sinjai Sub District were dominated by sand with 61.4%, 30.3% dust, and 8.31% clay (sandy clay). The soil texture under mangrove vegetation is very different, depending on rock material or the origin of the substrate that is formed. The results of the study by [16], stated that the texture of the substrate under mangrove stands in Balinggi Sub District, Parigi Moutong Regency was dusty clay. On the contrary, the results of the research by [17], stated that the soil texture in the mangrove ecosystem in Kuala Sub District, Bireuen Regency was sandy clay.

The results of soil chemical analysis for acidity (pH) parameters averaged 6.30 which are included in the rather sour value. Overall, the pH value at all observation stations ranged from 5.18 to 7.60 with slightly sour values. The results of the analysis of C-Organic content were 4.75% which is included in high levels. Overall, the C-Organic content of the substrate under the mangrove stands in the District of East Sinjai varies greatly from 0.26% (very low) to 11.99% (very high). The results of Nitrogen content analysis 0.12% which is included in the low level. The results of this study are not much different from the research of [18] which states that Nitrogen levels in soil under mangrove vegetation in Buleleng Regency, Bali ranged from 0.06% to 0.13%. The index that is often used to determine the quality of organic matter related to the decomposition rate is C / N ratio. The results of the analysis show, overall, the value of C / N ratio at all observation stations is 34.97 which are included at a very high level.

The important things in determining the water quality of waters are pH parameters. Based on the results of measuring the pH value of water in the mangrove ecosystem is 7.028 which is in the neutral range. Neutral pH value is a pH value that is good for the life of marine organisms ranging from 6.5 to 8.5. So the condition of pH in mangrove waters in East Sinjai District is still relatively good for the development of marine organisms. Based on the Decree of the State Minister for the Environment, Number 51 of 2004 concerning sea water quality standards, the pH standard for the life of marine organisms is 7 - 8.5. Salinity is defined as the amount of weight of salt dissolved in 1 liter of water, usually expressed in units of ‰ (per mile, gram per liter). Based on the results of measurements in the field using a portable refractometer, the level of salinity is in the range of 10.50 ‰ to 26 ‰, with an average value at all measurement stations 16.29 ‰. Quality standards according to the Decree of the Minister of Environment No. 51 of 2004 concerning sea water quality standards for marine biota, water salinity parameters in mangrove waters a maximum of 34 ‰. Based on these standards, water salinity in the study location is still below the quality standard threshold so that aquatic biota can live normally. Dissolved oxygen has a very important role in the survival of aquatic organisms for
respiration, reproduction, and fertility. The dissolved oxygen level in the mangrove ecosystem in East Sinjai District ranged from 2.88 ppm to 6.72 ppm with the average value in all sampling locations was 5.12 ppm. The threshold standard for DO quality for marine life is > 5 ppm.

3.4 Macozoobenthic and plankton diversity

Abundance and diversity of macozoobenthic can be used as a tool to assess water health. This is based on the life characteristics of macozoobenthic which tend to settle at the bottom of the waters, have relatively slow movements and have a relatively long life cycle so that these organisms have the ability to respond to changes in water quality. The results of the observation of macozoobenthic obtained a total of 275 individuals consisting of 11 species, 11 genera and 9 families with a density level of 4 individuals / m². The type of macozoobenthic found was dominated by Littorina Scabra.

The results of macrozoobenthic diversity index (H’) under mangrove stands in East Sinjai Subdistrict were 1.365. The level of river pollution based on the diversity index, which is highly polluted, moderately polluted, and heavily polluted with a diversity index >3; 1 - 3 and <1. Based on the grouping, the quality of the waters below the mangrove stands in East Sinjai Subdistrict are included in the medium polluted waters. Plankton can be used as a biological indicator of aquatic fertility because they are fish and shrimp food. The results of the identification of plankton in mangrove waters in the district of East Sinjai have identified 18 types of plankton, consisting of 11 types of phytoplankton and 7 types of zooplankton. The average level of abundance is 101 cells/ml. The type found was dominated by the type of Coscinodiscus sp. and Leptocylindricus sp. Diversity index of 1.711 which is included in the "medium" category.

4. Conclusion

The mangrove forest ecosystem in Sinjai District was originally the result of community rehabilitation carried out independently. Based on the species composition, there are 18 types of mangroves consisting of 12 major mangrove species and 6 minor mangrove species. Rhizophoramucronata is the dominant species at all growth rates with the highest INP values at each growth level. Species diversity index at all growth levels include seedlings, saplings, and trees, have a "Low" diversity level. The structure of forest stands in the research location shows the characteristics resembling the inverted "J" letter with the level of mangrove categorized at the "good". Substrate texture under mangrove stands is dominated by sandy clays with pH levels between slightly acidic to neutral. Water quality is in a good category with an average pH level of 7.03 (neutral) and an average dissolved oxygen content (DO) of 5.12. The level of diversity of macrozoobenthic is included in the "medium" category, dominated by Littorinascabra. The level of plankton diversity is in the "medium" category dominated by Coscinodiscus sp.

5. References

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