Condition of Mangrove Ecosystems in Sungai Apit Siak Distric Based on Standard Damage Criteria and Quality Indicators Mangrove Environment

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Abstract. Mangroves are one of the ecosystems in coastal areas that have an important role, but nowadays many are experiencing threats. The purpose of this study was to determine the condition of mangrove ecosystems in Kecamatan Sungai Apit seen from standard criteria for mangrove damage and the indicators of mangrove environmental quality (species association, tree cover, seedling cover and number of seedlings species). This research was conducted in April 2018 in Kecamatan Sungai Apit, Siak Distric. The method used in this research was survey method. Types and density of mangroves were observed at three stations (Desa Lalang, Desa Bunsur and Desa Sungai Rawa) using line transects and plots. The results showed that the condition of the mangrove ecosystem in the coastal area of Kecamatan Sungai Apit based on the standard criteria of damage (Minister of Environment No. 201 of 2004), seen from the group of trees classified as damaged to good with rare to dense criteria, but when combined with a group of sapling, the conditions mangroves in Kecamatan Sungai Apit were classified as good with very dense criteria. Mangrove conditions based on indicators of mangrove environmental quality in the three stations included in the category of high environmental conditions with successively Qe values (mangrove environmental conditions) were 67.96% (Desa Lalang), 64.37% (Desa Bunsur) and 84.68% (Desa Sungai Rawa).

Keywords: Quality of mangrove environment, standard criteria of damage, Kecamatan Sungai Apit.

1. Introduction

Mangrove ecosystems are one of the main ecosystems found in coastal areas, in addition to coral reefs and seagrass ecosystems. Mangroves are tropical and sub-tropical coastal vegetation communities that are dominated by several types of mangrove trees that are able to grow and develop in muddy coastal tidal areas. In general, a mangrove ecosystem is composed by various types of vegetation, although there are also in some places only a single species or one or two species overgrown, either because of the results of restoration with one or two species or because the environment allows only certain species to live.

Vegetation of mangrove forests in Indonesia has high species diversity. The number of mangrove species was 202 species consisting of 89 trees, 5 types of palms, 19 species of lianas, 44 species of epiphytes, and 1 type of cycads. However, there are only approximately 47 specific species of mangrove forests [1]. Mangrove ecosystems have several important functions and roles. Mangrove ecosystem has a function as a food source or coastal fertility, a place of refuge, breeding or an
enlargement of other marine biota [2]. Mangrove ecosystems have ecological and economic functions [1] [3]. Ecologically, mangroves can guarantee the maintenance of physical environments such as waves, winds and breeding grounds for various types of marine life, such as fish, shrimp, crabs, shellfish, snails and other types of animals. One area that has mangrove resources in Riau Province is found in coastal waters Sungai Apit District, which is dominated by *Avicennia marina* and *Sonneratia alba* [4]. The problem of mangrove ecosystems is found in the coastal area of Sungai Apit which faces the island of Padang where on the island there is an oil exploitation activity by PT Kondur Petroleum located on the island of Padang. This activity has the potential to produce oil spills as well as logging by humans. In 2014 an oil spill came from PT Koundur Petroleum. This caused many mangroves to be damaged by the oil spill.

The importance of the existence of mangroves, it is necessary to maintain it. The effort that needs to be done is to find out the current condition of the mangrove ecosystem. Considering the lack of information about the condition of mangrove forests in the coastal area of Sungai Apit Subdistrict, it is necessary to study the condition of the mangrove ecosystem that can be used as a guide for its management.

### 2. Material and Methods

This research was carried out in April 2018 on the coast of Kecamatan Sungai Apit, Siak District (Figure 1). The tools used for this research were meter, squares plot, mangrove identification book and stationery along with its complementary tools used to obtain primary data (measurement of physical parameters) namely GPS, Thermometer, pH Indicator, Hand refractometer and camera.

![Figure 1. Map of research locations in Kecamatan Sungai Apit](image)

The method used in this study was a survey method, namely by observing and taking samples directly in the field. The research used 3 stations. Sediment samples obtained at each station were analyzed at the Marine Chemistry Laboratory, Department of Marine Sciences, Faculty of Fisheries and Marine, University of Riau. The research station was determined by purposive sampling method by determining the location of the study to pay attention to the conditions of the surrounding research area. To get an overview of the
research area was divided into 3 stations that are considered to have represented the area, namely Station 1 (Desa Lalang), Station 2 (Desa Bunsu), and Station 3 (Desa Sungai Rawa).

To obtain mangrove data based on mangrove identification books according to [1]. Withdrawal of line transects was done at each station. Each station consists of 9 transects and each transect was placed 3 plots of 10 mx 10 m for the tree category (diameter > 4 cm), in the square of 10 mx 10 m, the square was 5 mx 5 m for sapling (diameter <4 cm, height tree> 1m) and measuring 2 mx 2 m for seedlings (height <1 m). Mangrove stands found in each plot were identified and counted for each category and measured the diameter of the stem at chest height (1.3 m) [5].

Environmental parameters were measured in situ at each observation location. The measured environmental parameters are: pH, temperature, salinity and substrate. Measurements are made with 3 repetitions. Measurement of environmental parameters was done to determine environmental conditions

2.1. Density of Mangrove Vegetation

The density of mangrove vegetation type (Di) is the number of individuals per unit area with individual units per hectare (ind / ha) [1].

\[ Di = \frac{n_i}{A} \]

Information:
- Di : Species density
- ni : The total number of species i
- A : Total plot size plot

2.2. Mangrove Environmental Quality

Indicators of the quality of the mangrove environment were used to determine the quality of the mangrove environment. The research uses four indicators as shown in Table 2.

| No | Indicator of mangrove environmental conditions value | Value (W) |
|----|-----------------------------------------------|----------|
| 1  | Species association                           | 22       |
| 2  | Tree cover (%)                                | 17       |
| 3  | Seedling cover (%)                            | 13       |
| 4  | Number of seedlings                           | 12       |

Source: [6]
Species associations based on dominant species and the thickness of mangrove zones seen from the sea to land. Tree cover (Pk) was obtained from the number of trees found with the equation of the modification [6]

\[ Pk = \left( \frac{\sum K}{\sum Sk} \right) \times 100\% \]

Information:
- \( Pk \) = Tree cover (%)
- \( \sum K \) = Number of trees in a community
- \( \sum Sk \) = Number of all categories of mangroves (seedlings, saplings and trees).

Seedling cover (Ps) was obtained from the number of seedlings species found with the Canter and Hill modification equation [6]):

\[ Ps = \left( \frac{\sum S}{\sum Sk} \right) \times 100\% \]

Information:
- \( Ps \) = seedling cover (%)
- \( \sum S \) = Number of seedlings in a community
- \( KSk \) = Number of all mangrove categories in a community

The number of seedlings was obtained from the number of seedlings species in the research location.

The mangrove environmental quality index of each indicator was known based on the value of each environmental quality indicator in the graph of the mangrove environmental quality index which can be seen in Figures 4.5, 6, and 7. The value of each indicator occupies the X axis while the index value of each indicator (Qi) occupies the Y axis.

The environmental quality of mangroves in Kecamatan Sungai Apit was calculated using the Canter and Hill modification formula [6]:

\[ Qe = \frac{\sum (Qi \times W)}{\sum W} \]

Where:
- \( Qe \) : Quality of mangrove environment
- \( Qi \) : Environmental quality index of mangrove land
- \( W \) : Weight of each indicator

Range of \( Qe \) values, namely:
- \( Qe <30\% \) : Low environmental quality
- \( 30\% \leq Qe \leq 60\% \) : Medium environmenta quality
- \( 60\% < Qe \leq 100\% \) : High environmental quality

3. Results and Discussion

3.1. Environmental Quality Parameters

Measurement of water quality parameters carried out was temperature, salinity and pH. The observed base water environment was the substrate. The average results of environmental quality measurements in mangrove forest Kecamatan Sungai Apit can be seen in Table 3.
Table 3. Results of measurement of Aquatic Quality Mangrove Forest in Kecamatan Sungai Apit

| Station | Temperature (°C) | Salinity (%) | pH       | Sediment Types |
|---------|-----------------|--------------|----------|----------------|
| 1       | 29 - 30         | 15 - 21      | 5 - 6    | Sandy mud      |
| 2       | 30 - 32         | 10 - 29      | 5 - 6    | Sandy mud      |
| 3       | 27 - 30         | 25 - 30      | 6 - 7    | Sandy mud      |

Water temperature in the Sungai Apit mangrove ecosystem during the study ranged from 27-32 °C. This temperature is good for mangrove growth. A good temperature for mangrove growth is around 30 °C, while temperatures above 40 °C tend not to have a significant effect on the level of mangrove life [7].

In addition to temperature, environmental parameters that fluctuate in mangrove ecosystems are salinity. Salinity is an important factor in growth, durability and zoning of mangrove species. The salinity found in the mangrove area of Kecamatan Sungai Apit ranged between 10-31 ‰. Salinity in this region was good for mangrove growth in the estuary area with salinity of 10-30 ‰ [8].

The pH range of the waters in the mangrove area of Kecamatan Sungai Apit was between 5-7. This pH value is considered good because in this area including waters suitable for mangrove and other biota life. Mangroves can live at a low pH which is natural for the environment [9].

The type of sediment in the mangrove ecosystem Kecamatan Sungai Apit has a type of sandy mud sediment. The muddy substrate was found in mangroves located in the river mouth, but there was only one large river at the location of this study. River flow tends to carry fine sedimentary material that comes from erosion on land leading to the sea area. The existence of mud sediments is influenced by the number of suspended particles carried by fresh water, as well as the factors that influence the clotting and deposition of suspended materials, such as the presence of currents from the sea [10].

3.2. Density of Mangrove Vegetation

Mangrove species found in Kecamatan Sungai Apit at stations 1, 2 and 3 were dominated by *Avicennia alba*, *Sonneratia alba* and *Rhizophora apiculata*. The number of species and density of mangroves at each station can be seen in Table 4. *Avicennia alba* and *Sonneratia alba* types that are dominant in all stations related to the basic substrate of mangrove ecosystems in Sungai Apit District are sandy mud. This result was in line with that obtained [11], Avicennia dominates the mangrove ecosystem in Sungai Rawa Village. The condition of the density of mangroves in the research location, especially the species of *Sonneratia alba*, *Avicennia alba*, *Rhizophora apiculata*, *Lumnitzera racemosa*, *Xylocarpus granatum* shows that they are able to adapt to the surrounding environment. This situation has a tendency to form a diversity of standing community structures that play an important role as sediment sediment traps, form communities to stabilize shorelines, protect coastal erosion, sea and land buffers in absorbing wave energy, inhibit sea water intrusion into land, produce habitat to sustain species diversity and absorb pollutants to reduce pollution from the environment [12]. More mangrove species in Desa Sungai Rawa are related to its existence which is close to the Sungai Rawa estuary which has a better habitat for the growth of many types of mangroves.
The density of mangrove vegetation in the coastal area of Kecamatan Sungai Apit for the category of trees ranged from 822 ind/ha (rare) to 1281 ind / ha (dense), while the sapling ranged from 2475 to 3407 ind/ha (very dense). The seedling group ranged from 10278 to 38796 ind/ha (very dense). Based on the standard criteria for mangrove damage Minister of Environment No. 201 of 2004, the condition of mangroves in Sungai Apit Subdistrict based on the density of tree groups classified as damaged to good with rare to solid criteria, but when combined with seedlings, the condition of mangroves in Sungai Apit District classified as good with very dense criteria.

**Table 4.** Types and density of mangroves groups of trees, saplings and seedlings in Kecamatan Sungai Apit

| Station       | Species            | Density (Ind/ha) |      |
|---------------|--------------------|------------------|------|
|               |                    | Tree  | Sapling | Seedling |
| Desa Lalang   | Avicennia alba     | 300   | 978     | 3056     |
|               | Sonneratia alba    | 326   | 933     | 1667     |
|               | Rhizophora apiculata | 155 | 1378    | 5555     |
|               | Xylocarpus granatum | 411 | 44      | 0        |
|               | Total              | 822   | 3333    | 10278    |
| Desa Bunsur   | Avicennia alba     | 256   | 948     | 17500    |
|               | Sonneratia alba    | 433   | 1733    | 15278    |
|               | Rhizophora apiculata | 496 | 415     | 5463     |
|               | Xylocarpus granatum | 85  | 267     | 555      |
|               | Lumnitzera racemosa | 0   | 30      | 0        |
|               | Bruguiera sp.      | 11    | 15      | 0        |
|               | Total              | 1281  | 3407    | 38796    |
| Desa Sungai Rawa | Avicennia alba | 211   | 711     | 6759     |
|               | Sonneratia alba    | 111   | 252     | 3518     |
|               | Rhizophora apiculata | 181 | 904     | 3426     |
|               | Rhizophora mucronata | 41  | 15      | 93       |
|               | Xylocarpus granatum | 56  | 163     | 926      |
|               | Lumnitzera racemosa | 78  | 193     | 0        |
|               | Lumnitzera littorea | 96   | 0       | 0        |
|               | Heritiera littoralis | 7   | 15      | 0        |
|               | Scyphiphora        | 115   | 178     | 93       |
|               | hydrophyllacea     |       |         |          |
|               | Ceriops decandra   | 4     | 0       | 0        |
|               | Excoecaria agallocha | 19  | 44      | 0        |
|               | Hibiscus tiliceus  | 0     | 0       | 0        |
|               | Total              | 919   | 2475    | 14815    |

3.3. Mangrove Environmental Quality Indicator

Types of mangrove environmental quality indicators include species association, tree cover, seedling cover and number of seedlings. Based on the calculation of mangrove
environmental quality indicators obtained the value of the mangrove environmental quality index as in Figures 2, 3, 4 and 5.

Figure 2. Results of the relationship chart of species associations with mangrove environmental quality index

Figure 3. Graph of relationship between tree cover with mangrove environmental quality index at each station

Figure 4. Graph of relationship between seedling cover with mangrove environmental quality index at each station
The value of mangrove environmental quality in Kecamatan Sungai Apit which shows the condition of mangrove forests at three stations can be seen in Tables 5, 6, 7.

Table 5. Results of measurement of mangrove environmental quality indicators in Kecamatan Sungai Apit

| Station       | Indicator Type | Value of each indicator | Mangrove environmental quality index (Qi) | Value (W) | Qi x W |
|---------------|----------------|-------------------------|------------------------------------------|-----------|-------|
| Desa Lalang   | Species association | Sonneratia, Avicennia, dan Rhizophora | 0.6                                      | 22        | 13.2  |
|               | Tree cover            | 53.21 %                  | 0.9                                      | 17        | 15.3  |
|               | Seedlings cover       | 32.83 %                  | 0.6                                      | 13        | 7.8   |
|               | Number of seedlings species | 3                      | 0.6                                      | 12        | 7.2   |
|               | Total number           |                          |                                          | 64        | 43.5  |

Environmental quality (Qe) Station 1 = 67.96% (high environmental conditions)

| Station       | Indicator Type | Value of each indicator | Mangrove environmental quality index (Qi) | Value (W) | Qi x W |
|---------------|----------------|-------------------------|------------------------------------------|-----------|-------|
| Desa Bunsur   | Species association | Sonneratia, Avicennia, dan Rhizophora | 0.6                                      | 22        | 13.2  |
|               | Tree cover            | 34.76 %                  | 0.7                                      | 17        | 11.9  |
|               | Seedlings cover       | 23.44 %                  | 0.5                                      | 13        | 6.5   |
|               | Number of seedlings species | 4                      | 0.8                                      | 12        | 9.6   |
|               | Total number           |                          |                                          | 64        | 41.2  |

Environmental quality (Qe) Station 1 = 64.37% (high environmental conditions)

| Station       | Indicator Type | Value of each indicator | Mangrove environmental quality index (Qi) | Value (W) | Qi x W |
|---------------|----------------|-------------------------|------------------------------------------|-----------|-------|
| Desa Sungai Rawa | Species association | Rhizophora sp., Avicennia sp., dan Sonneratia sp. | 1                                      | 22        | 22    |
|               | Tree cover            | 43.33 %                  | 0.8                                      | 17        | 13.6  |
|               | Seedlings cover       | 29.64 %                  | 0.6                                      | 13        | 7.8   |
|               | Number of seedlings species | 5                      | 0.9                                      | 12        | 10.8  |
|               | Total number           |                          |                                          | 64        | 54.2  |

Environmental quality (Qe) Station 1 = 84.68% (high environmental conditions)
Based on the analysis of mangrove environmental quality indicators, the condition of mangroves in Kecamatan Sungai Apit (Desa Lalang 67.96%, Desa Bunsur 64.37% and Desa Sungai Rawa 84.68%) are classified as high environmental conditions, namely >60%. This shows the environmental conditions in Kecamatan Sungai Apit according to the characteristics for mangrove growth and adaptation. The condition of mangroves with high environmental conditions was also obtained by [13] on the coast of Miangas Island, Talaud Regency, North Sulawesi Province, and [6] in Dukuh Tambaksari, Demak Regency. The condition of mangroves with the value of mangrove environmental quality being obtained [14] at Way Penet in East Lampung. Mangrove vegetation can live in tidal areas, high salinity with sandy mud substrate which is rich in organic matter and able to adapt to the surrounding environment to support its growth [2]. The quality of the mangrove environment is the state of the mangrove environment which can provide optimal carrying capacity for human survival with parameter indicators measured based on natural baseline conditions of a number of environmental variables that affect changes in environmental quality [15].

4. Conclusions

High density mangrove species in the three stations in Sungai Apit Subdistrict are Avicennia alba, Sonneratia alba and Rhizophora apiculata. Mangrove ecosystems in Kecamatan Sungai Apit based on standard criteria of damage seen from the density of the group of trees classified as damaged to good with rare to dense criteria, but when combined with a group of sapling, the condition of mangroves is good with very dense criteria. The condition of the mangrove ecosystem in Kecamatan Sungai Apit based on the quality of the mangrove environment was classified as high environmental conditions.

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