THE MANGROVE LANDSCAPING BASED ON WATER QUALITY
(Case Study in Segara Anakan Lagoon and Meranti Island)

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Abstract. The ability of mangrove ecosystem to decrease impact of water quality, including in Segara Anakan Lagoon (SAL) and Meranti Island. The mangrove ecosystem has specific species to adapt water quality and other environment factors. The method of this research used transects method, vegetation analysis and water quality analysis. The results showed that (1) the mangrove species were Aegiceras corniculatum, Avicennia alba, Avicennia marina, Bruguiera gymniriza, Bruguiera parviflora, Celedendrum inerme, Ceriops tagal, Excoecaria agallocha, Hibiscus tiliaeaceus, Lumnitzera racemosa, Nypa fruticans, Pandanus sp., Rhizophora apiculata, Xylocarpus granatum (Meranti Island) and Avicennia marina, Avicennia alba, Rhizophora mucronata, Rhizophora apiculata, Rhizophora stylosa, Sonneratia alba, Sonneratia caseolaris, Bruguiera gymnoryza, Bruguiera sexangula, Bruguiera parviflora, Aegyceras corniculatum, Ceriops tagal, Ceriops decandra, Xylocarpus mollucensis, Xylocarpus granatum, Excoecaria agallocha, Heritiera littoralis and Nypa fruticans (SAL) (2) Water qualities were salinity 14,27 ppt, pH 4,98, N-total 0,17 mg/l, phosphate 20,14 mg/l, pyrite 0,71 % (Meranti Island) and water salinity (18 until 31 ppt), pH of water (6,7 until 7,07), pH of soil (5,75 until 6,18), N-total (0,12 until 0,26%), phosphate (10,98 until 14,73 % ), C organic (1,18 until 1,57 %) (SAL).

Keyword : mangrove ecosystem, water quality, mangrove species, Segara Anakan, Meranti Island

1. Introduction

Mangrove ecosystem in Meranti Island and Segara Anakan Lagoon are the ecosystems which grow in the specific soil characteristic and water quality. The mangrove ecosystem in these area must have adaptation reducing impact of salinity, pH [1, 2, 3], abrasion [4],
sedimentation [5], sedimentation particles [6], soil texture[7], sea wave, sea water surface, sea tide [8; 9]. The oceanography, soil, and water quality are the trigger factors to give impact toward the mangrove species distribution in Meranti Island and Segara anakan. The main reason of mangrove distribution is water quality [10; 11] for examples are soil water salinity, pH, phosphate, nitrate, and pyrite.

The impact reducing of water quality, mangrove species must build the adaptation pattern with salt-excreting gland, [11; 7)] mangrove landscaping [1; 2], specific and root activity to decrease impact of water quality [12], activity to absorb and accumulate water salinity [13], and the root pattern to decrease impact of oxygen loss, soil texture [7, 14; 15].

Generally, the mangrove ecosystem in Meranti Island and Segara Anakan Lagoon have Aegiceras, Avicennia, Bruguiera, Nypa, Rhizophora, Sonneratia, Ceriops Hibiscus and Xylocarups as dominated species [3; 2]. The mangrove distribution in these areas followed water and soil water quality. The mangrove distribution expressed the landscaping of mangrove ecosystem as the pattern of mangrove adaptation to decrease impact of water quality, the habitat organism both of terrestrial or aquatic organism [16; 1; 17]. The species distribution of mangrove ecosystem also showed the mangrove adaptation of water pollution [18], environmental risk assessment and a sediment quality guideline (19). This paper has purpose to analysis mangrove distribution based on water and water soil quality and to develop the equation between mangrove densities with water quality.

2. Methods

2.1. Site Study

The research was conducted in Segara Anakan Lagoon Cilacap (focused in east Segara Anakan Lagoon) and Meranti Island (focused in Rangsang Island) on 2017 – 2018. The location of this research on Segara Anakan and Meranti Island can be seen on Table 1. This research used mangrove ecosystem, water and soil water quality as research variables.

| No | Segara Anakan Lagoon | Meranti Island (Rangsang) |
|----|----------------------|--------------------------|
|    | Latitude (North)     | Longitude (East)         |
| 1  | 07° 40’ 22.17”       | 109° 0’ 56.36”          |
| 2  | 07° 40’ 28.91”       | 109° 0’ 40.57”          |
| 3  | 07° 40’ 20.60”       | 109° 0’ 33.62”          |
|    | 01° 00’ 47.20”       | 102° 42’ 15.95”         |
|    | 01° 01’ 33.82”       | 102° 41’ 15.03”         |
|    | 01° 01’ 27.33”       | 102° 40’ 54.83”         |

Table 1. The research stations in Segara Anakan Lagoon and Meranti Island
2.2. Research Procedure

2.2.1. Mangrove density

The analysis of mangrove density used the quadrant transect method with the quadrant size is 10 m x 10 m (to analysis mangrove trees) [20; 21] with equation

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

Where:
- \( D_i \) = density (trees/ha)
- \( n_i \) = the mangrove trees (trees)
- \( A \) = Area of mangrove (ha)

This research compared the result of mangrove density (diameter > 10 cm) with Menteri Lingkungan Hidup No. 201 in 2004 to analysis degradation of mangrove ecosystem. The mangrove degradation would show the mangrove density in Segara Anakan Lagoon and Meranti Island.

2.2.2. Species richness

The analysis the species richness of mangrove species used Margalef index [22; 23], with equation was

\[ Di = \frac{n_i}{A} \]
\[ R = \frac{S - 1}{\ln(n)} \]

Note: \( n \) = number of mangrove trees
\( s \) = number of mangrove species.

2.2.3. Heterogeneity

The analysis of mangrove heterogeneity used Shannon-wiener equations \([22; 23]\), with equation was:

\[ H' = \sum_{i=1}^{s} \left( \frac{n_i}{N} \right) \ln \left( \frac{n_i}{N} \right) \]

Note: \( n_i \) = number of trees/mangrove species,
\( N \) = total number of mangrove trees

2.2.4. Water Quality

The potential of water and soil water quality on Table 2 showed the water and soil water qualities in mangrove ecosystem.

Table 2. The water and soil water quality measurement

| No. | variables        | unit     | Method                     | Reference |
|-----|------------------|----------|----------------------------|-----------|
| 1.  | Temperature      | °C       | Thermometer                | [36]      |
| 2.  | Salinity         | ppt      | Salt handrefraktometer     | [36]      |
| 3.  | pH               | Unit     | pH indicator               | [36]      |
| 4.  | Dissolve oxygen  | Mg/L     | Titration                  | [36]      |
| 5.  | Pyrite (FeS\(_2\)) | Ppm | Spectrophotometric        | [37]      |
| 6.  | Phosphate        | Mg/l     | Ascorbic acid              | [37]      |
| 7.  | N-Total          | Mg/l     | Brucine                    | [38]      |

2.3. Data Analysis

Data analysis of this research used table of tabulation, descriptive analysis and landscaping analysis.

3. Results and Discussion

3.1. Mangrove Density

The mangrove density in Merbau Island, Rangsang Island and East Part of Segara Anakan Lagoon on Table 3 show that show that (1) *Rhizophora apiculata*, *Sonneratia alba* and *Xylocarpus granatum* dominated in Merbau Island. (2) *Aegiceras*
corniculatum, Avicennia alba, Rhizophora apiculata. dominated in Rangsang Island (3) Nypa frutican, Rhizophora sexangula, Rhizophora apiculata, Aegiceras corniculatum, Avicennia marina and Bruguiera gymnorrhiza. dominated in Eastern Part of Segara Anakan Lagoon. The mangrove density (trees/ha) based on distribution of mangrove species

| Mangrove species       | Mangrove density (trees/ha) | Merbau | Rangsang | East SAL |
|------------------------|-----------------------------|--------|----------|----------|
| Aegiceras corniculatum | 0 – 11                      | 33 – 1471 | 33 – 984 |
| Avicennia alba         | 10 – 889                    | 82 – 331 |
| Avicennia marina       | 17 – 69                     | 67 – 876 |
| Barimgtonia sp         | 0 – 21                      |         |          |
| Bruguiera gymnorrhiza  | 33-68                       | 33 – 530 |
| Bruguiera praviflora   | 50 – 134                    | 20 – 114 | 0 – 67   |
| Bruguiera sexangula    | 0 – 2                       | 57 – 365 |
| Celedenderum inerme    | 0 – 7                       |         |          |
| Ceriops decandra       |                             | 80 – 402 |
| Ceriops tagal          | 0 – 29                      | 71 – 250 |
| Excoecaria aggalocha   | 50 – 294                    | 10 – 233 |
| Gurah (local name)     | 0 – 29                      |         |          |
| Heritiera liitoralis   | 0 – 10                      | 0 – 16  | 20 – 114 |
| Hibiscus tiliaceus     | 0 – 123                     |         |          |
| Lumnitzera floridum    | 0 – 4                       |         |          |
| Lumnitzera racemosa    | 0 – 5                       |         |          |
| Nypa frutican          | 0 – 19                      | 366 – 1951 |
| Pandanus tectorius     | 0 – 12                      |         |          |
| Rhizophora apiculata   | 155 – 1430                  | 286 – 1923 | 62 – 652 |
| Rhizophora mucronata   | 30 – 95                     | 30- 100 | 59 – 372 |
| Rhizophora sexangula   | 117 – 1209                  |         |          |
| Sonneratia alba        | 50- 127                     | 67 – 335 | 100 – 987 |
| Sonneratia caseolaris  | 10 – 34                     | 26 -90 |          |
| Terminalia cattapa     | 0 – 10                      |         |          |
| Tespia sp              | 0 – 19                      |         |          |
| Vegetasi rawa (local name) | 0 – 29                  |         |          |
| Xylocarpus granatum    | 10 – 236                    | 20- 267 | 33 – 363 |
| Xylocarpus mollucensis | 0 – 29                      | 0 – 33  |          |
| Average                | 10 – 145                    | 33 – 338 | 64 – 545 |

Table 2 also shows that the potency of mangrove density in these area are (1) Merbau Island has density between 10 – 145 trees/ha, (2) Rangsang Island has density between 33 – 338 trees/ha and (3) Eastern part of Segara Anakan Lagoon has bigger density than other
locations between 64 – 545 trees/ha. Different with [1] noted that in North Jakarta is only dominated by *Avicennia alba, Rhizophora apiculata, Rhizophora mucronata, Sonneratia alba* with density between 0 – 127 trees/ha.

The mangrove density has correlation with the landscaping of mangrove ecosystem based on coastal disaster reducing [2], carbon conservation [7], source apportionment of sedimentary hydrocarbon [19], lead pollution reducing [10]. The mangrove density provide important ecosystem services, play important roles in terrestrial and aquatic ecosystem [24] including c cycling and carbon stock.

Generally the mangrove densities had negative correlation with forest reduction i.e. activity of deforestation, land use, mangrove degradation, mangrove cutting and pollution [25]. The mangrove degradation and deforestation will give negative impacts that are intrusion [1], carbon emitter [7], sedimentation [5], climate change [25], surface wave propagation [26], water pollution [10; 19] and other coastal disaster [2].

The mangrove density is a key indicator to reach coastal sustainability, because mangroves are one of the most important ecosystems of coastal and marine areas [16] and as a type of vegetation to cover terrestrial and marine environment. [26]. Mangrove density also be important to support and associate with aquatic and terrestrial organisms [27].

### 3.2. Mangrove diversity

The mangrove diversity in Merbau Island, Rangsang Island and East Part of Segara Anakan Lagoon on Table 4 showed that the potential of heterogeneity on Rangsang similar with Merbau but is lower than Eastern part of Segara Anakan Lagoon. And not different with species richness showed that Merbau and Rangsang has species richness lower than E-SAL. [23] and [22] noted that the mangrove diversity based on heterogeneity index and species richness index had moderate and high index

| Location   | Heterogeneity | Species richness |
|------------|---------------|-----------------|
|            | Min | Max | Min  | Max  |
| Merbau     | 0.083 | 1.45 | 0.271 | 1.77 |
| Rangsang   | 0.396 | 1.28 | 0.424 | 1.60 |
| E-SAL      | 1.85  | 2.32 | 2.43  | 2.55 |
[28] also noted that the diversity index including in mangrove ecosystem has impact to develop mangrove restoration. The active planting of mangrove trees to rehabilitate coastal area need information of diversity index. This information’s are used to develop rehabilitation planning and to choice mangrove species [28]. And the diversity index also supports the increasing of mangrove productivity to cover organism’s productivity both of terrestrial organisms or aquatic organisms.

3.3. Potential of Water and Soil Water Quality

The potential of water and soil water quality in Merbau Island, Rangsang Island and East Part of Segara Anakan Lagoon on Table 5 showed mangrove condition. Table 4 showed that the soil water properties were 3.51 – 6.18 (soil pH), 0.11 – 0.28 % (soil N total), 14.29 – 26.24 ppm (soil P), 0.13 – 2.69 % (soil pyrite), 12.42 – 31.48 ppt (soil salinity), and water quality were 6.75 – 8.18 (water pH), 24.66 – 33.36°C (water temperature), 8.00 – 34.01 ppt (water salinity). The soil water properties also showed Merbau Island and Rangsang Island had pH and N total similar with E-SAL. And Merbau Island and Rangsang Island higher than E-SAL, but pyrite and water salinity lower than E-SAL. The potential of water quality showed that Rangsang and Merbau Island had temperature higher than E-SAL, and had salinity lower than E-SAL.

Table 4. Water and Soil Water Quality in Mangrove Ecosystem

| Location | Statistic item | Soil water | Water |
|----------|----------------|------------|-------|
|          |                | pH | N - Total (%) | P (ppm) | Pyrite (%) | Salinity (ppt) | pH | Temperature (°C) | Salinity (ppt) |
| Merbau   | Average        | 4.34 | 0.13 | 21.48 | 2.25 | 21.39 | 7.64 | 31.60 | 13.75 |
|          | STDEV          | 0.83 | 0.02 | 4.76 | 0.50 | 1.14 | 0.54 | 1.26 | 1.26 |
| Rangsang | Average        | 5.31 | 0.16 | 19.60 | 0.47 | 16.88 | 7.39 | 31.86 | 10.00 |
|          | STDEV          | 0.84 | 0.04 | 4.53 | 0.34 | 4.46 | 0.64 | 1.50 | 2.00 |
| E-SAL    | Average        | 6.04 | 0.25 | 16.30 | 2.10 | 27.80 | 6.89 | 25.80 | 32.50 |
|          | STDEV          | 0.15 | 0.03 | 2.01 | 0.59 | 3.68 | 0.13 | 1.14 | 1.51 |
| Merbau   | min            | 3.51 | 0.11 | 16.73 | 1.75 | 20.25 | 7.10 | 30.34 | 12.49 |
|          | max            | 5.17 | 0.15 | 26.24 | 2.76 | 22.53 | 8.18 | 32.86 | 15.01 |
| Rangsang | min            | 4.47 | 0.11 | 15.06 | 0.13 | 12.42 | 6.75 | 30.35 | 8.00 |
|          | max            | 6.16 | 0.20 | 24.13 | 0.82 | 21.34 | 8.02 | 33.36 | 12.00 |
| E-SAL    | min            | 5.89 | 0.22 | 14.29 | 1.50 | 24.12 | 6.76 | 24.66 | 30.99 |
|          | max            | 6.18 | 0.28 | 18.31 | 2.69 | 31.48 | 7.02 | 26.94 | 34.01 |
[29] note that the potential pH to support mangrove growth between 6 – 8.5. Potential pH is a main aspect to support aquatic organism and decomposer activity. The other aspect to support mangrove growth is salinity. The mangrove vegetation had good growth on salinity between 2 – 22 ppt (brackish water) and until 38 % (seawater) (30).

Pyrite is a disturbance aspect of mangrove growth has correlation with the potential of iron and sulfur. Pyrite become Fe and H2SO4 give negative impact and has toxic characteristic for mangrove growth [31]. Basically N-total and Phosphate have positive impact to support mangrove growth [32,35]. The score of N-Total and phosphate in E-SAL, Rangsang Island and Merbau Island have good class to support mangrove growth.

Water salinity gives effect on growth and nitrogen assimilation [33]. [33] also note that the reduction in the N assimilation rate base on the increasing salinity in mangrove could be due to decreasing activity of N-assimilation enzyme[34]. Whereas mangrove has good adaptation of water salinity because mangrove has activity to sequestrate, accumulate and exclude water salinity [1].

4. Conclusion

The species domination in Merbau Island are Rhizophora apiculata, Bruguiera praviflora, Xylocarpus granatum, Sonneratia alba. The species domination in Rangsang Island are Rhizophora apiculata, Aegiceras corniculatum, Avicennia alba, Sonneratia alba. Whereas as the species domination in E-SAL are Nypa frutican, Rhizophora apiculata, Rhizophora mucronata, Rhizophora sexangula, Sonneratia alba and Aegiceras corniculatum. The diversity indexes in these areas show that the heterogeneity index are 0.083 – 2.32 and the species richnes between 0.271 – 255. The diversity index of E-SAL is bigger than merbau and Rangsang Island.

The soil properties and water quality are 3.51 – 6.18 (soil pH), 0.11 – 0.28 % (soil N total), 14.29 – 26.24 ppm (soil P), 0.13 – 2.69 % (soil pyrite), 12.42 – 31.48 ppt (soil salinity), 6.75 – 8.18 (water pH), 24.66 – 33.36°C (weter temperature), 8.00 – 34.01 ppt (water salinity).
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