Species composition and structure of mangrove in Tamo Rocky Cliff Beach Majene (West Sulawesi, Indonesia)

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Abstract. West Sulawesi is locally well known for its rocky cliff beach along the coastline between Majene and Mamuju regency. Dato beach in Majene, for instance, is popular for tourism destination. In the area between Tamo, a small fisherman village and Dato can be found one rocky cliff beach with beautiful scenery. Cliff height varied between 5 m - 60 m. At the base of the rocky cliff stretched a fairly extensive mangrove which is separated from the cliff by the lagoon. This mangrove vegetation is thick, however, the species composition and structure remain unknown. Therefore, research is required to know the species composition and structure of the mangrove communities in the Tamo rocky cliff beach. The sampling method used purposive sampling with four transects. All transects are combined with nested quadrat. A series of quadrat size, which is 1 x 1 m, 5 x 5 m and 10 x 10 m were used for counting the densities of mangrove seedling, stake, and trees respectively. All transect was set up crossing the mangrove area and perpendicular to the coastline. The result showed that mangrove composition consists of five true mangrove species, such as *Avicennia marina*, *Bruguiera gymnorrhiza*, *Rhizophora mucronata*, *Rhizophora stylosa*, *Sonneratia alba* with various associated mangrove species. Diversity and Evenness index was extremely low. In contrast, Simpson and Similarity index was high. Composition and structure of mangrove vegetation in Tamo rocky cliff beach dominated by monoculture stake of *Rhizophora stylosa* which is an importance value (IV) range between 182.90% - 300%.

1. Introduction
Mangrove generally defined as woody vegetation in marine and brackish environment [1]. The term “mangrove” can also be used to describe the plants, community, and habitat where this plant occurs between highest and lowest tide level in the coastal area [2, 3]. Indonesia has one of the most extensive mangrove areas and most diverse mangrove species in the world. However, most of the mangrove forest has been cut down for construction material, charcoal, and fuelwood. A cleared mangrove area then converted into fish and shrimp pond [4, 5].

Mangrove plays an important role in protecting shorelines from waves, winds, and storms [1, 6, 7]. Mangrove also provides a suitable environment for sheltered, foraging for foods, mating, laying eggs, spawning and support complex ecosystem for terrestrial and marine living creatures [1, 8, 9]. Economically, mangrove provides fisheries, forestry, medicine, and tourism product [4, 12].
Unfortunately, the mangrove ecosystem throughout Indonesia nowadays is in critical condition with limited monitoring and assessment. Quality and performance of mangrove forest can be assessed from its composition and structure. Composition of mangrove described floristic richness of the community which is influenced by environmental factors, such as climate, sediment or substrate, and sunlight intensity [10]. The composition also provides information about species variation, population, and interaction among populations or communities in the forest [11].

Forest structure is a life form of vegetation with a complex character which can be used to determining vertical and horizontal forest stratification and become the basis for determination of dominant, codominant, and depressed species. Horizontal stratification in mangrove related to salinity, duration and frequency of seawater inundation, type of sediment, freshwater availability, distribution of seed, and waves. Vertical stratification related to the need and competition for sunlight. Both of stratification can be determined from the diameter of stem, height, and coverage of the canopy, distribution and diversity of species. The vegetation can be divided into three components, i.e: vertical structure (canopy), horizontal structure (distribution of species in a population) and quantitative structure (density of species in a community) [10].

Most of Indonesia’s mangrove is concentrated in the larger islands including Sumatera, Java, Borneo, Sulawesi, Moluccas, and Western Papua. However, mangrove in these islands has been degraded rapidly. At the beginning of the 20th century, mangrove could be found along the coast of the island of Sulawesi. However, in the last few decades, most of the forests have been converted into fish and shrimp pond. Fairly extensive mangrove can still be found in West Sulawesi [12].

West Sulawesi is locally well known for its rocky cliff beach along the coastline between Majene and Mamuju regency. Dato beach in Majene, for instance, is a popular destination for domestic and local tourism. In the area between Tamo, a small fisherman village and Dato can be found one rocky cliff beach with beautiful scenery (Figure 1). Cliff height varied between 5 m - 60 m. This place situated in Baurung Village, East Banggae sub-district, Majene Regency, West Sulawesi. Tamo beach is part of the Mandar bay. The rocky cliff originated from limestone and petrified sediment above the seafloor, which has been lifted by geological processes for millions of years ago. At the base of the rocky cliff stretched a fairly extensive mangrove which is separated from the cliff by the lagoon. This mangrove vegetation is thick, however, the species composition and structure remain unknown. Therefore, research is required to become important information in managing biological resources around the mangrove forest area. This research aims to know the species composition and structure of the mangrove communities in the Tamo rocky cliff beach.

2. Material and Methods
2.1. Preparation
Preparation included some activities, such as research permit, literature study and information gathering related to the topics, observation of the study site, material and tool preparation that will be used in the field.

2.2. Sampling Design
Study site consists of mangrove area in a rectangular shape with various widths. The mangrove area stretched 500 m length in the northwest-southeast direction to the mainland. The width near the southeast tip of mangrove area is 200 m and near the northwest tip is 100 m. Consequently, the length of each transect that we used in this study was different because it must be adjusted to the width of the mangrove area. Data were collected using purposive sampling method with combined transect and nested quadrat in a determined area. We use four transects which is set up crossing the mangrove area and perpendicular to the coastline. Each transect location was chosen specifically to represent the different of mangrove communities in the study site. Each transect divided into 5 sampling points with a similar distance. A series of quadrat size, which is 1 x 1 m, 5 x 5 m and 10 x 10 m were placed in each sampling point for counting the densities of mangrove seedling, stake and tree respectively. The
first transect was set up crossing mangrove area near Tamo village with length 200 m. The next second transect with similar length placed parallel with distance 50 m from the previous transect. Furthermore, the third transect placed 75 m parallel from the second transect with length 150 m. The last, fourth transect also placed 75 m parallel from the previous transect with 100 m in length.

2.3. Data Collection
The data in this study were collected using a vegetation analysis technique to determine the structure and species composition of the mangrove. The mangrove habitus grouped into three categories based on their life form that can be seen in Table 1.

| Life Form | Description |
|-----------|-------------|
| Seedling  | Started from the young plant with two leaves to the plants < 1.5 m height |
| Stake     | Shrub with 1.5 – 8 m height, has many stems near the base and diameter of stem < 10 cm |
| Tree      | Tree with a diameter of the stem at breast height > 10 cm Height > 5 m with single stem from the base |

Nested quadrat consists of different size of a subplot which is a small subplot were set up in the larger one. This subplot used to calculate the density of individual plants. Size of the subplot is shown in Table 2.

| Life Form | Subplot Size | Description |
|-----------|--------------|-------------|
| Seedling  | 2 x 2 m      | Used for the count the number of mangrove seedling in forest floor |
| Stake     | 5 x 5 m      | Used for the count the number of mangrove stake |
| Tree      | 10 x 10 m    | Used for the count the number of mangrove trees |

The stem diameter of every counted stake and tree inside the nested quadrat were measured at breast-high. However, the stem of seedling was not measured. Data recorded on the datasheet for further analysis. Visual observation was also conducted to get an overview of mangrove species composition, structure, and stratification.

3. Data Analysis
3.1. Importance Value (IV)
Importance value can describe the species composition and dominance level in mangrove community. Importance value can be obtained by summing relative density (RD), relative frequency (RF) and basal area (BA) of the mangrove.

\[
\text{Density (D) } = \frac{\text{Number of individuals of a species}}{\text{Subplot area}}
\]

where D denotes the density in individual/Ha units.

\[
\text{Relative Density (RD): } \frac{\text{Number of individuals of a species}}{\text{Number of individuals of all species}} \times 100\%
\]
Frequency (D): \( \frac{\text{Number of subplots contain a species}}{\text{Total Subplot}} \)

Relative Frequency (RF): \( \frac{\text{Frequency of a species}}{\text{Frequency of all species}} \times 100\% \)

Basal Area (BA): \( \frac{1}{4} \pi D^2 \)

where D denotes the diameter of stake and tree stem (cm) and BA denotes basal area (m²).

Dominance (DBA): \( \frac{\text{Basal area of a species}}{\text{Subplot area}} \)

where DBA denotes dominance (basal area) in m²/Ha unit.

Relative Dominance (RDBA): \( \frac{\text{Dominance of a species}}{\text{Dominance of all species}} \times 100\% \)

Importance Value (IV) for Seedling: \( RD + RF \)

Importance Value (IV) for Stake and Tree: \( RD + RF + RDBA \)

where IV denotes the Importance Value in %.

3.2. Diversity Index
Diversity Index was calculated using the Shannon-Wiener Diversity Index [13].

\[
\text{Diversity Index (H')}: - \sum_{i=1}^{s} p_i \ln(p_i); \quad p_i = \frac{n_i}{N} = \frac{n_i}{\sum_{i=1}^{s} n_i}
\]

where \( H' \) denotes diversity index, \( N \) denotes the total number of individuals of all mangrove species, \( n_i \) denotes the number of species to-i and \( s \) denotes total mangrove species. The diversity index (\( H' \)) consists of three different categories: if \( H' < 2 \) this means the diversity index is low if \( 2 < H' < 3 \) the diversity index is moderate and if \( H' > 3 \) showed high diversity index.

3.3. Evenness Index
This index describes the evenness of individuals per species which is stated with an equation:

\[
\text{Evenness Index (E)}: \frac{H'}{\ln(S)}
\]

Where E denotes evenness index, \( H' \) denotes diversity index and \( S \) denotes the number of species. The Evenness index (E) is between 0 - 1 divide in three different categories: if \( E < 0.3 \) this means the evenness is low if \( 0.3 < H' < 0.6 \) the evenness is moderate and if \( E > 0.6 \) showed high evenness of individuals in a population of a species.

3.4. Species Dominance Index
Dominance Index, which is also known as Simpson Index describes the domination of a species in the mangrove area. This dominance index stated in equation [14]:

\[
\text{Species Dominance Index (C)}: \sum_{i=1}^{n} \left( \frac{n_i}{N} \right)^2
\]

Where C denotes Species Dominance Index, \( n_i \) denotes density to-i and \( N \) denotes the total number of density. Species Dominance Index (c) is between 0-1 if \( C = 0 \) showed that domination of a species did
not exist in the community. On the contrary, if $C=1$ showed that mangrove community dominated by one species [14].

3.5. Similarity Index

Similarity Index describes the similarity of species composition between two different plant communities.

\[
\text{Similarity Index (IS): } \frac{2w}{a+b} \times 100\%
\]

Where IS denotes Similarity Index, $a$ denotes importance value of community $a$, $b$ denotes an importance value of community $b$, $w$ denotes the smallest importance value for the species which existed in both compared communities. Both communities considered similar if $IS \geq 75 \%$. All data were analyzed descriptively and presented in tables and figures.

4. Result and Discussion

Species composition and structure of mangrove

The result of the study shows that true mangrove species in Tamo Beach consist of five species with various associated mangrove as shown in Table 3.

| No. | Plant Species | Indonesian Name | Family          |
|-----|---------------|-----------------|-----------------|
| Mangrove                        |                |                 |                 |
| 1.  | *Avicennia marina*  | Api-API | Acanthaceae     |
| 2.  | *Bruguiera gymnorrhiza* | Putut | Rhizophoraceae  |
| 3.  | *Rhizophora mucronata* | Bakau | Rhizophoraceae  |
| 4.  | *Rhizophora stylosa*  | Bakau | Rhizophoraceae  |
| 5.  | *Sonneratia alba*    | Pedada, Perepat | Lythraceae      |
| Shrubs and Trees                  |                |                 |                 |
| 1.  | *Calophyllum inophyllum* | Bintangur, Nyamplung | Calophyllaceae |
| 2.  | *Thespesia populnea* | Waru Laut | Malvaceae       |
| 3.  | *Hibiscus tiliaceus* | Waru | Malvaceae       |
| 4.  | *Caesalpinia bonduc* | Bagore | Fabaceae        |
| 5.  | *Cocos nucifera*    | Kelapa | Areaceae        |
| 6.  | *Cycas circinnalis* | Pakis Haji | Cycadaceae     |
| 7.  | *Terminalia catappa* | Ketapang | Combretaceae |
| 8.  | *Pandanus tectorius* | Pandan | Pandanaceae     |
| 9.  | *Morinda citrifolia* | Mengkudu | Rubiaceae      |
| Herbs and Grasses                |                |                 |                 |
| 1.  | *Ipomoea pes-caprae* | Katang-Katang | Convolvulaceae |
| 2.  | *Melanthera biflora* | Seruni Laut | Asteraceae      |
| 3.  | *Thuarea involuta*  | Rimput | Poaceae         |
| 4.  | *Spinifex littoreus* | Rimput Angin | Poaceae         |
| 5.  | *Sesuvium portulacastrum* | Kroket | Aizoaceae       |
| 6.  | *Stachytarpheta jamaicensis* | Jarong | Verbenaceae     |
| 7.  | *Portulaca oleracea* | Kroket | Portulaceae     |

The first transect stretches for 200 meters, started from the outer side of the beach crossing the mangrove area to the cliff. Mangrove and cliff separated by a lagoon which gradually narrows before Tamo Village (Figure 2). Seedling and sapling of *Rhizophora stylosa* can be found at the outer side of the mangrove area (Figure 3).
Figure 1. Tamo beach scenery with lagoon and the mangrove (study site) from top of the rocky cliff.

Figure 2. Tamo beach with extensive mangrove stake (left), lagoon (center) and rocky cliff (right).

Figure 3. Seedling of *Rhizophora stylosa* in outer part of mangrove area (left-top), dense stake of *Rhizophora stylosa* at first transect (right-top), various associated mangrove grow on the cliff rock, which is dominated by cycads *Cycas circinnalis* and Screw Pine *Pandanus tectorius* (left-below) and trees of *Sonneratia alba* at the base of the cliff and lagoon side (right-below).
The first 100 m of the transect, vegetation dominated by inaccessible thick bushes stake of *Rhizophora stylosa* which is density 14.080 individual/Ha (Table 4). After 100 meters, the density of *Rhizophora stylosa* decrease and sparse, the size of stake become larger and taller and the species composition gradually replaced with stake and tree of *Sonneratia alba* which is density 480 individual/Ha and 620 individual/Ha respectively (Table 4). The most common and widespread species of mangrove in Indonesia, *Rhizophora mucronata* is rare with stake density only 240 individual/Ha. The tree of *Sonneratia alba* mostly concentrated along the lagoon side (Figure 2).

The second transect has a similar length to the foregoing, placed after replanting seedling and stapling of *Rhizophora stylosa*. Half of the initial part of the transect was also dominated by the stake of *Rhizophora stylosa* which is density 5.920 individual/Ha (Table 4). The density is lower compared to the previous transect. Consequently, the stands become sparse, provide more space, sunlight and reduce the level of competition among stands. The stands of stake growing bigger with the basal area 2.414.78 m²/Ha compared to 1.599.97 m²/Ha from the previous transect. More space also gives a chance for the seedling of *Rhizophora stylosa* to grow, which is density 11.500 individual/Ha. This seedling is absent from the first transect because the stands of stake is very dense (Figure 3). In the next 100 m, vegetation is more diverse, sparse and bigger. The density of the *Sonneratia alba* tree was only 100 individual/Ha lower than the previous transect. The vegetation in this area dominated by seedling of *Sonneratia alba* (3.500 individual/Ha) which is absent in first transect (Table 4).

| Transect | Mangrove Species     | Density (ind/Ha) | F    | C        | Dominance (m²/Ha) | Importance Value |
|----------|----------------------|------------------|------|----------|-------------------|-----------------|
| 1        | *Rhizophora stylosa* (stake) | 14.080           | 0.8  | 0.9051   | 1.599.97         | 182.90          |
|          | *R. mucronata* (stake)    | 240              | 0.2  | 0.0003   | 1.015.03         | 55.33           |
|          | *Sonneratia alba* (stake) | 480              | 0.4  | 0.0011   | 2.610.70         | 81.77           |
|          | *Sonneratia alba* (tree)   | 620              | 0.5   | 1.0000   | 1.621.02         | 300.00          |
| 2        | *R. stylosa* (seedling)    | 11.500           | 0.2   | 0.5878   | -                 | 126.67          |
|          | *Rhizophora stylosa* (stake) | 5.920           | 1.0   | 1.0000   | 2414.78          | 300             |
|          | *Sonneratia alba* (seedling) | 3.500          | 0.2   | 0.0545   | -                 | 73.33           |
|          | *Sonneratia alba* (tree)   | 100              | 0.6   | 1.0000   | 1872.61          | 300             |
| 3        | *Rhizophora stylosa* (stake) | 12.880          | 1.0   | 1.0000   | 2547.77          | 300             |
| 4        | *Rhizophora stylosa* (stake) | 10.080          | 1.0   | 1.0000   | 2522.81          | 300             |

The third and fourth transect has 150 m and 100 m in length respectively. Both transects have a similar species composition and structure which is only dominated by the stake of *Rhizophora stylosa*. The stake formed very dense and tight pure stands with density 12.880 individual/Ha and 10.080 individual/Ha respectively. Some stands of stake near the end of both transect have very slim and tall structure. This is caused by local people which has been slashed the branches of this mangrove regularly to collect the leaves as fodder for their raised goat.

All of the transect come to an end in the lagoon which separated the mangrove area from the rocky cliff. This rocky cliff originated from limestone and petrified sandy sediment, stretched along the coastline between Dato and Tamo beach with height ranges between 5 to 60 m. The beach formed complex ecosystems because combined rocky cliff with coarse-sandy and terrigenous mudflats, vast reef flat, mangrove, seagrass bed, and coral reef. This habitat formed unique species composition when rocky cliff typical species encounter with mangrove species. Numerous of Cycads *Cycas circinnalis* a rare, wild and high valued ornamental plant was founded on this beach (Figure 3).

Vegetation at the base of rocky cliff dominated by large trees of *Sonneratia alba* and *Pandanus tectorius* (Figure 3). In the vicinity of the roots, *Sonneratia alba* grows shoots forming unusual life form with thick bushes spread follow the surface level of the water. This mangrove will distribute vegetatively and not forming pneumatophores roots if the substrate dominated by rock or corals (Figure 3) [8].
Mangrove forest in Indonesia mostly occurs alongside the river, delta, estuaries, bays, sandy beach, muddy beach and rocky beach [1, 12]. Mangrove communities which grow in a shallow reef flat around rocky cliffs similar to Tamo beach in Majene are uncommon in Indonesia.

Based on 100-200 m perpendicular transect, the result shows that the horizontal structure of mangrove in Tamo beach formed simple zonation with first 100 m to 150 m from shoreline dominated by very dense stake of *Rhizophora stylosa* then continued with *Sonneratia alba* and less stands of *Avicennia marina*, *Bruguiera gymnorrhiza*, *Rhizophora mucronata* and other coastal plants. Most of this mix mangrove species grow along the lagoon side.

Horizontal mangrove structure can be grouped into four communities: open mangrove, which is the outer part of mangrove forest that directly encounter with the sea, such as: *Rhizophora stylosa*, *Sonneratia alba*, *Avicennia alba* and *A. marina*; middle mangrove, consist of species that grow behind the open mangrove zone i.e: *Rhizophora mucronata*, *R. apiculata*, *Bruguiera gymnorrhiza* and *Xylocarpus granatum*; brackish mangrove, mostly grow along the riverside or estuary with more freshwater input, consists of *Sonneratia alba*, *Sonneratia caseolaris*, *Rhizophora mucronata*, *Rhizophora apiculata* and *Nypa fruticans*; terrestrial mangrove, the most diverse zone consist of *Lumnitzera racemosa*, *Pandanus sp.*, *Xylocarpus moluccensis* and other associated mangrove species [12]. Zonation of mangrove in Tamo beach consists of only two communities, open mangrove continued with terrestrial mangrove. Lack of river, freshwater and terrigenous sediment input along the beach caused middle mangrove and brackish mangrove communities do not exist.

Based on Specht’s structural categories [15], mangrove in Tamo beach were categorized as closed scrub communities with height ranges between 2-8 m, foliage cover dense (70-100%) and dominated with shrubs habitus or stake life form. Furthermore, based on Lugo and Snedaker’s physiographies and structural classifications [15], mangrove communities in Tamo beach was categorized as overwash mangrove forests which are characterized by the existence of waters in the windward (sea) and leeward side (lagoon) and inundated at high tide that causes much of organic matter washed away. The surface sediment of the lagoon in Tamo beach consists of rubble and coarse sand. Subsequently, based on Galloway’s geomorphological settings [15], mangrove in Tamo beach was categorized as barriers and lagoon mangrove which is characterized by higher wave energy at windward side and relatively low amount of water discharges. If terrigenous sediment from land is available, it will be accumulated in a sheltered area around the lagoon where extensive mangrove will grow in the vicinity.

**Dominance**

Seedling of *Rhizophora stylosa* and *Sonneratia alba* were found only in the second transect in the vicinity of the lagoon. Both seedlings have Simpson dominance Index 0.59 and 0.05 respectively (Table 4). This shows that seedling of mangrove in Tamo beach was dominated by *Rhizophora stylosa*. Stake category in all transect also dominated by *Rhizophora stylosa* with Simpson Index ranges from 0.9 to 1.0 (Table 4). *Sonneratia alba* is the only species in transect that grown in tree habitus. Therefore, *Rhizophora stylosa* has the highest influenced in mangrove community.

Domination of the mangrove community by only one mangrove species, mostly occur in mangrove rehabilitation area which used the monoculture system. This mangrove community characterized by very dense stake or trees with uniform structures. Various densities of *Rhizophora mucronata* from several mangrove rehabilitation areas was found in East Sinjai [16]. In the Tongke-Tongke, the average density of *Rhizophora mucronata* tree is reported to be 14,800 individual/Ha, Lappa (18,800 individual/Ha), Panaikang (19,600 individual/Ha) and Samatarring (24,400 individual/Ha) [16]. Local residents in east Sinjai use small distance planting (50 cm x 50 cm) to create very dense *Rhizophora mucronata* vegetation in order to protect the beach from strong waves and provide tree that economies can be harvested as fuelwood [16]. Furthermore, mangrove rehabilitation area in Tiwoho, a small village which is part of Bunaken National Park in North Sulawesi were dominated by *Ceriops tagal* trees with average density 1753.25 individual/Ha [17].

Conversely, the natural mangrove community is more diverse with the lower density of the tree compared to the rehabilitation mangrove area. Domination usually formed by more than one mangrove species. For instance, natural mangrove in Panikiang Island, South Sulawesi consists of 29 species
with 17 true mangroves species and 12 associated mangroves species [18]. The trees were dominated by *Rhizophora stylosa* with average density 425.5 individual/Ha, followed by *Rhizophora apiculata* (270 individual/Ha), *Bruguiera gymnorrhiza* (150 individual/Ha) and *Sonneratia alba* (130 individual/Ha) [18]. Natural mangrove in Kalimantan was also shown higher density in every stage or life form compared to monoculture mangrove. The density for *Rhizophora mucronata* in estuary and riverside of Serakaman, Sebuku Island, South Kalimantan reported 18.750 individual/Ha for seedling, 2.900 individual/Ha for stake and 425 individual/Ha for the tree [19].

**Importance Value**

The result shows that seedling of *Rhizophora stylosa*, and *Sonneratia alba* has importance value 126.67 % and 73.33 % respectively. The most dominant stakes was found in *Rhizophora stylosa* with an importance value between 182.90 % - 300 %. The stake dominated second, third and fourth transect with each importance value reach 300%. This shows that *Rhizophora stylosa* dominated space for growing, light, organic matter and all resources in Tamo beach.

The tree habitus was only founded in *Sonneratia alba* which is importance value 300% in first and second transect (Table 4). *Sonneratia alba* is a pioneer mangrove species which is not tolerant with freshwater in a long period of inundation. These species prefers to grow in sheltered areas with mixed sediment consist of mud and sand or rocky substrate [12].

**Diversity and Evenness**

Diversity and evenness index of mangrove communities in Tamo beach was extremely low (Table 5). This is showing that the composition of mangrove consists of fewer species with not evenly distributed. Open mangrove known for its very dynamic environmental change was not suitable for most mangrove species to grow. All of the mangrove area overgrown with stake of *Rhizophora stylosa*. This species reported growing well in a harsh environment with high salinity (55 per mil), hard substrate and long duration of inundation. *Rhizophora stylosa* grow in varied substrates such as sands, mud, rocks, and coral debris that mix with the fragment of calcareous algae [12].

Other habitus/life form i.e: seedling, stapling and tree are mostly absent from the study site. The very dense population of *Rhizophora stylosa* created a dense canopy that blocking sunlight from reaching the ground. Based on light requirements, mangrove divided into two groups [15]. The first group is mangrove that still grows in shady environments such as Aegiceras, Bruguiera, Ceriops, Excoecaria, Osbornia, and Xylocarpus. The second group is those species which are intolerant with shade environment, i.e: Acanthus, Aegialitis, Lumnitzera, Rhizophora, Scyphiphora, Acrostichum and Sonneratia. Avicennia seedling also not tolerant with shade, but the adult tree can grow in shading environment.

| Transect | Diversity | Evenness |
|----------|-----------|----------|
| 1        | 0.27      | 0.05     |
| 2        | 0.27      | 0.05     |
| 3        | -         | -        |
| 4        | -         | -        |

*Rhizophora mucronata* prefer to grow in an area with more freshwater supply such as riverside, river delta, and estuary with deep muddy substrate, rich organic material and a long period of inundation [8, 9, 12]. This explained why *Rhizophora mucronata*, one of the most common mangrove species in Indonesia is rare in the study site. Other species, *Rhizophora apiculata* were completely absent from Tamo beach.
Similarity

The results showed that all of the transects has similar species composition and structure except for first transect (Table 6). Species of mangrove will grow well in their suitable habitat with optimal environmental factors [15]. The first transect which is situated near Tamo village has deeper mud layer compared to another transect. The muddy layer tends to be decreased along with increasing transect distance from Tamo village. Domestic waste from Tamo village might be contributed more inputs of organic matter in the vicinity of the first transect. Deeper mud layer and more organic matter will support more species of mangrove to grow. In contrast, harsh environment with less organic matter, a rocky substrate with higher the energy of the wave, especially in third and fourth transect will support only one or two adaptable species that dominated most of the area.

Table 6. The similarity of mangrove communities (%).

| Study Site | Transect 1 | Transect 2 | Transect 3 | Transect 4 |
|------------|------------|------------|------------|------------|
| Transect 1  | -          | 60.97      | 60.97      | 60.97      |
| Transect 2  | -          | -          | 100        | 100        |
| Transect 3  | -          | -          | -          | 100        |
| Transect 4  | -          | -          | -          | -          |

The dense stands, uniformity in structure and extensive mangrove consist of only one species, mostly occurs in the monoculture mangrove area. This is can be found in several mangrove rehabilitation areas in Sulawesi, such as Tongke-Tongke in Sinjai Regency and Tanakeke islands in Takalar Regency [4], both in South Sulawesi and Tiwoho mangrove forest in North Minahasa, North Sulawesi [17]. Most of the mangrove independently planted by surrounding residents. The mangrove seeds (propagules) planted at a close distance to produce more mangrove stems [4, 17]. Similar mangrove characteristics and structure were also occurring on Tamo beach. The dense and uniform distance stands of mangrove in Tamo beach showed that extensive stake of *Rhizophora stylosa* come from planting activities that carried out by local residents for many years. Consequently, the composition and structure of natural mangrove have been changed with remaining native mangrove species can be found only at the base of a rocky cliff and along the lagoon side.

5. Conclusion

Based on the result of research, it can be concluded that the composition of mangrove species in Tamo beach consists of five true mangrove species, such as *Avicennina marina*, *Bruguiera gymnorrhiza*, *Rhizophora mucronata*, *Rhizophora stylosa* and *Sonneratia alba* with various associated mangrove. Diversity and Evenness index was extremely low. In contrast, Simpson and Similarity index was high. Composition and structure of mangrove vegetation in Tamo beach were dominated by monoculture stake of *Rhizophora stylosa* which is an importance value (IV) range between 182.90% -300%.

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