Coastal resources degradation in Tangerang, Banten Province: State and management action

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Abstract. Coastal degradation can be determined as mangrove destruction and water quality degradation. Erosion and accretion are the impacts of mangrove destruction in coastal areas. Ecosystem condition and coastal environment destruction were analyzed in Tangerang coastal areas. Soil, mangrove vegetation, and water quality analysis were carried out in this study. Soil quality was analyzed descriptively. Mangrove vegetation and water quality were analyzed with the Important Value Index and STORET Index, respectively. The results indicated that the coastal of Tangerang is damaged both in terms of mangrove and water quality. The causal analysis showed that the damage to the coastal environment in Tangerang is largely influenced by the high amount of plastic, domestic, and industrial waste. Management recommendations that can be carried out on the coast of Tangerang are silvofishery management and mangrove planting right behind the wave breaker.

Keywords: coastal ecosystem; degradation; mangrove

1. Introduction

Indonesia's coastal area has a potential resource of the most significant revenue source for local areas and the nation. Indeed, the local area intensively utilizes the coast for human activities such as the government center, housings, harbor industries, aquaculture, and tourism. It affects the increasing need for lands and other infrastructures, emerging new problems in the coast area, e.g., beach erosion, sedimentation causing the advancement of coastline, land subsidence, and seawater intrusion. These conditions occur in the coastal area of the Tangerang Regency. The pollution status assignment is an initial step to monitor and overcome the coast water quality degradation [1].

Over the last decade, the coastal resource damage rate in the Tangerang Regency has reached a worrisome condition [2]. Mangrove growth's death is generally caused by natural and anthropogenic factors. A natural factor causing this condition is erosion. Changes in the mangrove area will influence the mangrove area zoning [3]. On average, a damaged mangrove condition is due to an increase in...
human needs and industrial progress, which have experienced land conversion for aquaculture and industrial development areas [4]. Anthropogenic activities, such as industrial activities surrounding the mangrove area and watershed upstream, may damage mangroves in Tangerang. Tangerang Regency is the buffer zone of Jakarta Capital City affected by extensive urbanization [5]. Wastewater discharged from industrial activities, especially those containing heavy metals, reduces the water quality flowing downstream [6-8]. Furthermore, habitat damage may be caused by reclamation activities of mangrove area change for houings, shrimp farms, and harbors. Hydrological pattern change can also disrupt the balance between freshwater and seawater distribution [9].

Erosion occurring on the northern coast of The Tangerang Regency harms unanticipated area development in the past. Abrasion along the coastline poses disadvantages such as land area decrease and threats to population settlement and activities [10]. Land use in The Tangerang Regency is uncontrolled, where the land use as fish farming is bigger than mangrove areas. It causes the coastline to be prone to waves from the sea, increasing the abrasion rate. Therefore, integrated coastal management should focus on maintaining coastal sustainability and providing benefits for coastal communities [11]. This condition can be achieved by implementing planned area development principles. Meanwhile, integrated management can only be achieved upon accurate and complete information regarding the coast and ocean conditions, e.g., potentials, resource conditions, socio-economic activities in the coastal area, and institutional and stakeholder aspects in the coast and ocean area management. Thus, it is necessary to conduct a study to discover the coast damage status in The Tangerang Regency and provide appropriate management recommendations.

2. Materials and method
The study was carried out in coastal villages of The Tangerang Regency, Banten. The sampling site was located in the mangrove area, rivers, and estuaries passing coastal villages in Kronjo, Kemiri, Mauk, Paku Haji, Kosambi, and Teluk Naga Districts (figure 1). Primary data sampling was conducted for one week from 13-18 June 2019.

The soil data collection was carried out using the survey method. The soil sampling in the sample site was taken with soil depths between 0-30 cm. Qualitatively, identifying pyrite content in soils could be performed by spraying peroxide (H2O2) to soil samples. Soils containing pyrite will foam, and the number of foam demonstrates the pyrite concentration. The measurement method used to understand mangrove conditions was the Line Transect Plot method. The Line Transect Plot is a sampling method of an ecosystem by approaching the sample plot and drawn across the ecosystem area. This measurement method is the most common with high levels of accuracy. River water samples were taken in a depth of half from the water depth, while estuary water samples were taken in depths of 1-2 meters from the surface. The water quality data collection was conducted using a multifunctional water quality measuring tool/multitester.

The method employed in the study was the survey method. Data collected were primary and secondary data, i.e., soil quality, water quality (physical and chemical), and mangrove vegetation analysis results. Secondary data used were the monitoring results of water quality conducted by the Marine and Fisheries Office of Tangerang Regency.

The vegetation analysis was carried out by determining the Importance Value Index (IVI) of understories (non-wood) and saplings and determining the IVI of young and mature trees. The degradation level of mangrove forests was analyzed by standard criteria of mangrove destruction according to Ministerial Decree of State Minister for The Environment (Kepmen. LH) No. 201 in 2004 [12]. The following table is the standard criteria of mangrove degradation (table 1). Meanwhile, the water quality status analysis was performed by calculating the STORET Index based on Regulation of Environment Minister Number 115 of 2001 [13]. According to Barokah et al. [14], the STORET Index calculation is recommended to use for the assessment of pollution status in a watershed due to the sensitivity of the method analysis.
Figure 1. Map of research locations for coastal villages in Tangerang Regency.

Table 1. Standard criteria of mangrove destruction.

| Degradation class | Density criteria | Mangrove coverage | Mangrove density level (trees/ha) |
|-------------------|------------------|-------------------|----------------------------------|
| No degradation    | Dense            | ≥ 75              | ≥ 1500                           |
|                   | Moderate         | ≥ 50 - ≥ 75       | ≥ 1000 - < 1500                  |
| Degradation       | Rare             | < 50              | < 1000                           |

3. Results

Figure 2 illustrates that the mangrove ecosystem observation in the Kronjo District discovered tree categories of *Rhizophora stylosa*, *Avicennia marina*, and *Excoecaria agallocha*. Field observations and data analyses obtained the number of tree stands of 250 ind/ha, and therefore, based on the Regulation of Environment Minister Number 201 of 2004 [12], mangroves in the Kronjo District were degraded.

Observation results in the Kemiri District revealed that the mangrove ecosystem consisted of seedlings and saplings, i.e., *A. marina*. The survey results did not discover the tree category. Field observations and data analyses obtained the number of seedling stands of 5000 ind/ha while sapling stands were 1500 ind/ha. Mangroves in the Kemiri District were categorized as damaged.

Observation results in the Mauk District showed that the mangrove ecosystem found were seedlings and saplings, i.e., the *A. marina*. Field observations and data analyses obtained the number of seedling stands of 6785 ind/ha and sapling stands of 3200 ind/ha. In this area, the tree density was 516 ind/ha, so that mangroves in the Mauk District were categorized as damaged.

Observation results in the Paku Haji District showed that the mangrove ecosystem found were seedlings and saplings, i.e., the *A. marina*. The survey results did not discover seedling and sapling
categories. Field observations and data analyses obtained the number of tree stands of 833 ind/ha. Mangroves in the Paku Haji District were categorized as damaged. Based on the pyrite content analysis results, data demonstrated that all soils in the study site of Kronjo, Kemiri, Mauk, Paku Haji, Kosambi, and Teluk Naga Districts were exposed to pyrite (figure 3).

Figure 2. The mangrove ecosystem conditions in Tangerang Regency.

Figure 3. The soil exposed to pyrite gave off thick foam and the death of mangrove trees at the site.

The STORET Index value showed that the coastal water of the Tangerang Regency from 2015 to 2019 was polluted (figure 4). It was only in 2016 that the pollution status slightly declined to the moderately polluted level. Meanwhile, the status was heavily polluted level on other years. The polluted water condition was caused by parameters not following the standard quality. These water quality parameters that did not follow the standard quality were sourced from human activity wastes.

Figure 5 shows red dots indicating heavily polluted waters and yellow dots indicating moderately polluted waters. In 2019, moderately polluted areas were in the southern Tangerang Regency area. Meanwhile, other Tangerang Regency areas were heavily polluted. Moderately polluted villages were
Pagedangan Ilir, Mauk, Kronjo, and Patra Manggala, while heavily polluted villages were Ketapang, Margamulya, Karangserang, Kohod, Muara, and Dadap. If it were mapped from 2015-2019, the profile would appear in Figure 6, where yellow dots indicating moderate pollution appeared and distributed in the eastern Tangerang Regency area. It shows that before 2019, water conditions in the Tangerang Regency were better than in 2019.

**Figure 4.** STORET Index results in Tangerang Regency for 2015 – 2019 (according to quality standard: score 0; lightly polluted: score (-1) – (-10); moderately polluted: score (-11) – (-30); heavily polluted: score (> -30).

**Figure 5.** STORET Index mapping in Tangerang Regency (2019).
Figure 6. STORET Index mapping in Tangerang Regency (2015-2019).

Soil quality data, water quality data, and mangrove vegetation density analysis demonstrated that the northern Tangerang Regency coastal area was damaged. Based on table 2, mangrove ecosystem conditions in the northern Tangerang Regency coastal area were damaged, primarily in five study sites. Soils and water were polluted. The water quality observation resulted in existing conditions was only performed in the dry season. Therefore, a further study conducted in the rainy season is necessary so that the management to improve water quality damage can be carried out maximally and overall to all conditions.

Table 2. Existing conditions of environmental quality in the Tangerang Regency coastal area.

| No. | Study Site          | Mangrove ecosystem | Water quality | Soil quality       |
|-----|---------------------|---------------------|---------------|--------------------|
| 1   | Kronjo District     | Damaged             | Polluted      | Pyrite-exposed     |
| 2   | Kemiri District     | Damaged             | Polluted      | Pyrite-exposed     |
| 3   | Mauk District       | Damaged             | Polluted      | Pyrite-exposed     |
| 4   | Paku Haji District  | Damaged             | Polluted      | Pyrite-exposed     |
| 5   | Teluk Naga District | Damaged             | Polluted      | Pyrite-exposed     |

The environmental conditions of the Tangerang Regency coastal area were moderately and heavily damaged for the ecosystem and water quality. The following are the causal analysis results of coastal ecosystem damage in the Tangerang Regency (table 3).
## Table 3. Existing conditions of environmental quality in the Tangerang Regency coastal area.

| No | Environment               | Existing Condition          | Cause                                                                 | Result                                                                 |
|----|---------------------------|----------------------------|----------------------------------------------------------------------|------------------------------------------------------------------------|
| 1  | Mangrove ecosystem        | Moderately to heavily damaged | ▪ Reclamation for houses and other buildings  
▪ Pond opening  
▪ Solid and liquid waste disposal | ▪ Reduced fish production  
▪ Water quality gets polluted more quickly  
▪ Silting drains  
▪ Erosion |
| 2  | River water               | Heavily polluted           | ▪ Industrial wastes  
▪ Domestic wastes  
▪ Municipal wastes  
▪ Agricultural and farming wastes  
▪ Minimum WTP (Water Treatment Plant) | ▪ Polluted river water; hence, eliminating river services  
▪ River aesthetic values  
▪ Accumulation of pollutants in the river, causing:  
▪ Poisoning of river biota  
▪ Depletion of water oxygen causing mass fish deaths  
▪ Bioaccumulation of heavy metals in river fish  
▪ Silting rivers  
▪ E-coli transmission  
▪ Polluted seawater  
▪ Elimination of coastal and beach aesthetic values  
▪ Turbid and stinky water  
▪ Accumulation of pollutants, causing:  
▪ Blooming algae  
▪ Poisoning of biota  
▪ Depletion of water oxygen causing mass fish deaths  
▪ Bioaccumulation of heavy metals in fish  
▪ Silting rivers  
▪ Land expansion  |
| 3  | Estuary                   | Moderately and heavily polluted | ▪ Land-based material loads carried by the river flow  
▪ The causal activities are the same as river pollution | |
| 4  | Water in the coastal area | Moderately and heavily polluted | ▪ Material loads from rivers  
▪ Activities in the coastal area, such as household and industrial wastes  
▪ Waste disposal in the coastal area  
▪ Coastal tourism | ▪ Water in the coastal area gets polluted; hence, eliminating the environmental services (tourism, cultivation, etc.)  
▪ Elimination of coastal and beach aesthetic values  
▪ Turbid and stinky water  
▪ Accumulation of pollutants, causing:  
▪ Blooming algae  
▪ Poisoning of biota  
▪ Depletion of water oxygen causing mass fish deaths  
▪ E-coli transmission |
4. Discussion
Soils in the Tangerang Regency coastal area were problematic due to high exposure to pyrite (FeS\textsubscript{2}). If the pyrite layer is exposed to the air, it allows reactions that form sulfuric acid and iron oxides toxic to plants. It increases \(H^+\), \(Al^{3+}\), \(Fe^{3+}\), and \(Mn^{4+}\), followed by the low concentration of available-\textit{P} and basic saturation [15]. The increasing number of Tangerang Regency population increases anthropogenic activities. It increases the number of wastes discharged into the waters, both organic and inorganic waste [16]. Moreover, the minimum WTP applied by industries in the Tangerang Regency was another reason for water quality degradation.

The STORET index value indicating heavy pollution was caused by water quality parameters that did not follow the standard quality, i.e., TDS (Total Dissolved Solids) and DO (Dissolved Oxygen) according to Government Regulation Number 82 of 2001 [17]. Industrial wastes and tourism activities were other causes of high TDS concentration generated. Tangerang Regency, with various tourism destinations, contributes a substantial number of wastes to the waters. According to Retnosari and Shovitri [18], TDS is the number of dissolved solids sized ≤ 1 μm, where TDS value increase indicates that organic wastes have not been completely degraded into gas. According to Amarasinghe and Balasubramanian [19], mangrove litters are the biggest degradable organic matter in waters. Mangrove litters are mainly sourced from mangrove leaves, twigs, and trunks. These components contain proteins and carbohydrates easily degraded by degrading microorganisms. This statement is supported by the measured water parameter condition in the study, particularly DO. Most DO that measured in the study site was < 5 mg/L. It indicates that the oxygen need of degrading microorganisms in degrading organic matter was relatively high.

Dense activities performed in the Tangerang Regency caused pollution conditions never to decrease, and even tend to increase. When tracking the Tangerang Regency rivers, many rivers were surrounded by houses and utilized to wash laundry, domestic activities, and garbage dump. It increases the pollution concentration entering the waters [20]. River conditions in the Tangerang Regency mostly did not follow the standard quality, especially for the aquatic biota. Water conditions that tend to be dirty, turbid, shallow, and nearly have no flows eliminate the river recovery process. It affects the oxygen concentration that continues to decrease and reduces the aesthetic value of waters.

The dominant mangrove vegetations growing alongside the coastal area were the \textit{Rhizophora mucronata} and \textit{A. marina}. \textit{A. marina} mangrove is the most commonly discovered type. It is the pioneer type, that is, the first type that grows in empty lands, such as former pond lands. The abundance of \textit{A. marina} in the northern Tangerang Regency coastal area shows that the area was damaged and strived to recover through a vegetation succession process [21].

Coastal waters in the Tangerang Regency received many pollution inputs, both organic and inorganic, from various river flows to the estuary. In this case, sustainable management is necessary to be applied from upstream to downstream areas. The upstream management is preventive measures such as eliminating the habit of throwing garbage or waste into the river. Then, land use management in watersheds in the Tangerang Regency is required. Meanwhile, the downstream management is excellent WTP implementation by various industrial sectors so that wastes discharged into the waters follow the standard quality. Attempts such as community service to clean rivers every week can also be implemented to reduce Tangerang Regency waters' pollution level.

The ponds' water quality suggested that the suitability level was nearly suitable to a relatively suitable range. Relatively suitable indicates that ponds have fulfilled the minimum water quality requirements, while nearly suitable means that ponds have limiting factors and require special treatments. In this case, the limiting parameter was dissolved oxygen (DO) concentration [22]. The management to increase pond suitability level is pinwheel addition in ponds to create an oxygen circulation process. Furthermore, pond aeration can also be applied to increase the oxygen concentration in waters.

Given the importance of economic and ecological values on mangrove forests, it is necessary to have integrated mangrove ecosystem management and conservation [23]. Optimal achievement on the applied management can be performed by taking mitigation efforts in the site that becomes the major
rehabilitation attention. It has to be based on several things, such as identifying supporting and unsupporting factors for mangrove planting, determining locations, techniques, and planting methods.

The appropriate mangrove forest management is the silvofishery model [24]. It is supported Ministerial Decree of State Minister for Marine Affairs and Fisheries (Kepmen. KP) No. 28 in 2004 [25] concerning Pond Area Management, which states that ponds in the mangrove forest area should consider these things: 1) Replanting mangrove forests in areas around the ponds that are no longer productive. 2) Optimizing pond productivity with environmentally-friendly technologies. 3) Performing silvofishery or poly-cultivation (shrimps, milkfish, or seaweeds). This ditch pond model is an integrated model between mangrove plantation as the buffer zone in the pond area, where a 20% minimum ratio of the land area is used for ponds, and the rest (a maximum of 80% ratio) is planted with mangroves. The area comparison between mangrove stands and ponds is 4:1. The planting is performed at a distance of 5 x 2 meters. Vegetation types planted are Sonneratia sp., Lumnitzera sp., Rhizophora sp., Bruguiera sp., Ceriops sp., Avicennia sp., and Xylocarpus sp. This model requires community participation as the pond actor to commit to the implementation. Moreover, other attempts are the importance analysis of Wave Breaker and the assignment of the most optimum location/position to plant seeds to obtain the best mangrove growth opportunity.

5. Conclusion

The dominant mangrove type in all locations was the A. marina, the pioneer of the mangrove ecosystem. Mangroves in the Tangerang Regency coastal area were damaged and under the succession process (recovery). The water quality in all study sites was polluted, and the soil quality in all study sites was pyrite-exposed. It shows that the Tangerang Regency coastal area condition was damaged. Management recommendations for the Tangerang Regency coastal area are silvofishery management and a mangrove planting plan right behind the Wave Breaker.

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