Water Quality Evaluation of Some Beach With Variations of Human Activities and Land Use in Spermonde Archipelago of Makassar South Sulawesi

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Abstract. Spermonde Archipelago, Makassar South Sulawesi consists of hundreds of small islands with varied land uses and human activities. This will have an impact on decreasing the quality of coastal waters. The purpose of this study was to analyze the relationship between land use and human activities with water quality on the coast around the island. The study was carried out on five islands in the Makassar Spermonde Archipelago of South Sulawesi (Barrangcaddi, Badi, Baranglompo, Bonebatang and Kodingarengkeke Island). Water quality was measured included pH, DO, salinity, turbidity, BOD, nitrate, TP, H₂S, oil and grease, and Pb. The coastal water quality observation of each island was carried out in 1-3 stations depending on the size of the island. Repetition of water quality measurements for each station 3 times. Observation of land use and human activities in the study area using the environmental services indices (Hemeroby and Naturalness). The results showed pH (7.99-8.39), turbidity (0.6-1.3 NTU), total phosphate (<0.010 mg/L), H₂S (<0.01 mg/L), oil and fat (<0.1 mg/L), and Pb (<0.005 mg/L) still met quality standards of seawater based on Decree of the State Minister for Environment No. 51/2004 for marine biota. DO Levels of Baranglompo and Badi islands (6.1-7.7 mg/L) have met seawater quality standards for marine biota which require DO levels to be more than 5 mg/L. DO levels of water on the other coast of the island 4.6-4.9 mg/L. Water salinity in all water have range 29-30‰. BOD levels (25.4-29.8 mg/L) and nitrate (0.03-0.17 mg/L) have exceeded seawater quality standards for marine biota (20 mg/L for BOD and 0.008 mg/L for nitrates). Baranglompo Island with the highest land use and human activities (Hemeroby 5 and Naturalness 3) has had an impact on water quality degradation reflected in the high turbidity and BOD levels. Bonebatang and Badi islands which have the lowest human activity and land use (Index of Hemeroby 3 and Naturalness 5) have better water quality with low to moderate BOD and turbidity. In order to improve water quality on the coast, human activities on five islands need to be controlled.

1. Introduction

Makassar is a maritime city that is globally oriented and environmentally friendly with a coastline of +32 km. The development of coastal areas and islands in Makassar is currently intended for tourism [1]. The Spermonde Archipelago consists of several small islands spread west of the mainland of South Sulawesi Province which stretches from Takalar Regency to Barru Regency. The area inhabited
by 121 islands has a fairly high level of coral diversity. There are 78 genera with a total of 262 species [2]. Some of the islands are populated and some are not. The availability of fresh water is one of the main factors that causes island communities selected to settle on certain islands [3]. A short distance from the coast of Makassar causes the activity on the coast of Makassar also affect to several small islands in the Spermonde Archipelago. The coastal city of Makassar has several functions including for the port of Pelni ships, inter-island traditional vessels, fisheries, sea transportation routes, and tourist attractions. These activities cause changes in land use and contribute for nutrients and other toxic wastes to the water so eutrophication was often occurs [4][5]. This can trigger an increase in biomass as well as degradation and death of marine producers so then it can threaten the lives of other marine biota.

In the framework of efforts to prevent and control sea water pollution in accordance with the Decree of the State Minister for the Environment No. 51 of 2004, concerning Sea Water Quality Standards, it requires an evaluation method that is both physical and chemical parameters. This water quality assessment is important to know the impact of human activities and land use in the Spermonde archipelago. Land use and human activities in the some islands can be observed using Naturalness and Hemeroby indices.

Based on this background and also considering the development of the tourism sector and industrial activities in the coastal areas and small islands in the Spermonde archipelago will have an impact on water quality, it is necessary to manage. Based on those reason, this research objectives were evaluating the water quality of some beach in Spermonde Archipelago of Makassar south Sulawesi based on physico-chemical parameters and analyzing the relationship between land use and human activities with water quality on the coast around the island. The data can then be used as the basis for the strategic management of degraded water quality in the coast.

2. Research Methods
This research was conducted in April 2019 on five islands in the Spermonde archipelago namely Barrangeaddi Island and Barranglombo Island which are the middle inner zone area, located 5 km from the coast of Makassar city with a depth of ± 30 m; Bonebatang Island, Kodingarengkeke Island and Badi Island which are in the middle outer zone, are 12.5 km from the coast of Makassar city with a depth of ± 20-50 m. The measurement of physicochemical properties of water was carried out at the Health Laboratory, South Sulawesi. Determination of sampling locations based on differences in environmental and anthropogenic activities in 5 research locations. Map of research locations can be seen in Figure 1.
The study used the Ex Post Facto method, which is a method for selecting a causal effect phenomenon that has been evident in the field (natural phenomena) so that researchers do not need to give any more treatment but only see the effect on the dependent variable [6]. The basis of the research's systemic approach is the complete causal relationship (causal finalist) of the object being assessed, namely environmental conditions such as variation of land use and community activities around the ecosystem of the coastal water to the physicochemical quality of water. As dependent variables of this research were water physicochemical parameters, Hemeroby and Naturalness Indices and independent variables were variations of land use and human activities.

Observation of the water quality of each island was carried out in 1-3 stations depending on the size of the island. Repetition of water quality measurements for each station 3 times. Whereas for seawater sampling that requires laboratory analysis was done by inserting seawater samples into sample bottles and stored in a cool box for analysis at the Makassar Health Laboratory Center.

Water quality was measured included pH, DO, salinity, turbidity, BOD, nitrate, TP, H₂S, oil and grease, and Pb. The physics and chemical parameters of seawater tested in this study, as well as the measurement methods and analysis standards used, are presented in Table 1. Data analysis of the results of measurements in situ and the results of laboratory analysis of water quality parameters are carried out descriptively, by comparing the results obtained with the standard the quality of seawater for marine biota based on the Decree of the Minister of Environment No. 51 of 2004 concerning Sea Water Quality Standards, which are devoted to marine life.

### Table 1. Water physics chemical were measured in this research

| Parameters                  | Unit | Methods            |
|-----------------------------|------|--------------------|
| pH                          | -    | pH meter           |
| Dissolved Oxygen (DO)       | mg/L | DO meter           |
| Salinity                    | %o   | Refractometer      |
| Turbidity                   | NTU  | Turbidimeter       |
| BOD                         | mg/L | Winkler            |
| Nitrate                     | mg/L | Colorimetric       |
| Phosphate                   | mg/L | Colorimetric       |
| Sulfide as H₂S              | mg/L | Colorimetric       |
| Oil and Grease              | mg/L | Gravimetric        |
| Lead (Pb)                   | mg/L | AAS                |
Observation of land use and human activities in the study area using the environmental services indices (Hemeroby and Naturalness). In determining the naturalness index and hemeroby index, direct observations were made in each area. The parameters observed for the naturalness index were biotic elements, artificial elements, energy input, physical alteration, extraction of elements, level of fragmentation, dynamics [7]. As for the Hemeroby index, the parameters observed were mechanical disturbance of the soil, direct mechanical disturbance of the vegetation and chemical disturbance into account [8]. The information obtained is then matched with a hemeroby disorder index table and determined the level of disturbance from human activity.

3. Result and Discussion

3.1. Physics chemical water quality of some beach in Spermonde archipelago

The results of monitoring water beach quality in five island i.e Barrang caddi, Bonebatang, Barrang Lombo, Bonebatang and Kodingarengkeke showed that total phosphate in all beach <0.010 mg/L, H2S <0.01 mg/L, oil and grease <0.1 mg/L, and Pb <0.005 mg/L. These concentration still met quality standards of sea water based on Decree of the Indonesia State Minister for Environment No. 51/2004 for marine biota. The variation value of common other physics chemical parameters of water such as pH, temperature, salinity, dissolved oxygen (DO) Biological oxygen demand (BOD) and Nitrate is shown in Figure 2.

Temperature is an important factor to consider when assessing water quality [9]. Water temperature can affect the metabolic rates and biological activity of aquatic organisms [10]. Water temperature in some beach Spermonde archipelago ranged between 30.55-33.08°C. The lower temperature value (30.55°C) was recorded in Kodingarengkeke island station 4 and the higher value 33.08°C was recorded at Bonebatang island station 5. Compared to the quality standard value, the highest temperature value has exceeded the quality standard (> 30°C), but the value obtained from the results of the study is the normal ranged for macroalgae growth and other plant. While some aquatic plants tolerate cooler waters, most prefer warmer temperatures [11]. Tropical plants in particular will show restricted growth and dormancy in water temperatures below 21°C. The air temperature in this research ranged between 28.78 -32.33°C was recorded from station 1-station 5 respectively. There were variations in air and water temperatures across all the stations, however these variations were not significantly different (Figure 2 A).

Variation in pH of sea water can be made as one of the quality of sea water. In a certain range of pH values a change in water quality can be indicated. The result of monitoring, almost neutral pH is observed in all locations throughout the sampling events. Value of pH in coastal water was relatively more stable and usually was in the ranges of 7.99 and 8.39. PH value which is ideal for water biota is 7 - 8.5 [12]. The results show that the water from all locations were moderately alkaline (pH 7.91-8.18) and within the permissible limit (pH 6.5-8.5) for plankton growth.
Dissolved oxygen (DO) was the optimal range that will support the life of marine biota. Quality standards of sea water based on Decree of the State Minister for Environment No. 51/2004 for marine biota suggest dissolved oxygen $>5 \text{ mg/L}$. In the study area, DO Levels of Baranglompo and Badi islands (6.1-7.7 mg/L) have met seawater quality standards for marine biota which require DO levels to be more than 5 mg/L. DO level in the coastal water of other islands (Bonebatang, Barrangcaddi and Kodingarengkeke) lower i.e 4.6-4.9 mg / L indicated have not met to sea water quality standard for marine biota. But, in this range of Dissolved Oxygen, some of aquatic animals and aquatic insects can survive [13].

Salinity is a fundamental water quality parameter monitored by freshwater and marine ecologists because of its influence on the biota. Most of aquatic organisms are adapted only to a narrow range of salinity, beyond which they cannot maintain their osmotic and ionic balance. Some species tolerate only intermediate levels of salinity while broadly adopted species can acclimate to variable salinity ranging from fresh water to seawater. Generally, the range of salinity in brackish water is from 0.5 ppt to 30 ppt [14]. Salinity in the five islands has a value that was in significant different from the measured salinity value ranged from $29.3^\circ/\text{oo} - 30.1^\circ/\text{oo}$. Salinity in these waters in accordance with the salinity values found in coastal areas in general. The results of the study showed that salinity at 5 stations was lower than the standard of sea water quality standard in the Minister of Environment Decree No. 51 of 2004. This is caused by the tide in the area. Estuary areas are regions where the salinity level was reduced because the effect of incoming fresh water and also caused by the tide in that area.

Nitrate (NO3-N) is the main form of nitrogen in natural waters. Nitrate is a nutrient important compounds in animal protein synthesis and plants. High nitrate concentrations in waters can stimulate growth and development of aquatic organisms if supported by the availability of nutrients. Nitrification which is oxidation process of ammonia to nitrite and nitrate is an important process in the nitrogen cycle and take place in aerobic conditions. Ammonia oxidation being nitrite is carried out by the bacterium nitrosomonas, while the oxidation of nitrite to nitrate is carried out by nitrobacter [15]. The monitoring result on concentration of nitrate in some beach at Spermonde archipelago showed that concentration ranged between 0.03 to 0.17 mg/L. Based on the quality standard of nitrate content...
in waters using the Decree of the State Minister Environment No. 51 of 2004, indicated that nitrate content in 5 study area has exceeded the quality standard, where the nitrate concentration set for marine biota is 0.008 mg/L. This condition is very dangerous to marine biota. The concentration of nitrate-nitrogen which is more than 0.2 mg/L can result the occurrence of water eutrophication and then stimulates the growth of algae and aquatic plants rapidly (blooming). High nitrate concentrations in the study area can be caused by the entry of high organic matter from land activities which can be in the form of land erosion, input of household waste, agricultural waste in the form of residual fertilizer and others that carried into the waters of the sea.

Turbidity illustrates lack the transparency of the waters due to the presence of materials colloidal and suspended such as mud, organic matter and inorganic, and aquatic microorganisms. High suspended solids in the waters can inhibit sun penetration and subsequently have an impact on the primary productivity decline of macroalgae in the waters [16]. Turbidity value in the study location ranged from 0.63 NTU to 1.26 NTU. The highest turbidity value 1.26 NTU was recorded at Barranglompo Island , while the lowest turbidity value with 0.63 NTU was recorded at Kodingarengkeke Island. Based on sea water quality standards for marine biota in the Decree of the Minister of Environment No. 51 of 2004, the turbidity in the all of study areas was still in accordance with the requirements for marine biota metabolism and marine coastal ecosystems such as coral, sea grass, algae and mangrove which set a maximum allowable turbidity concentration of 5 NTU [12].

Biochemical Oxygen Demand (BOD) is the amount of dissolved oxygen needed (i.e. demanded) by aerobic microorganisms to break down organic material present in a given water sample at a certain temperature over a specific time period. High levels of BOD can indicate organic pollution in waters. This organic matter pollution will further influence changes in the structure of the community of aquatic organisms. Only organisms that are tolerant of this organic matter pollution will survive [17]. The highest BOD concentration was found on Badi Island i.e 29.81 mg/L and the lowest concentration was found on Bonebatang Island (25.39 mg/L). BOD levels in all locations have exceeded the quality standard set by the government at 10 mg / L. It was indicated that the organic content in the waters is more than what is needed by marine biota. This condition can endanger to marine biota due to high levels of natural pollutants in water.

3.2. Correlation between land use and human activities in islands with water quality in the beach of the study area

In the context of conservation biology, the term natural is used to define anything that has not been made or influenced by humans, particularly by technology. Natural is being the antonym of artificial. The naturalness is quality of being natural would express the level at which something occurs without artificial influence, a gradient ranking from the extreme of absolutely natural to the opposite, absolutely artificial. The Naturalness index is inversely proportional to the Hemeroby index, the higher value of the Naturalness index, the lower value Hemeroby index. Hemeroby is the sum of the effects of past and present human activities on the current site conditions. Hemeroby is an integrative measure for the impact of all human interventions on ecosystems [7] [8].
Figure 3. Variation of land use and human activity in five island of Spermonde archipelago based on the value of Naturalness and Hemeroby Indices

Based on monitoring results Baranglompo Island has highest land use and human activities with a Hemeroby index value 5 and Naturalness 3. This condition is caused by high human activity on Barranglompo Island when compared to other islands. The existence of Hasanuddin University marine field station was driving the increasing number of residents, researchers and tourists on this island.

Figure 4. Relationship between land use and human activities with water quality on the coast around of the island using scatter diagram of PCA and Biplot

Direct discharge of marine organic waste, ship sailing activities and infrastructure development have an impact on biodiversity decline. On the other hand Bonebatang Island and Badi island have the lowest human activity (Index of Hemeroby 3 and Naturalness 5). Bonebatang island is an uninhabited island and Badi island is a coral reef conservation area which have resulted in low human activity on both islands. While Barangcaddi and Kodingarengkeke have moderate level of human activity and land use. Barrangcaddi is the most populous island in the Spermonde archipelago. While Kodingarengkeke is an uninhabited island. However, Kodingarengkeke Island is being developed by the local government to become a tourist area by built one building and a bridge that be used for tourist spots.

Relationship between land use and human activities with water quality on the coast around of the islands can be seen from scatter diagram of biplot from principal component analyses (PCA), as shown in Figure 4. Bonebatang and Badi islands which have the lowest human activity and land use (Index of Hemeroby 3 and Naturalness 5) have better water quality with low to moderate BOD and
turbidity. On the contrary, Baranglompo Island with the highest land use and human activities (Hemeroby 5 and Naturalness 3) has had an impact on water quality degradation reflected in the high turbidity and BOD levels. This high concentration of turbidity and organic matter (BOD) in the waters can have an impact on decreasing of the primary productivity and changes in the structure of the aquatic organism community which will further reducing the ecological services [16].

The results of this study indicate that the quality of the environment can be influenced by human activities in the islands. This environmental quality can further determine the quality of water at the beach. The change of land use significantly with high human activity will reduce water quality. Thus the government as well as conservationists and communities need to develop the models of waters ecosystems coastal management through controlling human activities and land use activities that have an impact on changes in the quality of ecosystem services.

**Conclusion**

This study showed that some parameter of water quality such as pH, turbidity, total phosphate, H$_2$S, oil and grease, and lead (Pb) in the beach around of Barrang caddi, Bonebatang, Barrang Lompo, Bonebatang and Kodingarengkeke islands have met quality standards of sea water based on Decree of the State Minister for Environment No. 51/2004 for marine biota. Only DO Levels of Barranglompo and Badi islands have met seawater quality standards for marine biota. BOD and nitrate concentration in all location have exceeded sea water quality standards for marine biota. Island with land use and human activities highest caused degradation of water quality if be compared to lowest human activities. It can be seen from concentration of turbidity and BOD in the water.

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