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Analysis of Water Quality and Pollution Index at Karangantu Fishing Port Area, Banten

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Abstract

Karangantu fishing port symbolizes the rapid fishing industry in Serang, Banten. So many activities in the Karangantu fishing port area, such as a place for landing fisherman's boats, shipping fish catches, and tourism object. These activities may impact the water quality. This research aims to analyze the water quality and pollution index in Karangantu fishing port. The water sample was carried out by purposive sampling in three stations around the Karangantu fishing port area: the estuary area, the fish auction, and the dock. Twelve parameters were analyzed: temperature, turbidity, transparency, TDS, TSS, pH, DO, COD, nitrate, cadmium, lead, and total coliforms. The water quality analysis result was compared by Class III water classification based on PP RI Nomor 82. Water quality was determined by the pollution index based on the minister of environment decree No. 115/2003. The result indicates that the estuary area is polluted, with a PIj score of 6.35; the fish auction and the dock f are in the moderately polluted categories, with PIj scores of 4.99 and 3.90. The worse pollution can be prevented by raising public awareness about the importance of clean water and providing waste management facilities.

Keywords: Water quality, water pollution, Karangantu, fishing port

Introduction

Karangantu Fishing Port is the center of the fishing industry in Banten, Indonesia. This port symbolizes the rapid fishing industry in Serang, Banten. There are various activities in the Karangantu fishing port area, such as a landing place for anglers' boats, a shipping place for fish catches, a fisheries processing industry, a settlement of residences, and tourism objects. Not only is the fishing industry's center, but the Karangantu fishing port area is also used as a tourist object. There are various tourist objects around Karangantu fishing port, such as Gope Beach and Mangrove Forest tourism. Furthermore, there are many boats docked at Karangantu that usually take tourists to cross the islands near Banten Bay.

Karangantu Fishing Port has the potential to be developed. These potentials include strategic location in the religious tourism area of Banten, located at the mouth of a river with sufficient waves to make it easier for ships to dock so that Karangantu Fishing Port can develop into a marine port. Karangantu Fishing Port also has shortcomings, including inadequate port facilities; the dock is still narrow, so tourist boats lean close to fishing boats.

The rapid development in the fishing industry and many tourism potentials around the port can make the environment easily get polluted. Pollution waste may come from various activities around the Karangantu fishing port: boat washing, fish industry processing, and domestic waste disposal. Many actions around the Karangantu Fishing Port area impact water quality and the environment.

Water is essential for life (Pedro-Monzonís et al., 2015). Water in natural conditions has many benefits for human and marine life (Ujianti et al., 2018). Water is the most manageable resource because it can transport or recycle (Singh & Gupta, 2017). Water is said to be polluted if it is not in a natural condition. The primary sources of water pollution are domestic waste, industrial waste, population growth, pesticides, plastic waste, and weak water management system (Haseena et al., 2017).

The quality of water resources needs to be maintained to be appropriately used as water is the most manageable resource. It is stated in PP RI

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Nomor 82 (2001) that water pollution is when unwanted substances contaminate water; thus, water quality decreases. This pollution not only disrupts marine life but also disturbs the activities around the port. These disturbances may happen as water, which may not be in natural condition, can harm human health and marine life, contaminate the water purity, and disturb the potential of the tourism objects. Furthermore, chemical substances in the water may disturb humans' health, which will later cause various infectious diseases (Singh & Gupta, 2017).

Water quality is a measurement of whether the waters in an area are in good condition or polluted (Barang & Saptomo, 2019). The quality status of body waters shows a measure of the water conditions at a particular time compared to the required standard value. Water quality is determined based on physicochemical parameters and environmental conditions (Hamuna et al., 2018).

The water quality status analyzed based on the pollution index method provides information about the water quality for resources and various other purposes. The pollution index is a method used to determine the amount of pollution in waters in the form of numbers to make it easier to know the condition of pollution (Harahap et al., 2020). Calculating the value of the water quality index can

Based on research by Mutmainah & Adnan (2018) on the quality of the waters at the Bungus Ocean Fishing Port, it showed that the overall average of the waters is in good condition with PIj scores of 0.780, 0.794, 0.712 in three sampling points, respectively. However, several parameters exceed the quality standards, namely turbidity, BOD, and Cd metal, but are still within tolerance limits. Research at PPN Kejawanan (Sudirman et al., 2013) showed that the port area is moderately polluted, with PIj scores of 2.64, 2.25, and 1.52 in three sampling points, respectively. Parameter pH, zinc metal, and ammonia have values exceeding the specified quality standards. Research at Australian Port was conducted by Jahan & Strezov (2017). It showed that the water quality in the port is poor due to many human activities (Jahan & Strezov, 2017).

Based on previous research on water quality and pollution index in several ports, it is crucial to know the water quality and pollution index. Research studies on the quality of water analysis at Karangantu Fishing Port Area are very much needed as the area develops. This research aims to determine the water quality based on the pollution index at Karangantu Fishing Port Area. The water quality and pollution index analysis was carried out based on physical, chemical, and microbiological parameters. The parameters measured for this research are temperature, turbidity, transparency, TDS, TSS, pH, DO, COD, nitrate, heavy metals Pb and Cd, and Total Coliforms. The determination of each test parameter is based on a pre-analysis of conditions in the Karangantu fishing port area. Several activities around the waters, such as the fishing industry, tourism, agriculture, and settlements, can affect the entry of pollutant loads into these waters.

The pH parameter can show the level of acidity or alkalinity in the waters. Activities in the fishing market, fishing port, and tourism can affect turbidity, transparency, TSS, TDS, DO, and COD. Meanwhile, Mangrove Forest and domestic waste near Karangantu fishing port are influenced mainly by nitrate. Heavy metals Cd and Pb may be affected by refueling and painting activity on the ships. Total coliform is a microbiological parameter affected by agricultural waste and organic matters.

The study results can provide information about the water quality status at Karangantu Fishing Port. In addition, this study is also beneficial for the water management system so that it will not disturb marine life, will not pollute the environment, will not harm the health of the residents, and will provide clean water for the people around the area.

Methods

The researchers applied the descriptive observational method and analyzed it in the laboratory. The research was conducted in the Karangantu Fishing Port Area and the laboratory for analysis. The purposive sampling method was applied to take the samples, which means that the sampling point was determined by the characteristics of the water condition, the ease of access to sampling, and the consideration of time and cost. The sampling points were on three locations representing Karangantu Fishing Port Area: estuary area, fish auction, and dock, as shown in **Figure 1**. Three water samples were combined at each point to produce 1L of the water sample. Regarding surface water samples, the sampling technique was based on SNI 6989.57 (Badan Standarisasi Nasional, 2008).

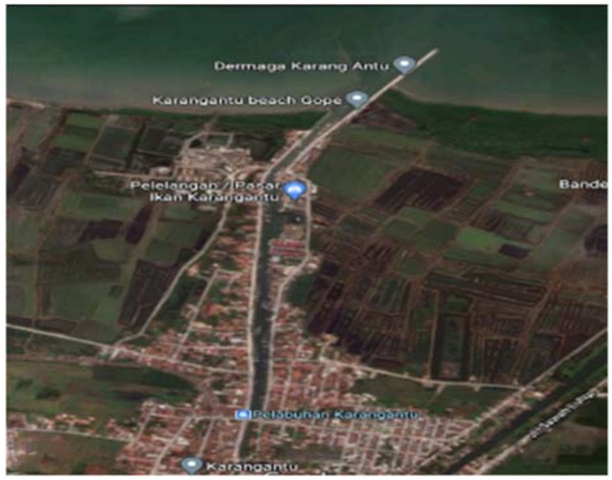

Figure 1. Locations of observation at Karangantu fishing port area

The data collection methods were carried out in situ to measure the physical parameter using the prepared equipment and ex-situ laboratory. The parameters analyzed included temperature, turbidity, transparency, TDS, TSS, pH, DO, COD, NO_3-N, metals Cd, Pb, and total E. Coliforms. The equipment used for in situ research were GPS (Global Positioning System) Garmin eTrex 10, thermometer and pH meter digital Hanna HI98107, mercury-in-glass thermometer, Secchi disk with 200 mm diameter, polyethylene bottles 500 mL and 1000 mL, and more excellent box Lion Star 12s for storage. The materials needed for the research were water samples from three sampling points at the Karangantu fishing port area, H_2SO_4 95–97% (*Merck*), and ice gel thermafreeze. These samples were analyzed at Serang District Health Laboratory. The quality of water samples was analyzed based on physical, chemical, and biological parameters, then compared to the quality standard based on the PP RI Nomor 82 (2001) concerning Water Quality Management and Water Pollution Control.

The researchers applied the pollution index calculation system to determine the water quality. The water pollution index analysis was based on the Decree of The Minister of the Environment Number 15 the Year 2003 concerning Guidelines for Determining the Status of Water Quality. The formula used to calculate the pollution index was as follows:

$$PI_j = \frac{\sqrt{\left(\frac{C_i}{L_{ij}}\right)^2_{avg} + \left(\frac{C_i}{L_{ij}}\right)^2_{max}}}{2}$$

Where:

PI_j	= Pollution Index
L_{ij}	= concentration of water quality parameters listed in water quality standard
C_i	= concentration of water quality based on the survey result
$(C_i/L_{ij})_{avg}$	= average value of C_i/L_{ij}
$(C_i/L_{ij})_{Max}$	= maximum value of C_i/L_{ij}

The determination of the PIj value results is as follows in **Table 1**. The pollution index method not only showed the pollution level but also determined the appropriate status of water area for specific purposes based on particular parameters.

Table 1. Classification of water quality status

Score	Criteria
0	Good
1.0 < PIj<5.0	Moderately polluted
5.0<PIj<10	Polluted
PIj>10	Extremely polluted

Results and Discussion

Water quality measures whether the waters in an area are in good condition or polluted. Water quality can be seen from the content of suspended sediment and chemicals contained in the water (Barang & Saptomo, 2019). Water quality in an environment can be influenced by several environmental activities, such as domestic activities, industry, fisheries, agriculture, regional development, and public awareness. Water quality testing can be analyzed based on physical, chemical, and microbiological parameters. Parameters tested in this study include physical parameters, namely temperature, turbidity, transparency, TDS, and TSS. The chemical parameters tested were pH, DO, COD, nitrate, and heavy metals Cd and Pb. Meanwhile, the microbiological parameter tried was Total Coliform.

Water quality assessment around Karangantu Fishing Port Area was conducted based on PP RI Nomor 82 (2001) concerning Water Quality Management and Water Pollution Control. The water quality values exceeded the maximum permissible quality standard were categorized as polluted water. The results of the water quality analysis around Karangantu Fishing Port are shown in **Table 2.**

Temperature, as an essential factor for the life of the aquatic organism, was very much influenced by sun intensity, environmental condition, water depth, circulation, etc. (Mutmainah & Adnan, 2018). The temperature measurement result around the Karangantu Fishing Port area showed a water temperature of 30 ºC for each observation station. This result meant that the temperature in the area met the quality standard as the temperature becomes an essential parameter for life biotic and abiotic ecosystems (Singh & Shrivastava, 2015). The temperature value, which is within the standard quality value, shows that the waters around the Karangantu fishing port area still follow the water quality criteria according to their designation. The temperature value in this range also shows that the waters around the Karangantu fishing port area are still ideal for marine tourism in terms of water temperature parameters. Water temperature can affect the growth of marine life. Water temperature is influenced by season, air circulation, time of the day, water flow, and water depth (Hamuna et al., 2018).

Table 2. Water quality of karangantu fishing port area

No	Parameter	GR No 82/2001 class III	Unit	Stations		
				St. 1	St. 2	St. 3
1	Temperature	±3 ºC room temperature	ºC	30	30	30
2	Turbidity	*	NTU	25.59	73.85	163.08
3	Transparency	*	m	0.33	0.27	0.17
4	TDS	1000	mg/l	36053	15642	7719
5	TSS	400	mg/l	165	45	62
6	pH	6.0 – 9.0	-	8.24	8.14	7.59
7	DO	4	mg/l	7.35	7.35	4.9
8	COD	50	mg/l	118	8	8
9	Nitrate	20	mg/l	2.8	2.5	1.3
10	Cadmium (Cd)	0.01	mg/l	0.003	0.003	0.003
11	Timbal (Pb)	0.03	mg/l	0.093	0.031	0.028
12	Total coliforms	10000	MPN/100 ml	3000	16000	16000

Remarks: *not specified value in standard
St 1: the estuary area
St 2: the fish auction
St 3: the dock

Turbidity is an optical property of water. Turbidity indicates the large number of particles in water that affect respiration and photosynthesis (Mutmainah & Adnan, 2018). Turbidity could arise due to the water's organic and inorganic materials caused by ship waste, fishing industry waste, domestic waste, etc. The researchers found high turbidity values at the three observation points at 25.59 NTU, 73.85 NTU, and 163.08 NTU for stations 1, 2, and 3. Turbidity is a physical parameter that is not specified in the standard value. The third station's wharf received the highest turbidity score due to loading and unloading activities. This activity can lead to the presence of mud, microorganisms, oil due to refueling ships, and waste from ships leaning on the dock, which causes the waters to become more turbid. Turbidity affects the decrease in the level of penetration of sunlight in water so that it can reduce the process of photosynthesis. Turbidity can affect colonies of aquatic animals (Khaeksi et al., 2015).

Transparency is a physical parameter to indicate the part of the eye's light that can penetrate water. Transparency stated the level of light penetration in the water. It is understood that good light penetration in the water affects the rate of the photosynthesis process, so the waters around the area become productive (Riza et al., 2015). The transparency of the water was measured by using a Secchi disk. This research obtained the transparency value sequentially at 0.33, 0.27, and 0.17 m. Transparency is not a specified value in standard. But, based on research shows that the water is so muddy. Transparency and turbidity are parameters that influence each other. The low transparency value in sampling points shows dark penetration in water that can disturb the photosynthesis process in the water. Observation station 3 has the lowest transparency value. It is due to input from ship exhausts which can cause a decrease in the transparency of the waters. Common transparency values indicated the number of suspended particles in the waters (Hamuna et al., 2018). The low transparency value can be affected by depth. Low water depth can make it easier for water to carry particles that are on the seabed (Haerudin & Putra, 2019).

Total Dissolved Solids (TDS) measure the dissolved combined value of all inorganic and organic substances in the water (Singh & Shrivastava, 2015). TDS also indicates the presence of carcinogenic compounds. Solid objects in the waters can be sourced from organic substances such as mud, plankton, industrial waste, and dirt. Other TDS pollutant sources are household waste, pesticides from agriculture, and so on. TDS pollutant sources can be inorganic substances, including rocks and air containing calcium bicarbonate, nitrogen, iron, and other minerals. The measurement results showed TDS values of TDS 36053, 15642, and 7719 mg/L. These results showed that the TDS values were above the quality standard value, with the standard value of 1000 mg/L. The high TDS values at the three observation stations can be caused by the presence of mineral salts from Mangrove Forest tourism in the waters. High TDS values can affect the salty and bitter taste in water. The higher the TDS values are, the more unpleasant the water will smell.

Total Suspended Solids (TSS) are one of the critical factors in decreasing the water quality, causing physical, chemical, and biological changes in the waters. TSS can be used as a parameter to evaluate the water quality status and determine the treatment unit's efficiency. The primary sources of TSS pollution are solid substances, namely sand, mud, and clay, as well as aquatic living substances such as phytoplankton, zooplankton, bacteria, and fungi, as well as inanimate substances or inorganic particles (Asuhadi & Manan, 2018). In this research, TSS values obtained were below the quality standard at the three observation stations, 162, 45, and 62 mg/L, with the standard value of 400 mg/L. At observation station 1, the highest TSS value was obtained. It is because at observation station 1, there is a Mangrove Forest, so sediment from this Mangrove Forest enters the water body, thereby increasing the total solid in the waters. At the fish auction place or observation station 2, the results of the TSS measurement with the lowest value are obtained. It is because there has been sediment deposition in the water. In addition, the relatively low water flow also causes a low TSS. At dock or station 3, the TSS value is generated by resident activities. TSS can reduce the productivity of water because it can block sunlight that penetrates the water so that it can affect photosynthesis.

The pH measurement shows the level of acidity or alkalinity in the waters. The pH value is closely related to CO_2 and bite (Tanjung et al., 2019). Based on PP RI Nomor 82 (2001), the pH value that meets the quality standard is between 6.0 and 9.0. In this research, the results of pH measurement at three observation stations were 8.24, 8.14, and 7.15. It means that the pH values met the required quality standard. At observation station 1, the estuary has the highest pH value. At this location, the source of pollutants affecting the high pH compared to other areas can come from tourism activities around the dock. These activities can lead to domestic waste containing microorganisms and toxic chemicals. The higher the pH values, the higher the acidity of the waters. It is also directly proportional to the level of CO_2 (Mutmainah & Adnan, 2018). A low pH value affects the mobility of toxic heavy metal compounds, while a high pH value disrupts the balance of biological life (Sidabutar et al., 2017).

Dissolved Oxygen (DO) measurement at the three observation stations showed a value of 7.35 mg/L at stations 1 and 2 and 4.9 mg/L at stations 3. The standard value of DO is 4.0 mg/L. The high DO value at observation stations 1 and 2 can be caused by the water flow condition, which is still quite heavy compared to observation station 3 at the dock. Abnormal water conditions can also cause a decrease in DO at station 3. The low DO value causes the photosynthetic process of aquatic biota to be not good—the greater the DO value, the better the condition of the waters. DO works as a parameter indicating the amount of dissolved oxygen in the water and is influenced by temperature and minerals in the water. The dissolved oxygen value indicates the presence of organic substance contamination (Riza et al., 2015). It is an important parameter as it shows the level of water pollution (Ujianti et al., 2018). A low DO value indicates polluted waters, which can affect the growth of aquatic biota. The high DO value indicates the amount of oxygen available in the waters is high, so it is suitable for developing marine biota (Katili et al., 2020).

Chemical Oxygen Demand (COD) measurement was used to determine the amount of dissolved organic compounds in the water. This research obtained COD contents at 118 mg/L at observation stations 1 and 8 mg/L at observation stations 2 and 3. The standard value of COD is 50 mg/L. These results show that the COD content at observation 1 was higher than the acceptable quality standard, while the COD content at observation stations 2 and 3 was below the excellent quality standard. The highest COD content at observation station 1 was located around the estuary. This high content also indicates that the area around the estuary had the highest level of water pollution. Activities that cause high COD contents at observation station 1 are agriculture, fisheries, marine tourism, and residential areas. The COD content at Station 2 is mainly caused by fishing industry activities, while at Station 3 is caused by loading and unloading ships and residential areas. The high COD value in waters causes the number of oxygen microorganisms to need to oxidize waste through chemical reactions to be very high. COD levels are also caused by increased organic and inorganic substances in the environment and the presence of pollutants in the water (Kalagbor et al., 2021).

Nitrate becomes the primary nutrient for aquatic plants as it is the final product of the nitrogen oxidation process. The nitrate measurement results showed contents of 2.8, 2.5, and 1.3 mg/L, respectively, for three observation stations, with a common value is 20 mg/L. These results also showed that the nitrate content at the three observation stations was below the quality standard, meaning that the water was not polluted by nitrate. At observation station 1, the nitrate concentration is the highest in the waters. The presence of mangrove forests may cause this and agricultural fertilizer waste carried into the waters. At observation Station 3, the nitrate concentration was the lowest. This result can be caused by the dock's location far from the farm. Nitrate contamination at the ports can be caused by domestic activity in settlements around the pier. Nitrate content in waters is vital for aquatic ecosystems. Nitrate is a critical element in the process of photosynthesis and can be used for the growth of phytoplankton. However, excessive nitrate content in waters has a destructive impact on organisms because excessive nitrate can cause the growth of algae in unlimited quantities (Guntur et al., 2017).

Heavy metals contained in water bodies can cause damage to the aquatic environment. Heavy metals can kill marine biota. It can dissolve in water to form a solution and cannot be separated physically in water. This research analyzed heavy metals Cadmium (Cd) and Lead (Pb), mainly because Cd and Pb harm humans and the environment. In large quantities, Cd can harm humans' health and damage human body organs (Roberts, 2014, Pradika et al., 2019). This research found that the Cd metal measurement result showed a content of 0.003 mg/L for the three observation stations, with a common value of Cd metal of 0.01 mg/L. This result was below the acceptable quality standard. Cd metal has a high toxicity in water. Cd metal accumulates in living things' bodies and can cause poisoning, health problems, and even death (Wardani et al., 2018). Observation Cd metal in station 1 may come from agricultural waste, fertilizers, pesticides around the Mangrove Forest and agricultural land, and domestic tourist waste. Observation Cd metal in station 2 may come from fish trading activities at fish auctions. Meanwhile, Cd metal at observation station 3 in the dock can come from ships leaning on the port. Many anglers carry out ship painting activities at the pier, affecting the Cd concentration around the waters.

Meanwhile, the measurement of Pb metal showed contents of 0.093, 0.031, and 0.028 mg/L, with standard value of Pb is 0.03 mg/L. The result indicated that the metal contents of Pb at observation stations 1 and 2 were above the quality standard, while the metal content at observation stations 3 or the dock was below the quality standard. The Pb metal measurement results at station 1 show a content that exceeds the allowable standard. It could be due to the large number of ships passing through observation station 1 or the estuary. The ships that pass include tourist and fishing boats that will catch fish around Banten Bay. These ships can produce exhaust emissions containing Pb. Pb metal detected at station 2 may come from the activities of the fishing industry and refueling around the fish auction place. Meanwhile, at station 3 Pb, metal may come from market waste near the dock carried by water and ship waste flow. The high level of lead metal in water will most likely disrupt the health and survival of aquatic organisms (Yolanda et al., 2017).

Total coliform is water analysis based on biological parameters. Total coliform shows how much water is polluted by e-Coli bacteria. Sources of e-Coli bacteria contamination can come from domestic competitions, toilets, agricultural waste, organic materials, etc. The result of total coliform measurement showed a content of 3000 mL at observation stations 1 and 16000 mL at observation stations 2 and 3. The high concentration of the total coliform at the fish auction site and the dock is caused by the activity of the population, which causes domestic waste to the waters, selling and purchasing activities, and the fishing industry at the fish auction site. Coliform is a microorganism that can be used as an indicator of water contaminated with pathogenic bacteria (Adrianto, 2018). The high total coliform concentration indicates a large load of organic pollution entering the waters, indicating the possibility of the waters containing pathogenic bacteria. The total number of E. Coliforms becomes one of the water quality indicators caused by contaminations of human and animal feces. The total number of E. Coliforms was also influenced by several factors, including poor toilet sanitation, waste disposal in water, human and animal feces, etc. (Sidabutar et al., 2017).

The water pollution index method can determine the pollution level at Karangantu Fishing Port Area. Water is said to be polluted if some of the tested parameters exceed the permissible quality standard values. The results of the pollution index at the Karangantu Fishing Port Area are shown in **Table 3**.

Table 3. Water pollution index at Karangantu fishing port area

Stations	Pollution Index	Water Quality Status
St. 1	6.35	Polluted
St. 2	4.99	Moderately polluted
St. 3	3.90	Moderately polluted

The analysis results using the pollution index method show that the water condition at observation station 1 (the estuary area) was polluted. The pollution around the estuary area is caused by tourist objects such as beaches and mangrove forests. In addition, many tourist boats take tourists to circle the coast and to take tourists to cross islands in Banten Bay.

The water condition at observation station 2 at the fish auction area and observation station 3 at the dock was moderately polluted. The water condition at the fishing auction area and the port were moderately polluted because of the fishing industry's activities and ships' loading and unloading activities. The state of the waters at observation station3 can also be influenced by the presence of markets around the area.

The difference in the pollution index's value and the water quality status in the Karanganttu fishing port area can be shown by the difference in the concentration of parameters at the three observation stations. Based on the analysis of water quality and water quality status, it can be seen that the concentration of pollutants in the waters is strongly influenced by the activities at the observation stations that cause waste to enter the waters. These wastes can come from domestic activities, ship activities, buying and selling fish, packing fish, and tourism activities around the Karangantu fishing port Area.

The result of the pollution index can provide information about the water quality status at Karangantu Fishing Port Area. Also, it can be used for water resources management. Good management of water resources is needed to maintain the marine biota, keep the clean environment and public health, and provide clean water for people around the Karangantu fishing port area.

Conclusions

The water quality at the Karangantu fishing port area with TDS, DO, Pb metal, and Total Coliform has exceeded the water quality standard. Meanwhile, temperature, TSS, pH, COD, nitrate, and Cd metal did not exceed the quality standard. Analyzed based on the pollution index showed that waters at the estuary area (station 1) were polluted with a 6.35 PIj score, at the fish auction (station 2) and the dock (station 3) were moderately polluted, with 4.99 and 3.90 PIj scores respectively. The worse pollution can be prevented by raising public awareness about the importance of clean water and providing waste management facilities.

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