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Quality and Environmental Conservation of Coastal Ecosystems in Purworejo, Indonesia

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Abstract

The quality of coastal ecosystems in Purworejo - Central Java tends to degrade due to pollution and environmental degradation. This study aims to identify indicators, including soil ecosystem, water quality, wastewater, and seawater quality. The methods include geo-electrical survey, field observation, and laboratory test. The results show that the area is polluted and degraded. Salinity distribution varies between 0.01 and 0.13 due to geological factors and seawater intrusion. Another finding shows that TSS reaches 1000-13.000 mg/L with 162-551 mg/L BOD, 2.24-4.77 mg/L Sulfide, and 0.61-2.06 mg/L Nitrite allegedly caused by shrimp farming activities. Clean water sources are polluted as total coliforms reach 46x103 – 195x103 MPN/100 ml. Seawater quality is also degraded with 8.96 pH. Pb, Cd, Cr, and Hg exceed the standard. This study recommends that, for a sustainable coastal area, shrimp farming should apply the best practice management with a wastewater treatment plant. Such area requires sanitation facilities to minimize pollution by coliforms. Firm control should be performed on industrial activities that contaminate seawater with heavy metals. Clean water pumping through wells should not exceed 16.82 m of depth to anticipate seawater intrusion.

Keywords: Pollution, Degradation, Conservation, Coastal area

1 Introduction

Marine and coastal ecosystems are continuously exposed to pollution caused by eutrophication, toxic substances such as pesticides and POPs, heavy metals, ocean acidification, and direct human activities (1). One of the marine and coastal ecosystems with decreasing quality is located in Purworejo Regency, Central Java, Indonesia.

Approximately 80% marine and coastal pollution is caused by industrial, agricultural, and fish-farming activities as well as land-use activities (2). The fish farming activities contributing to the pollution in marine and coastal ecosystems of Purworejo Regency is shrimp farming. Coastal pollution can be triggered by pollutants along the coastline and/or indirectly through river flows, offshore activities, seawater intrusion into the ground, and others. Shrimp-farming operating activities use a very large amount of groundwater, leading to a significant reduce in groundwater quantity. In addition, untreated wastewater drained from shrimp ponds is immediately discharged into the surroundings in a vast quantity with unidentified quality, making the environment more burdened.

According to (3), on a global scale, irrigation contributes the largest volume of wastewater and the livestock sector produces more animal waste than human. Such activities deteriorate groundwater condition, and seawater intrusion flows further inland, which also leads to changes in the physical characteristics of land. Concentration of Nitrite in pollutants greatly increases when neraby farm lands who predominantly uses inorganic fertilizers, pesticides and insecticides (4).

Such study is intended to make recommendations for the management of pollution and environmental damage in coastal ecosystems as part of conservation planning and environmental recovery.

2 Materials and methods

The research stages consist of secondary data collection, survey and inventory, testing, data analysis, classification of status, and conclusions. Geo-electrical survey was carried out to identify underground damage, which includes the depth and quantity of groundwater and the extent of seawater intrusion inland. Wastewater testing was conducted on the wastewater from shrimp ponds and industries with three sample points. The parameters tested comprised TSS, turbidity, pH, BOD, Phosphate, Nitrite, Nitrate, Sulphates, Ammonia, and H2S. Clean water quality testing was performed for groundwater with ten sample points. The parameters tested consisted of colour, turbidity, pH, total hardness (CaCO3), Fluoride, (F), Chloride (Cl), Manganese (Mn), Iron (Fe), Nitrite, Nitrate,

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Sulphates, $KMnO_4$, dissolved solids (TDS), Cyanide (CN), coliform MPN, and salinity. Seawater quality testing was carried out on the seawater along the coastal ecosystems in Purworejo Regency with five sample points. The parameters tested included total coliform, Zn, Pb, Cu, Cd, Cr, Hg, and pH.

Geological analysis was conducted on the results of geo-electrical survey. Identification analysis of underground degradation correlates with the extent of seawater intrusion inland. Analysis of wastewater and clean water pollution was done to the results of wastewater-quality laboratory test, and comparison was made with the environmental quality standards. The quality standards for the analysis of clean water pollution referred to the Regulation of the Minister of Health Number 32 of 2017 concerning the Quality Standards of Clean Water and Drinking Water, and for that of wastewater pollution, the Regional Regulation of Central Java Province Number 5 of 2012 concerning Wastewater Quality Standards for Other Industrial Activities was utilized. Meanwhile, the results of seawater-quality laboratory test was analyzed for seawater pollution and compared with the quality standards from the Decree of the Minister of Environment Number 51 of 2004 concerning Seawater Quality Standards.

3 Results and discussion

3.1 Wastewater Pollution

Shrimp-farming activities around a marine and coastal ecosystem lead to declining environmental quality. Wastewater sampling is done at three points of shrimp-pond outlet followed by a laboratory-scale analysis. The results indicate a number of pollutant parameters with excessive values. These parameters include TSS of 1470, 13430, and 1047.5 mg/L (100 mg/L EQS) in samples 1, 2, and 3 respectively, with BOD values of 440, 551, and 162 mg/L (EQS = 50), and sulphide parameters of 4.77, 3.74, and 1.24 mg/L (1 mg/L EQS). In addition, the parameter of Nitrite as N at the wastewater sample points 1 and 2 is 2.05 and 2.06 mg/L (1 mg/L EQS), while that of sample 3 is 0.65 mg/L indicating that it remains below the environmental quality standards. The high values of physical, chemical, and organic chemical parameters result from the fact that shrimp farming uses a number of chemicals in the feed, antibiotics, or drugs that protect shrimp from disease, allowing optimum shrimp growth and larger yields (5). Furthermore, in the absence of Wastewater Treatment Plant, shrimp-farming waste will pollute water bodies. According to (6), if the best practice management of shrimp farming is not implemented, the effect appears as pollution from leftover feed and other solutes in the wastewater.

3.2 Clean Water Pollution

The test results indicate several parameters that exceed the environmental quality standards for clean water set in the Regulation of the Minister of Health No. 32 of 2017. Parameters above the threshold can indicate groundwater pollution in the study area. These parameters include water turbidity of 26.7 NTU (EQS = 25 NTU) at sample point 10, manganese (Mn) of 1.49 mg/L (0.5 mg/L EQS) at point 10, water hardness of 704 mg/L at point 2, 1562 mg/L at point 7, 2068 mg/L at point 8, 904 mg/L at point 9, and 1672 mg/L at point 10 with 500 mg/L EQS. Another key parameter exceeding the environmental quality standard is the total coliform in all well points that reaches a range of 46×10^3 – 116×10^3 MPN/100 ml (threshold = 50 MPN/100 ml).

Meanwhile, the results of river water testing show that the key parameters exceeding the environmental quality standard for clean water include the hardness and total coliform, reaching 506 mg/L (500 mg/L EQS) and 105×10^3 MPN/100 ml (50 MPN/100 ml EQS), respectively. Hard water is caused by Ca^{2+} and Mg^{2+} ions or by such other elements as Al, Fe, Mn, and Zn (7). The level of water hardness is also influenced by land topography in which lands with flat topography tend to have a high level of hardness because the movement of minerals in water becomes slower and they settle at certain points. In addition to hardness, the river water has been polluted by total coliform. Such pollutant overload can indicate the existence of pollutant sources intruding clean water resources. According to (8), when total coliform bacteria are located, it is highly likely that there has been pollution due to human organic waste or animal waste. Such pollution comes from poor sanitation practices, such as the high percentage of people practicing open defecation reaching 22.7% in 2015 (9), poor sanitation facilities such as open unsecured latrines, and the sewer system that is mixed with the system for rainwater and domestic waste among the community in the study area.

3.3 Seawater Pollution

Test sampling is conducted at 5 points spreading from the east to the west. The test results in key parameters that indicate seawater pollution in the coastal ecosystem. These parameters include pH and heavy metals (Pb, Cd, Cr, Hg) as well as the biological parameter of total coliform. The pH level exceeds the quality standard at sample point 4 with 8.96 (7 – 8.5 EQS). The levels of Pb at 5 sample points are all above the threshold of environmental quality standard with 0.27 mg/L at point 1, 0.16 mg/L at point 2, 0.19 mg/L at point 3, 0.25 mg/L at point 4, and 0.25 mg/L at point 5 while the EQS is 0.005 mg/L. This is similar to the parameters of Cd, Cr and Hg in which all points have greater levels than 0.002 mg/L EQS threshold.

The levels of heavy metal content that exceed the quality standard are caused by various activities, including waste from industries, mining, agriculture, and domestic activities that contain heavy metals (10). In the industrial sector (11), it records the existence of small-scale to large-scale industries in Purworejo Regency as a form of support for the local economy, such as the textile industry in Banyuurip, wood processing in Bayan, and widespread food industries as well as other small-scale and medium-scale industries. Such activities as wood processing, agriculture, and tourism have significantly affected the hydrological aspect of the environment with lowered water productivity and disrupted water quality.

3.4 Geo-electrical Analysis

From the results of geo-electrical resistivity analysis conducted using a computer program and correlated with the geological conditions, it is interpreted that there are 3 types of lithology based on the resistivity level of rock types, including the cover layer, the clay layer, and the sand layer. The depth and resistivity of each layer can be seen in Table 1. Table 1 shows that there is a lithology at the observation point with the potential of water content in the form of sand layer at a depth of 13.97 – 16.82 meters. However, since the layer thickness is less than 3 meters, it is estimated that the potential of water discharge is relatively small.

Table 1: Depth, Resistivity and interpretation of rock unit in the geo-electrical analysis

Layer	Depth (Meter)	Resistivity (Ohm-m)	Interpretation of Rock Unit
1	0 – 1.03	5.96 – 71.04	Cover layer
2	1.03 – 4.52	5.66	Clay
3	4.52 – 13.97	8.17	Cl ay
4	13.97 – 16.82	27.16	Sand
5	16.82 – 48.69	3.87	Clay/Sand
6	>48.69	4.05	Clay/Sand

Source: Results of Geo-electrical Analysis

Meanwhile, in the lower layer deeper than 16.82 meters, the resistivity value shows a lithology in the form of clay without the potential to become an aquifer. Because the assessment site is located in the coastal ecosystem, the small resistivity value leads to another possibility of sand layer containing water with seawater intrusion. Therefore, if drilling is carried out to reach a depth of more than 16.82 meters, the possibilities are: (a) no layer with water resource is found, or (b) a layer containing water is located but with seawater intrusion.

3.5 Conservation of Coastal Ecosystems

A final assessment indicates whether environmental degradation has incurred based on water pollution and land-use change. From the samples studied, most of the parameters tested remain below the quality standard thresholds except for the levels of hardness and total coliform that exceed the quality standard. These two parameters will not have a significant effect on environmental degradation because such condition commonly occurs in a normal environment. It is hereby suggested that no significant environmental degradation due to water pollution has occurred. A number of recommendations are made as a step to approach a sustainable conservation program for the coastal ecosystems. Shrimp farming should implement the best practice management of environmentally friendly shrimp farming by constructing wastewater treatment plants. In addition, coastal ecosystems should be completed with appropriate sanitation facilities to minimize total coliform bacteria pollution in water resources. Industrial activities that pollute seawater with heavy metals (Pb, Cu, Cr, and Hg) should also be kept under firm control. Clean water collection through wells should not exceed a depth of 16.82 meters to anticipate seawater intrusion into fresh water resources. In addition, coastal ecosystems should provide greenbelts as a windbreak, such as with Australian pine trees or other plants alike. There are six main socio-economic categories for ensuring the sustainable development of economic, industrial, cultural, recreational and, consequently, ecological sphere of city's life (12): (a) territory management or administrative apparatus; (b) economic state of the territory; (c) state of the cultural sphere; (d) pace of economic development; (d) production sector; and (e) state of the social sphere.

4 Conclusion

Identification of pollution and degradation to the coastal ecosystems in Purworejo Regency indicates that some areas are polluted, however, in general the study area is an insignificant environmental damage. This conclusion is supported by the fact that the water pollution factors remain under normal conditions.

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Ethical issue

Authors are aware of, and comply with, best practice in publication ethics specifically with regard to authorship (avoidance of guest authorship), dual submission, manipulation of figures, competing interests and compliance with policies on research ethics. Authors adhere to publication requirements that submitted work is original and has not been published elsewhere in any language.

Competing interests

The authors declare that there is no conflict of interest that would prejudice the impartiality of this scientific work.

Authors' contribution

All authors of this study have a complete contribution for data collection, data analyses and manuscript writing.

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