

Study on water quality around mangrove ecosystem for coastal rehabilitation

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Abstract. Coastal ecosystems are vulnerable to environmental degradation including the declining water quality in the coastal environment due to the influence of human activities where the river becomes one of the input channels. Some areas in the coastal regions of East Java directly facing the Madura Strait indicate having experienced the environmental degradation, especially regarding the water quality. This research was conducted in the coastal area of Probolinggo Regency, East Java, aiming to analyze the water quality as the basis for coastal rehabilitation planning. This study was carried out using survey and observation methods. Water quality measurement results were analyzed conforming to predetermined quality standards. The coastal area rehabilitation planning as a means to restore the degraded water quality parameters is presumably implemented through mangrove planting. Thus, the mangrove mapping was also devised in this research. Based on 40 sampling points, the results illustrate that according to the quality standard, the water quality in the study area is likely to be deteriorated. On account of the mapping analysis of mangrove distribution in the study area, the rehabilitation of the coastal zone can be done through planning the mangrove forest plantation. The recommended coastal area maintenance is a periodic water quality observation planning in the river region which is divided into three zones to monitor the impact of fluctuating changes in land use or human activities on the coastal water quality.

Keywords: coastal, mangrove, rehabilitation, water quality

1. Introduction

Marine ecosystems in the northern coastal areas of Java and Madura Strait have been declining functionally during the last ten years. Sporadic and perfunctory marine ecosystem improvements will certainly not sufficiently compensate for the deterioration, even are considered futile having spent a lot of time and cost. In general, the ecosystem condition of the sea on the island of Java has greatly declined. Therefore, ecosystem control activities must be initiated, starting from restoring the damaged ecosystem first. East Java Province has conducted coastal environmental rehabilitation activities



through the empowerment of surrounding communities. Fish planting projects have been commenced in four regencies of Banyuwangi, Lamongan, Probolinggo, and Pacitan. Rehabilitation of corals has also been conducted by making artificial reefs in Situbondo and Malang. Those measures of fish stocking, artificial reefs, and coral transplants have been carried out in the last four years, yet have not demonstrated a concrete success in restoring the coastal ecosystems in East Java. These unsuccessful attempts are allegedly affected by two factors. Firstly, the rehabilitation activities are lacking, so there is no equilibrium point between the healthy and damaged environments which resulting in the shortage of environmental supporting capacity to accelerate the rehabilitation. Secondly, there is the influence of wider environmental conditions. Marine waters are runoff from the upstream areas, and if these upper waters are contaminated, the pollutants will be possibly accumulating in the coastal regions.

Rehabilitation is one of the options in increasing the carrying capacity of the coastal environment, particularly in damaged areas. In the long run, the coastal rehabilitation is expected to improve the function and benefits of coastal natural resources for the community [1]. The planning of coastal environmental rehabilitation should be followed by directional, measurable, and comprehensive studies. Technical improvements of ecosystems can be made through the initial assessment in the form of observations and water quality analysis. One manifestation of coastal rehabilitation is the cultivation of mangrove forests along with the debarment of coastal areas destruction by their own communities [2]. This study aims to analyze the water quality in the study area as a basis for coastal rehabilitation planning.



Figure 1. Research area.

2. Research Method

2.1. Research Areas

This study was conducted in coastal regions of Probolinggo Regency (Figure 1). This research area is part of the Madura Strait waters which gets a lot of groundwater input towards the ocean.

2.2. Methods

This study is a survey research—research that does not make changes or give special treatments to the variables studied. Survey research is a study conducted to obtain the facts of the symptoms that exist and seek information factually. One of the first important steps is the collection of data and information related to the study to ensure that the activities are going well and reaches the objectives. The statistics used in this research consist of water quality parameter data through samplings, land use data, spatial planning documents, mangrove area map, and profile of the research area.

2.3. Data Analysis

Data analysis was done by comparing the sampling and laboratory analysis results with the water quality standard as stated in the Decree of Minister of Environment No. 51 of 2004 on the Quality Standard of Sea Water [3]. The parameters of seawater quality observed in this study consist of physical and chemical characteristics. The information obtained is a temporary water condition that represents one season at the time of sampling. The water quality analysis comprises of (1) biological parameters of coliform Bacteria; (2) chemical parameters of DO, BOD, $\text{NH}_3\text{-N}$, detergent/surfactants, and phenol compounds; as well as (3) physical parameters of turbidity level and suspended solids. The spatial analysis was conducted to obtain data on land use conditions in coastal areas and coastlines, as well as to overlap various spatial data using a mapping software.

2.4. Research Flow

The research flow explains the activities undertaken from the beginning to obtain results and to deduce conclusions at the end of this study. In general, the research concepts employed in these two areas are described in Figure 2 below.

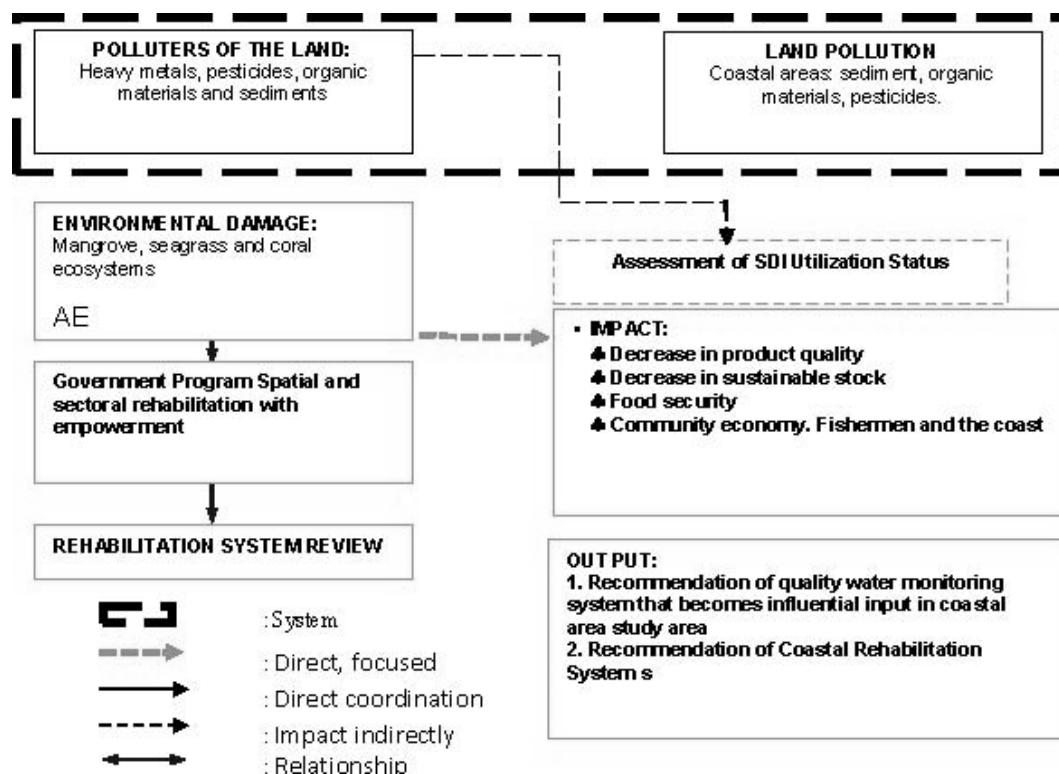


Figure 2. Research flow diagram.

3. Results and Discussion

3.1. Research Results

Water quality is a measure of water conditions seen from its physical, chemical, and biological characteristics [4]. The water quality also shows the water conditions relative to the needs of water and human biota [5]. The water conditions vary over time depending on the local ecological states so that the water quality includes complex subjects of the environmental science. Industrial activities such as manufacturing, mining, construction, and transportation are major causes of water pollution, as well as surface runoff from agriculture and urban areas. It is considered a complicated matter, reflected in the type of measurement and water indicator used. This measurement will be more accurate if it is done directly on site because the water is in equilibrium condition with the environment. Sampling in this

study was conducted in some regions that are assumed to be marine areas affected by the river as illustrated in the map of Figure 3.



Figure 3. Sampling location map.

The location used as the sampling point in this study is a large coastal area whose input water gets influence from the mainland through the river. The distribution of the sampling points and the parameters tested are presented in Table 1.

Table 1. Sampling points and field measurement results on water quality parameters.

Station Name	Position Lat. Lon.	Sal (ppt)	DO (mg/L)	Temperature (°C)	pH	Brightness	Phytoplankton (ind/L)	Zooplankton (ind/L)
S 1	S7 43 44.5 E113 15 30.0	30	8.4	29.4	7.19	1.50	7,458,333,336	4,166,666
S 2	S7 45 38.1 E113 17 07.3	29	9.9	28.9	7.1	2.25	6,835,186,351	1,153,765,471
S 3	S7 42 59.9 E113 10 37.8	28	9.1	29.2	7.14	1.80	20,833,333	2,083,333
S 4	S7 42 52.6 E113 08 04.1	28	7.7	30.5	7.16	1.80	20,833,333	2,083,333
S 5	S7 45 21.6 E113 18 39.2	26	7.1	29.8	7.14	-	3,356,408,643	1,223,690,651
S 6	S7 44 29.6 E113 20 47.7	28	6.4	28.8	7.16	0.50	191,666,666	2,038,333
S 7	S7 43 47.3 E113 22 43.5	27	5.2	29	7.6	1.25	175,000	6,250
S 8	S7 43 26.3 E113 24 16.4	25	7.8	29.4	7.16	2.00	1,905,461,157	2,447,381,302
S 9	S7 43 04.3 E113 25 24.5	26	6.1	30	7.12	1.00	1,922,942,452	1,573,316,551
S 10	S7 42 43.2 E113 26 20.2	23	5.8	30.1	7.14	3.50	1,940,423,747	4,166,667
S 11	S7 42 09.1 E113 27 26.3	25	7.6	30.5	7.12	1.50	14,583,334	3,671,071,953
S 12	S7 41 39.1 E113 28 35.2	28	5.9	29.9	7.12	2.00	1,083,840,291	6,992,518,006
S 13	S7 41 25.5 E113 29 36.7	26	7.2	31.7	7.12	4.20	1,485,910,076	0
S 14	S7 41 34.9 E113 31 02.7	26	7.1	30.8	7.15	6.50	29,166,667	8,740,647,507
S 15	S7 41 59.8 E113 32 33.7	29	7.8	30.2	7.12	17.0	1,011,157,438	2,272,568,352
S 16	S7 41 58.6 E113 34 32.3	26	6.7	28.4	7.25	10.20	1,730,648,206	3,146,633,103
S 17	S7 41 01.7 E113 33 28.6	28	6.8	30.9	7.24	10.0	3,915,810,083	4,195,510,803
S 18	S7 40 40.6 E113 31 34.7	27	7.4	30.1	7.22	5.00	3,199,076,988	2,097,755,402
S 19	S7 40 40.6 E113 29 45.8	28	6.9	30.3	7.23	11.0	8,006,433,117	1,573,316,551
S 20	S7 41 00.7 E113 28 01.0	28	6.8	28.6	7.24	8.80	1,241,171,946	2,097,755,402
S 21	S7 41 18.4 E113 25 47.6	29	6.7	28.5	7.27	7.00	5,226,907,209	1,922,942,452
S 22	S7 41 46.0 E113 24 17.8	28	7.1	28.1	7.28	3.50	1,206,209,356	1,048,877,701
S 23	S7 42 20.6 E113 20 47.6	30	6.4	29.9	7.15	2.30	7,272,218,726	3,146,633,103
S 24	S7 42 29.0 E113 17 55.7	28	5.1	27.9	7.12	2.00	4,510,174,114	4,370,323,754
S 25	S7 42 50.2 E113 12 07.5	29	4.3	28.8	7.11	1.00	5,226,907,209	41,666,666
S 26	S7 43 03.3 E113 09 19.3	28	6.1	28.6	7.1	0.50	5,436,682,749	6,468,079,155
S 27	S7 42 45.6 E113 07 02.9	27	6.4	28.3	7.09	0.50	8,333,333	0
S 28	S7 41 28.6 E113 06 29.0	27	5.6	28.5	7.5	1.00	1,031,396,406	1,223,690,651
S 29	S7 40 44.2 E113 07 39.7	28	4.5	29	7.13	2.00	12,499,999	8,740,647,507
S 30	S7 39 38.0 E113 08 49.4	29	4.9	29.2	7.12	2.20	5,069,575,554	41,666,663

Station Name	Position		Sal (ppt)	DO (mg/L)	Temperature (°C)	pH	Brightness	Phytoplankton (ind/L)	Zooplankton (ind/L)
	Lat.	Lon.							
S 31	S7 39 50.5	E113 10 23.8	29	5.7	29.6	7.2	2.00	7,691,769,806	1,048,877,701
S 32	S7 39 52.7	E113 11 50.3	28	5.1	29.5	7.17	8.00	613,341,068	-
S 33	S7 40 20.3	E113 12 46.9	28	6.0	29.7	7.69	7.00	4,575,051,553	-
S 34	S7 40 33.7	E113 13 34.4	29	6.1	29.3	7.09	5.10	3,016,692,427	-
S 35	S7 40 28.8	E113 14 17.4	27	6.9	28.8	7.09	7.00	14,583,333	-
S 36	S7 39 39.5	E113 14 48.8	26	6	29.1	7.8	6.50	3,234,039,578	-
S 37	S7 38 57.6	E113 15 32.1	30	7	29	7.08	5.00	-	-
S 38	S7 40 01.7	E113 15 59.9	29	7.4	29.7	7.11	6.00	-	-
S 39	S7 41 28.0	E113 16 24.4	29	6.6	31.7	7.16	3.50	-	-
S 40	S7 42 44.9	E113 14 18.6	27	6.8	33.3	7.2	3.10	-	-
Average			27.65	6.61	29.575	7.2045	4.175	-	-

The water quality in several locations of both coasts and rivers having a direct or indirect impact on the coastal ecosystem cannot be separated from the influence of the surrounding land use. The results of field identification explain some types of land use that have the opportunity to affect the river flow until the stream reaches the coastal area and adversely affect the dynamics of the existing ecosystem. Land covers around the river include the form of mangroves, ponds, settlements, industries, mooring activities, and intensive ponds.

3.2. Rehabilitation Prospect Analysis

This study identifies some of the internal strengths of the coastal area of Probolinggo Regency, i.e., the community's positive perception of rehabilitation activities, the availability of potential sites for rehabilitation, and the full support of local authorities. In addition, there are opportunities where the program can get help from the government (e.g., seedlings). However, the lack of technical capacity and the threat of coastal environmental degradation due to the input of pollutants into the river and carried down to the coast are the two limiting factors that need to be handled properly. With the dominant strengths and opportunities described above, coastal rehabilitation activities have prospects to be implemented in the coastal area of Probolinggo Regency. These strengths and opportunities must be optimized, while the limiting factors must be overcome. Based on the survey results including the measurements of the water quality, this coastal rehabilitation program is highly feasible. Thus, the rehabilitation of mangroves is recommended, starting from the area as illustrated in Figure 4. The suggested planting system is for a location of the expanse type, then planting can be done with a medium to a dense distance of (1 m x 1 m), (1 m x 2 m), or (2 m x 2 m) from the back side toward the front zone. Reaching the regions of inundation and strong wave currents, the planting should be stopped (As for the planting along drains or ditches, it can be carried out more closely with the distance Figure 4a). between plants of 20–60 cm in 1–5 rows according to the conditions in the field (Figure 4b).

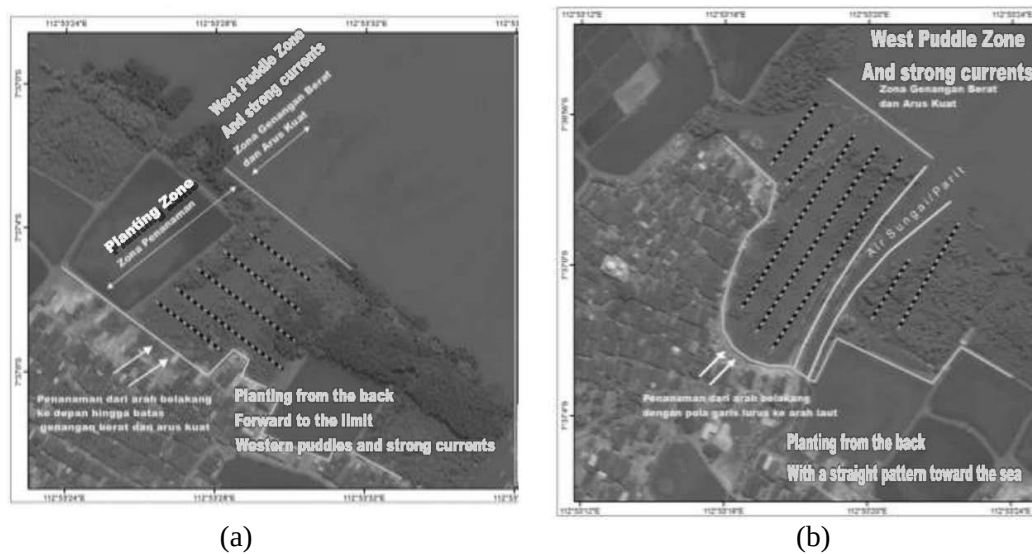


Figure 4. (a) Planting patterns in sandy coastal landscapes; (b) Planting patterns in the area along the river/ditch channel.

4. Conclusion

The results of water quality measurements in the coastal area of Probolinggo Regency indicate an environmental degradation, probably due to the influence of river runoff that leads to the coastal region of Probolinggo. The outcome of the tabulation of strengths, weaknesses, opportunities, and threats of the coastal area rehabilitation planning suggests a means of mangrove rehabilitation. This study is a multi-year research that will assess the impact of water quality reduction on fisheries activities as well as the design of control systems on the quality of waters in coastal areas.

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