Efforts to Mitigate the Quality of Surabaya River Water as a Drinking Water Source

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Abstract. The aim of this study is to decide the strategy of mitigating the quality of river water of the Surabaya River as raw source for drinking water. The study was carried out during both the rainy (January – February 2021) and dry seasons (September – October 2021). Research sampling uses random sampling in term of observation at four Locations with different activities. The sample obtained was tested for its quality of water indicators, such as temperature, brightness, pH, dissolved oxygen, organic matter, nitrates, and phosphates). The results showed that indicator of pH, temperature, and nitrates, met class II water quality standards. However, indicators of dissolved oxygen, organic matter, and phosphates had not met class II as stated in the Regulation of Government 82/2001. Lightly pollution identified the water quality status of the Surabaya River in the rainy and dry seasons. As a result, efforts to mitigate water quality were required, including regulating water infiltration, monitoring water quality at water sources, conducting afforeLocation programs, reorganizing settlements and industries on watershed banks, and incorporating biological treatment using biofilter technology into the Surabaya River's initial water treatment process.

Keywords. Mitigation, Water Quality, Pollution Index Method, Surabaya River

1 Introduction

Rivers have a very dynamic system where activities around water banks can influence water quality that can change from up to downstream. The area of around water bodies, including resident area, industries, and agricultural activities, will impact the entry of polluted materials into river flows [1]. One of the rivers used as a raw source by the drinking water work companies in Surabaya City is the Surabaya River. The high pollution level cannot be separated from the weak pollution control mechanism. The pollution that enters the Surabaya River includes industry, domestic, and agriculture. Domestic waste is the most significant contributor to pollutants in the Surabaya River [2]. Therefore, monitoring and controlling the quality of raw resources should be conducted in order keep the Surabaya River in compliance with quality standards.

The quality of water is related to the natural of existing water and the components of living beings, energies, substances or other components in the water. In addition, it is also an adjustment to water for its use, for example, for fisheries, recreation, drinking water, irrigation, industry, etc. The quality and quantity of water sources are highly dependent on the catchment area's vegetation, the amount and type of activity that will lead to water sources, and the ability of water sources to assimilate pollutants they receive. [3]. Water quality assessment is essential to reduce and prevent water pollution from producing an excellent ecological or potential water status [4]. Water quality assessment can identify sources or factors of pollution and understand the timing or spatial conditions in water quality in term of management for effectiveness the quality of raw sources [5]. A water quality evaluation will affect the index of river quality by showing polluted or unpolluted water conditions in the designation of water sources and raw water needs within a specific time.

Raw water with decent quality and quantity is needed as the population grows. The need for drinking water is increasing, while the supply of natural water for drinking water is decreasing both in quantity and quality. Technological developments also increase water needs in several sectors, such as domestic needs, industry, agriculture, hydroelectric power plants, plantations, Etc. [6]. Climate change influences the hydrological cycle [7], causing the demand for raw water to decrease in quality and quantity, potentially resulting in hydrological disasters. However, supporting the accurate data through improvement of technologies and sciences could be used to anticipate and to minimize

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any losses due to environmental damage in Surabaya River watershed. An early warning system, which acts as a non-structural measure [8], is a significant issue in disaster risk minimization and is important to mitigate the possibility of a hydrological disaster, therefore the damage can be reduced and policies that make the community better prepared to face disasters can be implemented for stakeholders [9].

Based on the above problems, there is a need for research into efforts to mitigate the quality of water in the Surabaya River in order to treat as a drinking water source. The objective of this study is to analyze the rank or position quality of water based on pollution index values [10, 11, 12, 13], where changes in the quality of water quality Surabaya River will affect mitigation efforts in treating the source Surabaya River as raw water for drinking water.

2 Research Method

The study was conducted at four sampling Locations in the Surabaya River Watershed, where river water was sampled. Chemical parameter analysis was carried out at the UPN Veteran Jawa Timur Environmental Engineering Laboratory. Water sampling is carried out in the rainy season (January – February 2021) and the dry season (September – October 2021). The physical parameters of the water analyzed are temperature and brightness, while the chemical indicators are pH, dissolved oxygen, organic matter as BOD, Nitrate, and Phosphate.

The method of determining the sampling Location is carried out by purposive sampling, which is a way of determining the sample by considering the condition of the state of the research area from direct observations in the field.

Evaluation of water quality is carried out by referring to Regulation of Government number 82/2001 about class II water quality level [14]. Water quality is measured by using Pollution Index based on The Minister of Environment Decree, Number 115 of 2003 [15]. The advantage of the Pollution Index method is that it can know the quality level of raw water monitored with only one data series, requiring a short cost and time. The Pollution Index (IP) is determined for an allotment and could be improved for several designations for the whole water bodies or part of a river. The Pollution Index (IP) includes various independent and meaningful quality parameters commonly used to know the level quality of water. The quality level of the water as shown in Table 1.

Table 1. Water quality level is based on the index of pollution value

Index of Pollution Value	Status of Water Quality
IPj ≥ 10	Heavy Polluted
5 ≤ IPj ≤ 10	Fairly Polluted
1 ≤ IPj ≤ 5	Lightly Polluted
0 ≤ IPj ≤ 1	Good Condition

Source: The Minister of Environment Decree, Number115/ 2003

While the formula for the Index of Pollution Method is:

$$IP_j = \sqrt{\frac{\left(C_i/L_{ij}\right)_M^2 + \left(C_i/L_{ij}\right)_R^2}{2}} \quad (1)$$

Suppose Lij defined the indicators of water quality concentration recorded in the water quality standards (j) and Ci indicates the parameters of water quality concentration (i) got from the results of water snippet analysis at a Location where footage is taken from a river channel. In that case, IPj is the index of pollution for the classification (j), which is a role of Ci /Lij. In the IP model, the mean value of the overall Ci/Lij value is needed as a pollution benchmark, however, if one of the Ci/Lij values is greater than 1, the value will be ignored. So this index should include the maximum Ci/Lij value with (Ci/Lij) R as the average Ci/Lij value; (Ci/Lij) M maximum Ci/Lij value. An allotment (j) will further pollute waters if (Ci/Lij) R and or (Ci/Lij) M are more significant than 1.

The results of determining the level of water quality considered the index of pollution will be associated with deciding mitigation strategies in treating the Surabaya River water as a drinking water source.

3 Result and Discussion

3.1 Water Quality of Surabaya River

According to the results of water quality sampling in the Surabaya River during the wet and dry seasons at four observation locations, it is known that the water quality condition of the Surabaya River is included in lightly polluted conditions. Therefore, the results of the quality of water interpretation of the Surabaya River are demonstrated in Table 2 and Table 3.

Table 2. Data of water quality interpretation in Surabaya River in the rainy season

Parameters	Unit	Standard Quality Class II	Location 1	Location 2	Location 3	Location 4	Average
pH	-	6 – 9	9.475	9.331	9.263	9.294	9.341
Temperature	°C	± 3	27.78	27.59	28.08	27.63	27.78

Brightness	Cm	-	9.37	12.00	6.06	5.56	8.25
Dissolved Oxygen	mg/L	4	5.99	4.53	3.77	3.69	4.50
Biological Oxygen Demand	mg/L	3	16.13	18.54	14.98	13.52	15.80
Nitrate	mg/L	10	6.00	4.64	4.47	5.15	5.07
Phosphate	mg/L	0.2	0.36	0.32	0.36	0.29	0.34

Table 3. Data of water quality interpretation in Surabaya River in the dry season

Parameters	Unit	Standard Quality Class II	Location 1	Location 2	Location 3	Location 4	Average
pH	-	6 – 9	9.06	8.96	9.72	9.72	9.37
Temperature	◦C	± 3	29.94	29.82	29.16	29.39	29.58
Brightness	Cm	-	71.84	63.18	25.69	21.50	45.55
Dissolved Oxygen	mg/L	4	4.04	3.97	1.50	1.32	2.71
Biological Oxygen Demand	mg/L	3	25.97	23.33	21.65	20.84	22.95
Nitrate	mg/L	10	3.31	2.49	2.32	4.53	3.17
Phosphate	mg/L	0.2	0.49	0.65	0.68	1.24	0.77

Based on the reference to Government Regulation 82 of 2001, it is known that the average degree of acidity (pH) in all observation locations in the rainy season is 9.34 and dry season is 9.37. This shows that the average pH is still within class II river water quality standards, 5-9.

From the results of temperature measurements at four observation locations, the average temperature in the rainy season was 27.78 OC and the dry season was 29.58 OC. This shows that the average temperature in both seasons is still the standard in between class II water quality standards, between 23-33OC. However, the surrounding air temperature influences river water temperature, so the benchmark used in the quality standard is normal air temperature. The normal air temperature is 28OC [16].

The results of measuring water brightness at four observation locations obtained the average water brightness in the rainy season of 8.25 cm and the dry season of 45.55 cm. This shows that the low brightness of the water in the wet season is due to the murky river conditions compared to the dry season. The brightness of water demonstrated the clarity of the water. The higher the water's brightness, the deeper the light penetrates the water. The brightness of the water depends on the color and turbidity. The reduced brightness of water will reduce the photosynthesis ability of aquatic plants, and it can also affect the physiological activities of aquatic biota. In this case, materials in water, especially in the form of suspensions, can reduce the brightness of water [17].

The average dissolved oxygen is 4.5 mg/L from the measurement results in the rainy and dry seasons at 2.71 mg/L. While the minimum class II river DO quality standard was 4 mg/L. It indicates that the dissolved oxygen content in the wet season still meets the quality standards, while in the dry season, it does not fulfill the standards of class II river quality.

The analysis obtained the average need for biological oxygen Demand (BOD) from the rainy season results at 15.8 mg/L and the dry season at 22.95 mg/L. in comparison, the maximum BOD quality standard for class II rivers was 3 mg/L. This study presents that the raw water of Surabaya River is in high contamination condition or does not fulfill the standards of class II river quality in both seasons. Therefore, the status of Surabaya River as raw water presents a heavily contamination as shown by organic matter of BOD due to exceeds than 3 mg/L [18].

From the nitrate and phosphate analysis results in all observation locations, the average nitrate in during wet and dry seasons was 5.07 mg/L and 3.17 mg/L, respectively. The maximum class II river quality standard is 10 mg/L. This shows that the nitrate content in river water is below the class II river quality standard both seasons. Meanwhile, the average phosphate in the wet season was obtained at 0.34 mg/L, and 0.77 mg/L was obtained during the dry season. Class II river quality standards allowed a maximum of 0.2 mg/L. This shows that river water contains of phosphate, which has not fulfill the class II river quality standards in both seasons.

3.2 Water Quality Status of Surabaya River

Water quality status is the level of water quality information that present a contaminated or unpolluted water environment of a river under certain time according to the determined the standards of water quality as comparison [19]. The Index of Pollution (IP) is applied to describe the water quality index of Surabaya River, concerning the value of the water quality test indicators for each observation location and the value of the water quality standard class II of Regulation of Government 82/2001. The IP method is a national standard for river water quality [20]. The calculation of the index contamination or IP of the Surabaya River are described in Table 4.

Table 4. Data of water quality status of Surabaya River

Location	Rainy season		Dry season	
	Average index of pollution (IPj)	Water quality status	Average index of pollution (IPj)	Water quality status

1	3.28	Lightly Polluted	3.89	Lightly Polluted
2	3.41	Lightly Polluted	3.90	Lightly Polluted
3	3.15	Lightly Polluted	3.80	Lightly Polluted
4	2.98	Lightly Polluted	4.85	Lightly Polluted

According on the calculation of water quality level in Table 4, The water quality status found at all observation locations in the rainy and dry seasons was classified as a lightly contaminant. In the rainy season, the highest average index of pollution value is known in Location 2 at 3.41 and the lowest in Location 4 at 2.98. The average index of pollution value is seen to have decreased water quality status, showing a reaeration process along the watershed. The reaeration process adds O2 content to water due to turbulence, so O2 diffusion occurs from air to water. Meanwhile, in the dry season, the highest average pollution index value is known at Location 4 at 4.85 and the lowest at Location 1 at 3.89. The average index of pollution value seems to have increased water quality status, and this shows that the many community and industrial activities around the Surabaya River watersheds play a crucial role in influencing the water quality of the Surabaya River. The relationship between the community, industrial activities, and water quality information is complicated and tends to be specific location, so it takes hard work to realize its measurable numbers [11]. The situation of the water quality level based on the average index of pollution value at each observation location in the Surabaya River is presented in Fig. 1 and Fig. 2.

Fig. 1. shows that the average index of pollution value is between 2.98 – 3.41. These results are classified as lightly polluted water quality status. There was an increase in the IP value at Location 2 due to the high influx of pollutants due to the existence of a landfill and the activities of the surrounding community that disposed of domestic waste. While in Fig. 2. shows that the average index of pollution value is between 3.80 – 4.89. These results are also still classified as lightly polluted water quality status. There is an increase in the IP value at each observation location due to the non-optimal process of self-purification by the river from pollutants. This is shown by the high content of organic matter (BOD) along the Surabaya River watershed.

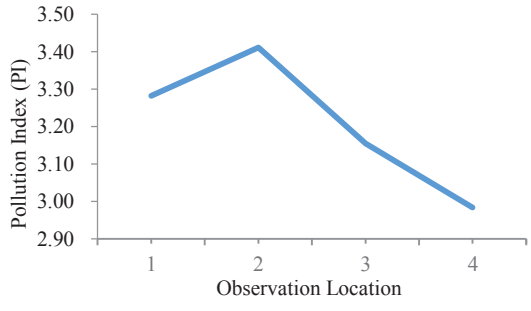

Fig. 1. Water Pollution Index Refers to Class II Water Quality Status Conditions in the Rainy Season

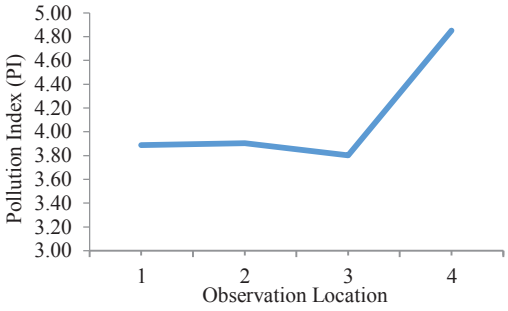

Fig. 2. Water Pollution Index Refer Class II Water Quality Status Conditions in the Dry Season

3.3 Water Quality Status of Surabaya River

Mitigation efforts are carried out to reduce some negative impacts and risks of decreasing quality of raw source Surabaya River which will be used as a drinking water source. Therefore, such efforts need to be made by:

a. Regulate wastewater infiltration in agricultural areas and comprehensively control household waste from all sources of pollutants around the watershed. However, efforts to achieve significant environmental quality improvement, especially water quality management, require a relatively long time and considerable funding from internal resources. Therefore, properly identifying water quality conditions in river systems based on limited observation is the main task of finding the environmental management objectives, especially river water quality management [21].

b. Conducting afforeLocation programs on the banks of the Surabaya River watershed and in the upstream area of the river so that pollutants are not directly dumped into the river to realize 30% of the Surabaya River watershed bank area for green open space in the context of controlling the microclimate and allocating green infiltration.

c. Reorganizing settlements and industries on the Surabaya River Watershed banks.

d. Adding biological processes using biofilter technology in the pre-treatment process of drinking water treatment systems. Because if the concentration of contaminants in raw water is very high, then conventional treatment with chemical deposition will not be able to remove these pollutants [22].

4 Conclusion

The conclusions that can be obtained from this study are:

1. The raw quality of water indicators of Surabaya River, such as pH, temperature, and nitrates, still meet class II water quality standards. In contrast, DO, BOD, and phosphates have not met class II water quality standards, refers to the Government Regulation Number 82/2001.
2. The raw quality of source water status of Surabaya River during whole season is identified in the category of lightly contaminants refers to the Minister of Environment Decree Number115/2003,
3. To reduce some negative impacts and risks of decreasing water quality of Surabaya River as a raw

material for drinking water, it is necessary to strive for water quality mitigation, which includes regulating water infiltration, monitoring water quality at water sources, conducting greening programs, reorganizing settlements and industries on watershed banks, and incorporating biological treatment using biofilter technology in the Surabaya River's initial treatment process.

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