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Analyzing raw water quality of drinking water of Pelayaran River: Tribute to Brantas River

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ABSTRACT

Raw water quality for drinking water is a strategic issue requiring attention and environmental dynamics. River quality changes are crucial for sustainability and monitoring suitability. Kali Pelayaran, a tributary of the Brantas River, is a key source for drinking water in Sidoarjo Regency. The aim of the research is to analyze the water quality status of the Kali Pelayaran river as a basis for mitigating the sustainability of raw drinking water in Sidoarjo Regency. The length of the segment analyzed starts from the upstream branch of the Brantas River which enters the Pelayaran River to the intake of the Tawangsari WTP, a distance of 21 kilometers. The research method that will be implemented is: analyzing the existing condition of the water quality of the Kali Pelayaran river which is divided into 8 segments by measuring the quality status of the river using the Pollutant Index (IP). Next, use the K-means method to create clustering based on the measured level of quality status. The water and sediment quality parameters analyzed were pH, temperature, DO (Dissolved oxygen), BOD (Biological oxygen demand), COD (Chemical oxygen demand), TDS (Total dissolved solids), and TSS (Total suspended solid). Research conclusions was formulated in an integrated manner regarding the description of current conditions and predictions for the future, presented in the form of tables, graphs, and maps.

Keywords:

river water
raw water
drinking water
IP
water quality

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INTRODUCTION

Kali Pelayaran is used as a source of raw water for PDAM (*Perushaan Daerah Air Minum*, Indonesian regional water utility company) Delta Tirta, Sidoarjo Regency. River Water Treatment from Pelayaran River is carried out at IPAM (*Instalasi Pengolahan Air Minum*, Water Treatment Plan) Tawangsari managed by PT. Taman Tirta Sidoarjo and PT. Hanarida, is a foreign company from Malaysia and is the first drinking water treatment plant using concrete construction in Indonesia. Based on Nurjannah's practical work report, (2018), PT. Taman Tirta Sidoarjo takes raw water supply from Pelayaran River as much as 300 liters/second in accordance with the capacity of the IPA built. In accordance with the results of the water test of the Kali Pelayaran water body in the period 05 – 19 June 2023 by the accredited KAN (*Komite Akreditasi Nasional*, National Accreditation Committee)-accredited Laboratory of Perum Jasa Tirta I, it is known that the quality of Kali Pelayaran still does not meet quality standards, with the quality of the parameters BOD = 7.81 ppm, COD = 34.26 ppm, and TSS = 30 ppm; TDS = 356 ppm, Temperature = 29.70C, DO = 3.9 ppm, NO2-N (nitrite) = 0.0964 ppm, Ammonia (NH3-N) = 0.3002 ppm, and detergent = 0.3883 ppm, thus exceeding the maximum limit value according to PP (*Peraturan Pemerintah*, Government Regulation) No. 22 of 2021 with the class of water bodies is Class II. This condition is a major problem issue with the quality of the Shipping River.

Kali Pelayaran River which is the headwaters of the Brantas River which forks in two from the Mangetan Canal River and its estuary flows into the Porong River. Based on research that has been evaluated on 16 parameters that affect the water quality of the Brantas River, of which as many as 13 parameters with good data conditions > 60%. The results of statistical analysis involving temperature, 6 significant parameters are

known to affect the level of water pollution of the upstream Brantas River, namely TSS, DO, COD, and Faecal Coli, Total Coliform, and NH3-N (Gafur, 2018; Novita et al., 2020).

The water quality of the Pelayaran River is considered poor based on the findings of macrobenthos in sediments and waters starting upstream of the Mangetan Canal River which is the upstream canal of the Shipping River, that macrobenthos diversity in the Mangetan Canal is very rare, and found 6 types of macrobenthos family Chironomonidae as many as 167 heads. The macrobenthos family is a poor indicator of pollution because macrobenthos in that family have resistance to metal pollutants such as cadmium (Cd) and copper (Cu) in sediments and waters (Akbar, 2021). These two heavy metals are parameters that are indicators of raw water quality standards for drinking water in the required amounts based on the Minister of Health Regulation No. 2 of 2023 and Government Regulation of the Republic of Indonesia (PP) No. 22 of 2021 (Pram, 2023; Saputra et al., 2023; Waluyo, 2023).

Based on the quality standards of water body classes, rivers in Sidoarjo Regency are one of the regions of East Java Province, having raw water sources from river water, the majority of which are in Class III and IV. The raw water sources in Sidoarjo Regency are entirely in the form of afvour rivers, so based on quality aspects they are inadequate and not suitable for consumption (Akbar, 2021). Therefore, the level of clean water services in Sidoarjo Regency currently needs to be optimally improved, especially in terms of quality.

Based on information from Perumda (*Perusahaan Umum Daerah*, Regional Public Enterprise) Delta Tirta, currently the target clean water service area in Sidoarjo Regency is Taman and Waru Districts, according to considerations from technical aspects (quality, quantity, continuity and affordability), and non-technical aspects in the form of social, economic, cultural, environmental. Based on secondary data, the level of clean water services in Taman and Waru sub-districts is still quite low, reaching only 36% using piped network installations with very small flows and sometimes even not flowing. Water quality is also inadequate where in the rainy season water actually tends to bring high turbidity levels (Adu-Manu et al., 2017; Jerves-Cobo et al., 2020; Ratnanik et al., 2018; Sibanda et al., 2014; Souza et al., 2023).

Based on the Business Plan Perumda Delta Tirta Sidoarjo (2023), the fulfillment of clean water needs in the Taman and Waru District service areas will be served from the Tawangsari IPA where the raw water source comes from the Pelayaran River. The target of serving water needs at the Tawangsari IPA is up to 1000 liters/second, and currently only operates as much as a capacity of 850 liters / second. Changes in quality and factors causing changes in water quality have never been studied. So efforts are needed to monitor the quality and sediment of raw water sources that will be used and support planning data for the future period.

The aim of the research is to analyze the water quality status of the Kali Pelayaran river as a basis for mitigating the sustainability of raw drinking water in Sidoarjo Regency. It is hoped that the research results will be able to analyze the water quality status of the Kali Pelayaran river as a mitigation effort for the sustainability of raw drinking water.

METHOD

The research method uses primary data analysis of the results of measuring the water quality of the Kali Pelayaran river which is divided into 8 segments along 21 km, starting from the upstream branch downstream of the Brantas River which enters the Pelayaran River to the Tawangsari IPA Intake. The segment under study can be shown in Figure 1.

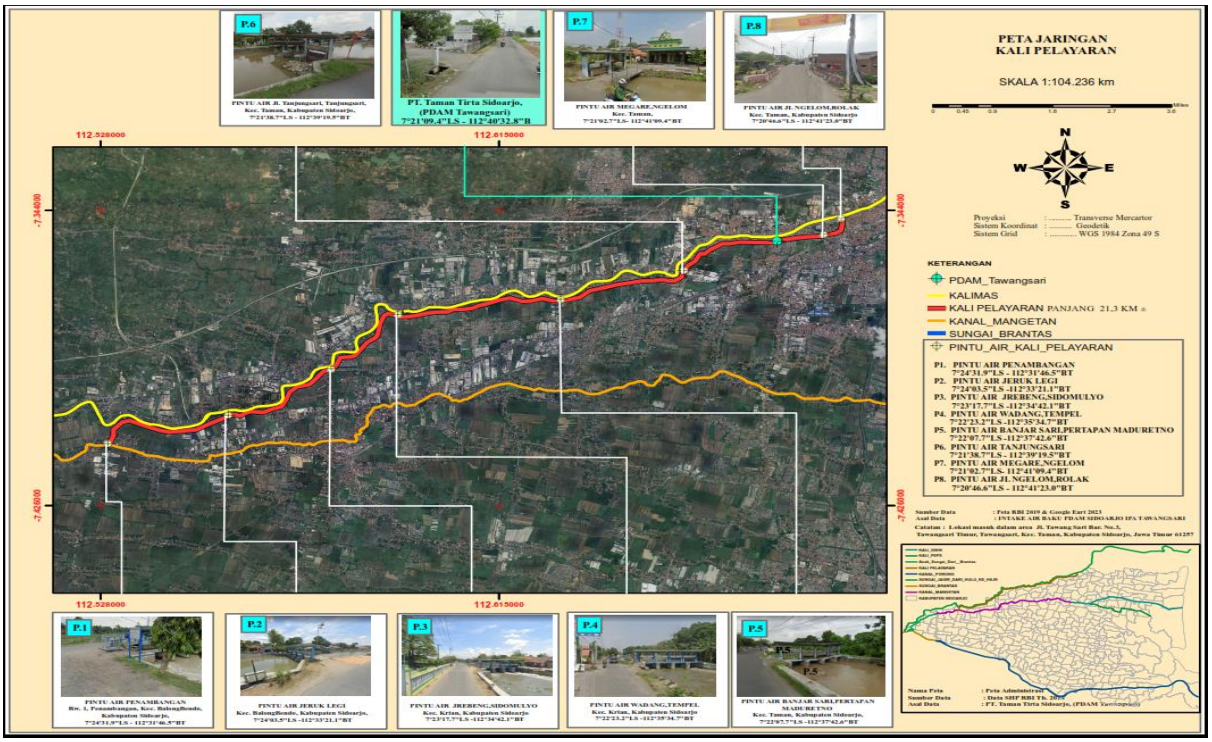


Figure 1. Sampling Point Location

Analysis of pollution levels using the IP (Pollutant Index Level Classification) method is carried out to determine the level of pollution relative to certain water quality parameters. The steps to determine the level of pollution by selecting the concentration of quality standard parameters that do not have a range, calculating the Ci / Lij price of each parameter at each sampling location.

The procedure for using the IP method

1. Lij = concentration of water quality parameters listed in the quality standards of a water designation (j)
2. Ci = concentration of water quality parameters (i) obtained from the results of water snippet analysis at a location where footage is taken from a river channel
3. IPj = pollution index for allocation (j) which is a function of Ci/Lij

$$IPj = \frac{\sqrt{\left(\frac{Ci}{Lij}\right)^2 M \; - \left(\frac{Ci}{Lij}\right)^2 R}}{2} \qquad (1)$$

Information

IPj	= Pollution Index for Allocation (J)
Ci	= Concentration of water quality parameters (i)
Lij	= Water Allocation Quality (J)
(Ci/Lij) M	= Max value of Ci/Lij
(Ci/Lij) R	= average value of Ci/Lij

IP value categories are:

IPj $0 \leq \leq 1.0$	= meet quality standards (Good)
$1,0 < IPj \leq 5,0$	= lightly polluted (slightly polluted)
$5,0 < IPj \leq 10$	= moderately polluted (fairly polluted)
$IPj > 10.0$	= heavily contaminated (heavily polluted)

RESULTS AND DISCUSSION

Pelayaran River is a tributary of the Brantas River which along the river bank is surrounded by residential areas. There are many household drain pipes to the river which of course without processing first. Analysis of the water quality of the Kali Pelayaran river is important to do considering that Kali Pelayaran is one of the sources of raw water taken by PDAM Delta Tirta to meet the drinking water needs of Sidoarjo Regency residents. Several segment points in the study also show the activities of the surrounding community

for freshwater aquaculture. Monitoring of Kali Pelayaran river water quality is carried out routinely by Perum Jasa Tirta with laboratory tests every six months. The results of the Pelayaran River water quality test are shown in Table 1.

Table 1. Pelayaran River Water Quality Test Results

Segment	Point	Concentration (mg/L)						
		pH	***Temperature***	***DO***	***BE***	***COD***	***TSS***	***TDS***
seg.1 - 2	1	8,3	26	4,2	13	28	80	19400
seg. 2 - 3	2	8,28	26	2,8	19	40	288	19700
seg.3 - 4	3	8,3	26	4,8	9	20	196	20400
seg. 4 - 5	4	8,35	26	2,6	18	40	128	20700
seg. 5 - 6	5	8,45	26	2,7	19	40	148	20700
seg. 6 - 7	6	8,5	26	1,8	26	56	154	21300
seg. 7 - 8	7	8,45	26	1,2	28	60	126	20900
seg. 8	8	8,55	26	2	26	56	76	21500

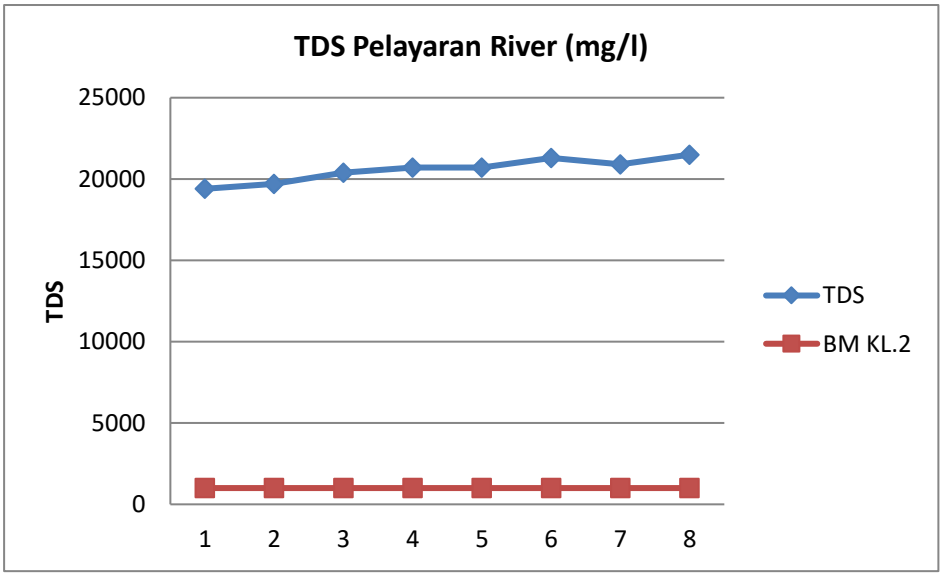
Source: Primary data,, 2023

Water Quality Analysis

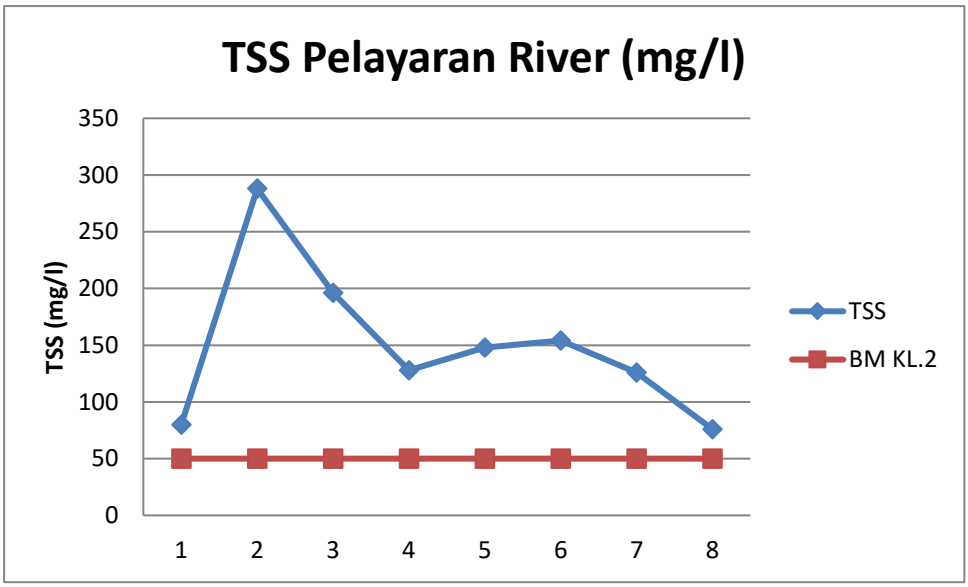
Testing of river water parameters of Kali Pelayaran will be measured based on Water Quality Standards of River Water Bodies and the like in accordance with Government Regulation Number 22 of 2021 concerning Environmental Protection and Management. Quality standards are thresholds for the levels of living things, energy substances, or components that exist or must be present and/or pollutant elements that are tolerated for their presence in water (AKBAR, 2022).

Physical parameters

Physical parameters include: temperature, TDS, TSS. The results of water quality tests can show that the temperature at all points is the same, which is 260 C. The highest TDS level in segment 8 is 21,500 mg / l and the lowest level is 19,400 mg / l at point 1 (segment 1). The TDS content is very high when adjusted to the threshold of quality standards, PP 22/2021 in Annex VI, which is 1000 mg/l with a measurement method using gravimetery.



While the TSS parameter has a safe threshold of quality standards at 50 mg / l. based on the results of the analysis of TSS content measurement in Kali Pelayaran River water is the highest 288 mg / l at point 3 and the lowest level is 76 mg / l.

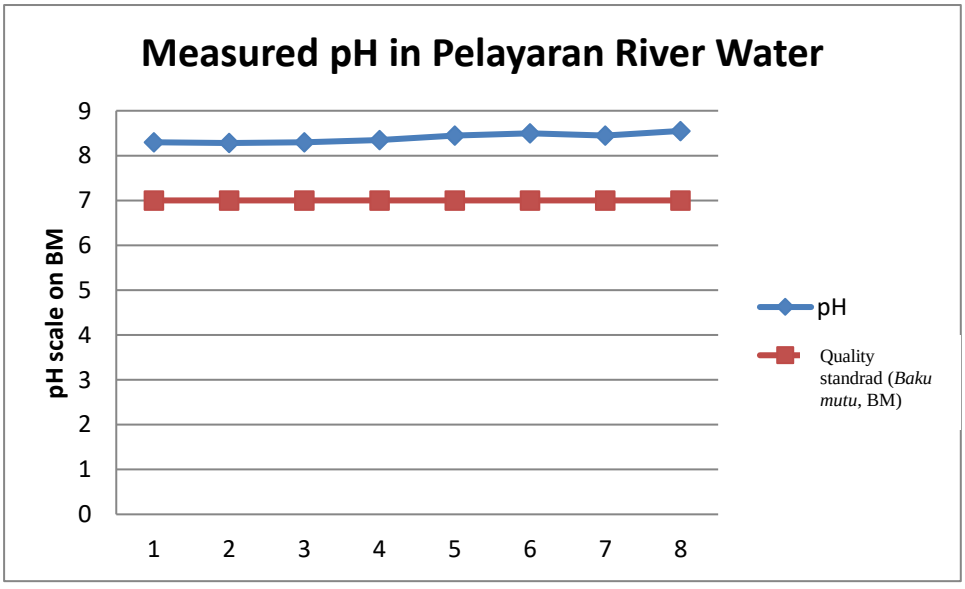


Both TDS and TSS based on the results of the study obtained results that exceed the required quality standards. TDS parameters are components of inorganic salts and a small amount of organic matter in adequate amounts in nature, caused both by hydrogeological conditions, domestic activities, and other activities around the banks of the Kali Pepelayaran river.

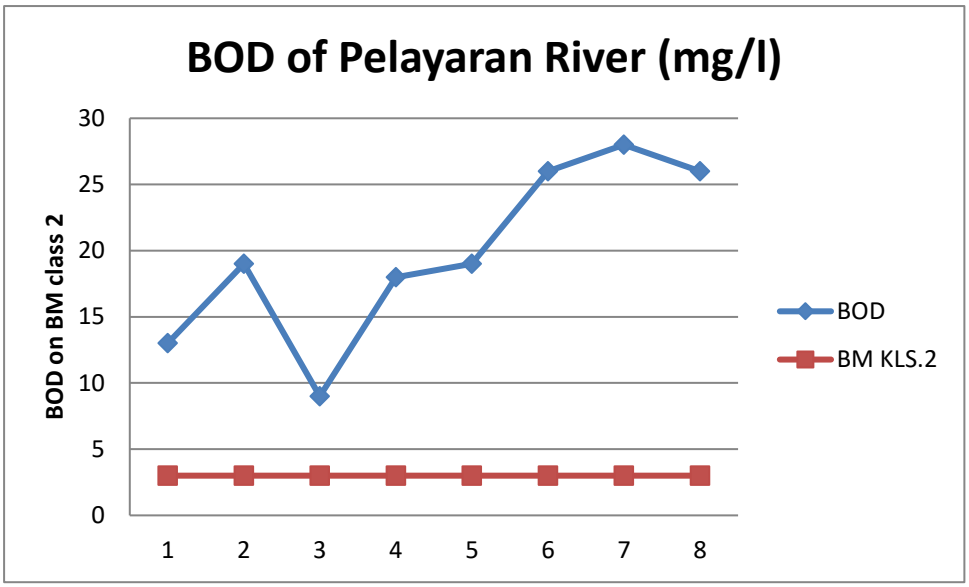
The influence of river location on high TDS levels is caused by ionic elements Na+ and Cl^-, so it is equated with the levels of these two ionic elements in seawater, where seawater has high TDS levels (Orji et al., 2013). Turbidity can be converted with TDS and TSS levels. The higher the TDS level, the higher the turbidity of the waters.

Chemical Parameters

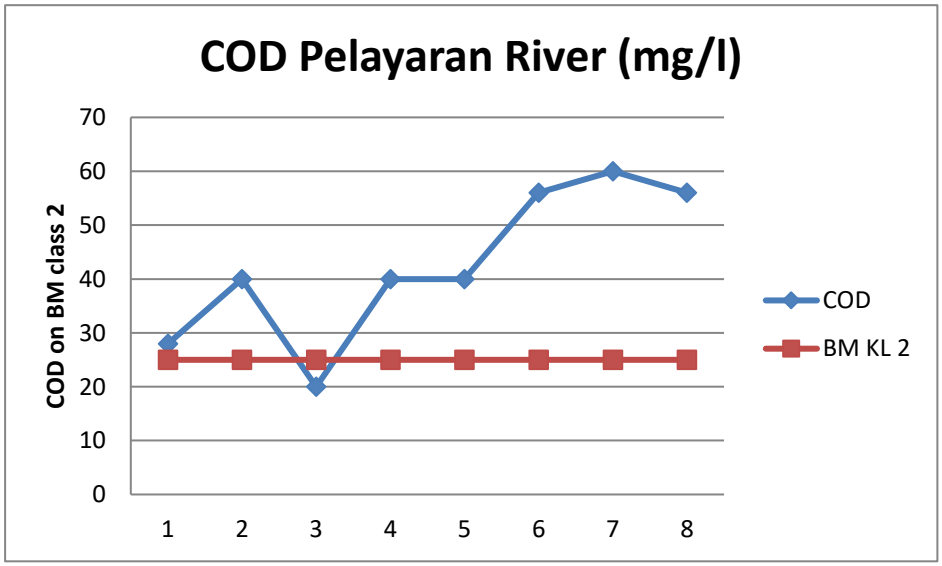
Based on the results of Kali Pelayaran river water measurement, it was found that the pH conditions on all segments of the monitoring point were in a state of high acidity, close to alkaline, which is above 8. This condition shows that the presence of pont source and nonn point source affects the pH condition in the Kali Pepelayaran river, apart from local settlements. pH close to alkaline can be due to contamination from detergents that can result from household activities (Access, 2018).



The concentration of BOD at all monitored segment points exceeded the required quality standard of 3 mg/l.

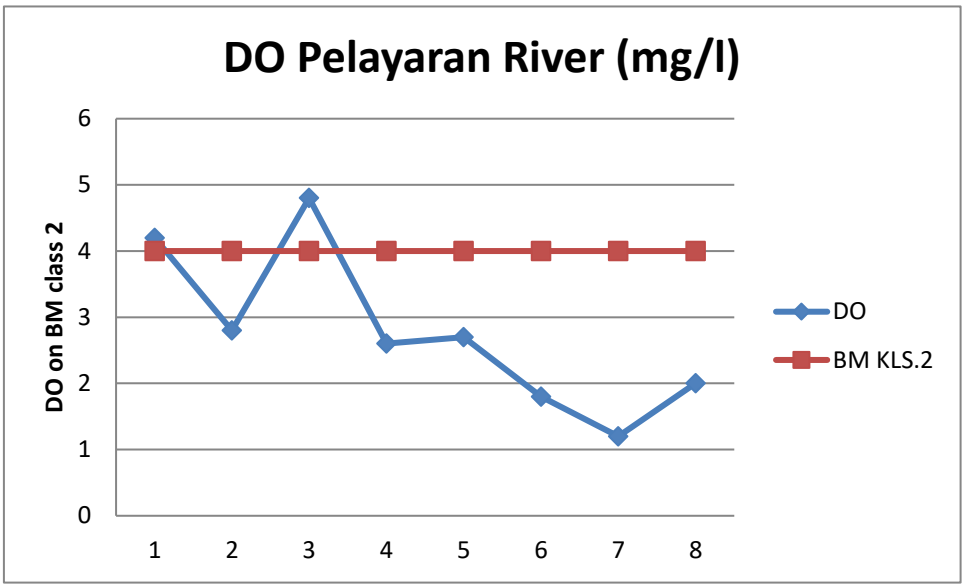


Similarly, COD levels at almost all points of the segment tested exceeded the required quality standards, namely 25 mg / l for the class of river water bodies and the like, class two.



The high levels of BOD in Kali Pelayaran river water are caused by the influx of domestic wastewater from households originating from settlements around the riverbanks. The concentration of BOD indicates high water pollution, because it means a high concentration of organic pollutants that enter the river. (Fulazzaky, 2009)

In general, high concentrations of BOD are followed by low dissolved oxygen (DO) content. Because microorganisms need a lot of oxygen to decompose organic matter that enters the river, so the DO levels are low. DO is one of the benchmarks of water quality, the higher the DO value the better the quality of the river (Gafur, 2018; Lusiana et al., 2020).



In accordance with PP no. 22 of 2021, the DO value has a threshold of 4 mg/l for the second class of river water bodies. The condition of DO is quite well measured at points 1 and 3, namely segments 1 -2 and segments 3 -4. This can be due to the fact that in this segment there are no settlements and only green open spaces are located on the banks of rivers.

High COD levels exceed quality standards due to the discharge of organic and organic pollutants into river water. This can be sourced from household and agricultural activities that become non-point sources around the banks of the Kali Pelayaran river. Factors that affect COD are dissolved oxygen, organic substances and other contaminants. Where oxygen solubility depends on temperature, atmospheric pressure and salt content in water (Komatina, 2020; Lusiana et al., 2020).

Biological parameters

The biological parameter observed was the microbiological concentration of E. Coli bacteria where the results of measuring E. Coli content along the Cruise River segment as many as 8 points all showed high E. Coli pollution conditions. Exceeding 10,000 MPN/100 ml. The content of coliform bacteria has the potential as a source of disease, so its existence is very dangerous, related to the function of the Kali Pelayaran river whose water is used as raw water for clean water which is processed into drinking water.

One of the causes of the high concentration of total coliform is due to activities around the river, one of which is domestic activities along the river flow.

Human and animal feces can be one of the sources of this coliform bacteria, which is a type of pathogenic bacteria. Pathogenic bacteria contained in human feces, among others: Eschericia coli, Shigella sp., Vibrio chloreae, Campylobacter jejuni, and Salmonella (Fulazzaky, 2009; Tosic et al., 2019).

Water Quality Status based on Pollution Index (IP)

Based on research conducted by Mayaza et al. (2023) based on the Decree of the Minister of Environment No. 115 of 2003 and PPRI No. 82 of 2001 concerning Water Quality Management and Water Pollution Control, management and monitoring efforts are desired so that the desired water quality is appropriate for its purpose in order to ensure its quality remains in its natural condition. Water pollution control is an effort to prevent and overcome water pollution and restore water quality to ensure water quality in accordance with water quality standards. It is explained that water quality is a condition of water quality that is measured or tested based on certain parameters and certain methods based on applicable laws and regulations.

Water class is a water quality rating that is considered still suitable for use for certain purposes. Water quality status is the level of water quality conditions that show the condition of pollution or good conditions in water sources within a certain time by comparing with established water quality standards. In Minister of Health Regulation No. 2 of 2023, it is stated that the requirements for raw water to be suitable as drinking water are to meet physical, chemical, and biological feasibility through a treatment process or without a treatment process.

The results of the assessment of the pollution index on the Kali Pelayaran River based on 8 sampling points can be shown as follows.

Table 2. IP Calculation of Cruise Times

Segment	Point	IP
seg.1 - 2	1	LIGHT - MEDIUM
Seg. 2 - 3	2	LIGHT - MEDIUM
Seg.3 - 4	3	LIGHT - MEDIUM
Seg. 4 - 5	4	LIGHT - MEDIUM
Seg. 5 - 6	5	LIGHT - MEDIUM
Seg. 6 - 7	6	MEDIUM - HEAVY
Seg. 7 - 8	7	MEDIUM - HEAVY
Seg. 8	8	MEDIUM - HEAVY

Source: Primary data,, 2023

Based on the results of quantitative calculations, it can be explained that at points 6 to 8 tend to be moderately to heavily polluted waters. Even though it is approaching the intake point of IPA Tawangsari PDAM Sidoarjo.

Naturally, water pollution only occurs on the surface. The calculation of the water quality status of Kali Pelayaran is compared with the second class river water quality standards. If you look at the designation and function of Kali Pelayaran as clean water raw water to be treated at the Water Treatment Plant, pre-treatment must be carried out first before further processing in the main treatment so that the quality of drinking water raw water can be produced according to the quality standards set based on Minister of Health Regulation No. 2 of 2023.

The influence of domestic discharges around the river banks causes the pollution index to be greater in value and the condition of the water status of the Kali Pelayaran river is increasingly polluted or heavily polluted. Therefore, support from all parties is needed to increase awareness of residents to improve their quality of life and improve the sustainability of life in the river, especially seeing that the river is used as a source of raw water, clean water and drinking water.

CONCLUSION

Based on the results of the analysis of the Water Quality Status of Shipping Times classified as Medium to Heavy pollution. If considering its designation as one of the sources of raw water for clean water and drinking water to be treated by PDAM Sidoarjo Regency to meet the drinking water needs bstraof some residents of Sidoarjo Regency, efforts are needed to improve the quality of Kali Pelayaran river water, in order to provide benefits according to its designation. The participation of all parties is needed to support the Clean River program and mitigation efforts are still needed to get an overview of the status of the Kali Playaran river water quality for the next few years in the future, as its feasibility to become a source of drinking water raw water.

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