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Assessing the Water Quality Status Using the Pollution Index Approach – Case Study for Tiku Subwatershed, North Musi Rawas Regency

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ABSTRACT

Monitoring and assessment of water quality in subwatershed areas are essential to support sustainable watershed management, pollution control, and protection the aquatic ecosystems. This study aimed to assess the water quality status of the Tiku Subwatershed using the Pollution Index (PI) approach based on 12 key physicochemical parameters. Water samples were collected from three monitoring stations representing upstream, midstream, and downstream segments in September 2024. The analyzed parameters included dissolved oxygen (DO), biochemical oxygen demand (BOD), chemical oxygen demand (COD), pH, and heavy metals. Laboratory analyses were carried out following standard procedures, and the PI was calculated according to the Decree of the Indonesian Minister of Environment No. 115 of 2003. The results showed that PI values ranged from 1.15 to 3.90, indicating that all sampling locations were classified as lightly polluted. These findings highlight the need for targeted pollution control measures, particularly in upstream and midstream areas, to maintain water quality and support the sustainable functioning of aquatic ecosystems in the Tiku Subwatershed.

1. INTRODUCTION

Water is a natural resource that has a vital role in human life and ecosystem sustainability. Good water quality is an important prerequisite for various activities, such as domestic consumption, industry and especially the agricultural sector. In the agricultural sector, the availability of clean and high-quality irrigation water greatly influences plant productivity and soil health. Therefore, regular monitoring of water quality is an important aspect in efforts to maintain environmental sustainability and food security (Vörösmarty *et al*., 2021). In addition, water quality also influences the efficiency of water use in irrigation, which in turn can reduce costs and increase agricultural yields (Koech & Langat, 2018). Polluted water can contain various pollutants, such as heavy metals, excess nutrients, and pathogenic microorganisms, which not only damage aquatic ecosystems but also have a negative impact on agricultural yields (Batarseh *et al*., 2021; Malakar *et al*., 2019). Therefore, monitoring water quality, as regulated in water quality standards, is very important to prevent negative impacts on the agricultural sector and support the sustainability of food production.

Changes in land use, population growth, and human activities that are not environmentally friendly have caused an increase in the pollution burden on water bodies. Domestic, agricultural and industrial waste is often dumped directly into rivers without going through an adequate treatment process, thereby reducing water quality and threatening the ecological and socio-economic functions of these water resources (Agaton *et al*., 2016; Nahib *et al*., 2021; Yokosawa & Mizunoya, 2022). Based on the report from North Musi Rawas Regency Environmental Service

(DLH, 2023), the water quality in the Tiku Sub-watershed shows indications of pollution. BOD values were recorded between 3.2–4.1 mg/L and COD 19–26 mg/L, both approaching or exceeding class II quality standards according to Presiden RI (2021). The DO value is in the range of 4.8–5.5 mg/L, close to the minimum limit of 4 mg/L, while the pH is in the range of 6.2–6.8. TSS was recorded between 42–75 mg/L, exceeding the 50 mg/L threshold at some points. This condition indicates significant pollution pressure, especially in downstream areas close to small-scale gold mining (PESK) activities and intensive agriculture.

Decreased water quality, caused by various factors such as chemical, biological, and physical pollution, can result in decreased agricultural yields, reduced water availability for irrigation, and increased potential for disease in plants (Liu *et al*., 2022; Shah *et al*., 2023). Water pollution that occurs due to industrial and agricultural waste can worsen soil quality and reduce agricultural efficiency, thereby increasing the challenges in ensuring food security (Berthet *et al*., 2021; Klages *et al*., 2020). In addition, polluted water can reduce the effectiveness of fertilizer use and increase the negative impact on plant growth (Kaewpuangdee *et al*., 2024). Therefore, effective and sustainable water quality management is very important to maintain ecosystem balance, support agricultural sustainability, and prevent negative impacts on public health (Cabrera *et al*., 2023; Madeira *et al*., 2023; Tian *et al*., 2018).

To assess water quality as a whole, one commonly used approach is the Pollution Index (IP) method. This method was developed to provide a quantitative description of the level of pollution of a water body based on relevant water quality parameters. The Pollution Index provides a classification of water quality into certain categories, ranging from good to very polluted, based on comparing the concentration of parameters against quality standards set by the government, as in Government Regulation Number 22 of 2021 concerning the Implementation of Environmental Protection and Management (Presiden RI, 2021).

Until now, there has been no research that comprehensively maps the water quality status in the Tiku Sub-watershed using the Pollution Index method. Previous research generally only focused on limited parameters or certain observation points, so it did not provide a comprehensive picture of water quality conditions. This research is novel because it is the first study that includes three observation points (upstream, midstream, downstream) with analysis of 12 main parameters, namely temperature, TDS, TSS, BOD, COD, DO, chloride, nitrate, nitrite, pH, *Escherichia coli* (E. coli), and Total Coliform, which were measured in September 2024.

Water quality analysis using the IP method provides a practical and informative approach to understanding the status of water quality in an area. Several previous studies have shown that this method is effective in describing general water conditions and can be used as a basis for formulating sustainable water resource management policies (Sutadian *et al*., 2016). Therefore, the application of the IP method becomes very relevant for use in water quality analysis in various areas, especially those experiencing pressure from anthropogenic activities. This research aims to assess the status of water quality in the Tiku Sub-watershed using the Pollution Index method based on these 12 parameters, so that the results can be used as a basis for making water quality management policies in this region. The expected benefit of this research is to provide accurate scientific information regarding pollution levels as input for local governments, watershed management institutions and other stakeholders in formulating effective water quality management strategies. In addition, it is hoped that the results of this research can become a reference in periodically monitoring water quality, evaluating the effectiveness of pollution control programs, as well as determining priorities for conservation and rehabilitation actions for aquatic ecosystems in the future.

2. RESEARCH MATERIALS AND METHODS

2.1. Research Location and Time

Sampling was carried out in September 2024, in the Tiku River, North Musi Rawas Regency, South Sumatra Province. The Tiku sub-watershed has an important role in providing water for domestic needs, agriculture and economic activities of the surrounding community. In general, the topography of the Tiku Sub-watershed area is dominated by flat to undulating land with a height of between ±125–250 meters above sea level, and is traversed by the Tiku river network which is the main source of surface water. Land use in this area is dominated by rice fields, rubber plantations and settlements, while upstream there are still secondary forest areas and national parks. The Tiku watershed map is shown in Figure 1.

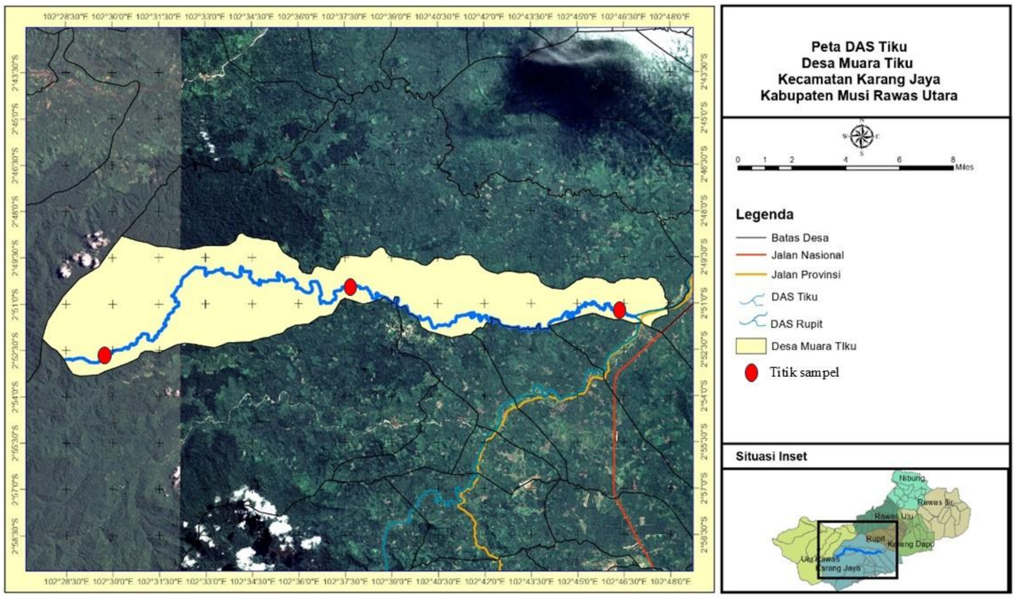

Figure 1. Location of sampling points (red dots)

2.2. Sampling

Water quality sampling was carried out at three observation points representing the upstream, middle and downstream parts of the Tiku Sub-watershed. Point selection criteria include representation of flow position (upstream–middle–downstream), ease of access, proximity to human activities that have the potential to affect water quality, and safety of the location for sampling. The upstream point is at coordinates S 02°51'50.51" and E 102°43'39.15", middle at S 02°50'58.10" and E 102°45'32.16", and downstream at S 02°51'15.86" and E 102°46'15.69". The sampling period was carried out in September 2024, which represents the transition from the dry season to the rainy season. Sampling was carried out once (single sampling) at each point in this period to obtain an overview of the water quality status at the time of observation.

Water quality parameters included water temperature (measured in situ using a digital thermometer), total dissolved solids or TDS and Total Suspended Solids or TSS (gravimetric method, SNI 6989.3-2019), Biochemical Oxygen Demand (BOD_5) (five-day BOD test, SNI 6989.72-2009), Chemical Oxygen Demand or COD (dichromate reflux method, SNI 6989.2-2019), Dissolved Oxygen or DO (Winkler titration method, SNI 06-6989.14-2004), Chloride (argentometric method, SNI 6989.19-2009), Nitrate (spectrophotometric method, SNI 06-2480-1991), Nitrite (diazotation colorimetric method, SNI 06-6989.09-2004), pH (electrometric method, SNI 6989.11-2019), and *Escherichia coli* bacteria and total coliforms (double tube method, SNI 2332.1:2015).

One liter of river water sample was taken at a depth of 20–50 cm from each research point using an integrated sampler. Samples were taken from the downstream (1 point), middle (1 point) and upstream (1 point) of the river. This river has a discharge of between 5 m^3/sec to 150 m^3/sec, and samples were taken at two points, respectively at a distance of 1/3 and 2/3 of the width of the river. The river water samples were then put into polyethylene (PE) bottles with a capacity of 1 liter and stored at 4 °C in a cool box. The pH and DO parameters were measured in situ using portable tools, namely a pH-meter and DO-meter.

2.3. Research Parameters

The parameters used in this research include physical, chemical and microbiological aspects which play an important role in comprehensively assessing water quality. Physical parameters consist of Total Suspended Solid (TSS) which is analyzed using the gravimetric method after titration, as well as Total Dissolved Solid (TDS) which is calculated from the difference between Total Solid (TS) and TSS. For chemical parameters, Biochemical Oxygen Demand (BOD) analysis was carried out using the incubation method in bottles for 3 days at a temperature of 27 °C, while Chemical Oxygen Demand (COD) was analyzed using the open reflux method. In addition, the nutrient content was analyzed by measuring nitrogen in the form of nitrite using the sulfanilamide spectrophotometric method, as well as nitrogen in the form of nitrate which was calculated based on the Total Oxidized Nitrogen and NO_2-N values. Chloride content (Cl^-) was analyzed using the argentometric titration method. Meanwhile, microbiological parameters include analysis of total coliforms and *Escherichia coli* (E. coli) which was carried out using the standard multiple tube fermentation method. All of these parameters are used to provide a comprehensive picture of the level of pollution and water quality status at the research location.

2.4. Data Analysis

Calculation of water quality status was carried out using the Pollution Index (IP) method referring to the Decree of the Minister of the Environment Number 115 of 2003 (Menteri Negara Lingkungan Hidup, 2003). Calculation steps included:

1. Determine parameters and quality standards

Water quality parameters are measured in the field and analyzed in the laboratory (e.g. TDS, TSS, BOD, COD, DO, pH, chloride, nitrate, nitrite, E. coli, and Total Coliform). The quality standard value was taken from the government regulation Presiden RI (2021) according to water use.

2. Calculation the ratio of each parameter: for each parameter, the measurement results (*Ci*) was divided by the quality standard (*Lij*) : $\frac{Ci}{Lij}$
3. Adjustments for custom parameters: the standard for DO is the minimum limit, then used the following formula:

$$\frac{Ci}{Lij}\,new = \frac{Cim - Ci\,result}{Cim - Lij} \tag{1}$$

where *Cim* is the maximum value of the parameter. If the new *Ci*/*Lij* value is > 1 then proceed with the following formula:

$$\frac{\mathrm{Ci}}{\mathrm{Lij}} = 1 + 5\log\frac{\mathrm{C}}{\mathrm{L}}\ \mathrm{measurement} \tag{2}$$

The quality standard set pH in a range value, then Equation (3) was used for *Ci* < *Li*, and Equation (4) for *Ci* > *Li* :

$$\frac{\mathrm{Ci}}{\mathrm{Lij}} = \frac{\mathrm{Ci - Li\ average}}{\mathrm{Li\ Min - Li\ average}} \tag{3}$$

$$\frac{\mathrm{Ci}}{\mathrm{Lij}} = \frac{\mathrm{Ci - Li\ average}}{\mathrm{Li\ Max - Li\ average}} \tag{4}$$

4. Determining the average (R) and maximum (M) values of *Ci/Lij* ratios.
5. Calculating the Pollution Index (IP) using the following formula:

$$\mathrm{IP} = \sqrt{\frac{(\frac{\mathrm{Ci}}{\mathrm{Lij}})^2_{\mathrm{M}} + (\frac{\mathrm{Ci}}{\mathrm{Lij}})^2_{\mathrm{R}}}{2}} \tag{6}$$

6. Determining the water quality status category: the Decree of the Ministry of Environment 115/2003 categorizes water quality according to te IP values as the following: IP ≤ 1 (meet quality standard); 1 < IP ≤ 5 (lightly polluted); 5 < IP ≤ 10 (moderately polluted); and IP > 10 (heavily polluted).

2.5. Statistical Analysis

Data from measurements of water quality parameters were analyzed descriptively to determine the minimum, maximum, average and standard deviation values for each parameter. These values are used in calculating the Pollution Index (IP) according to KepMenLH No. 115 of 2003. In addition, a comparative analysis was carried out between sampling points (upstream, midstream and downstream) to identify differences in water quality status at each location. The IP calculation results are then categorized into water quality classes (meets quality standards, lightly, moderately or heavily polluted) in accordance with regulatory provisions.

3. RESULTS AND DISCUSSION

3.1. Land Use in the Tiku Sub-Watershed

Figure 1 shows that land use around the Tiku River Subwatershed with detail information is presented in Table 1. The Tiku River Subwatershed is dominated by forested areas, namely limited production forests (60.27%), production forests (23.03%), and national parks (10.04%), which ecologically play an important role in maintaining hydrological balance, reducing surface runoff, and maintaining water quality. Meanwhile, land use for cultivation activities such as rice fields (2.64%), plantations (2.43%), and settlements (0.18%) is relatively small but still has the potential to be a source of pollution, especially if it is not managed in an environmentally friendly manner. The existence of river borders (0.79%) and water catchment areas (0.18%) have a strategic function in protecting water quality, although the areas of both are still limited. This land use composition shows that the area around the Tiku River has high conservation potential, but still requires integrated monitoring and management to minimize the impact of human activities on river water quality.

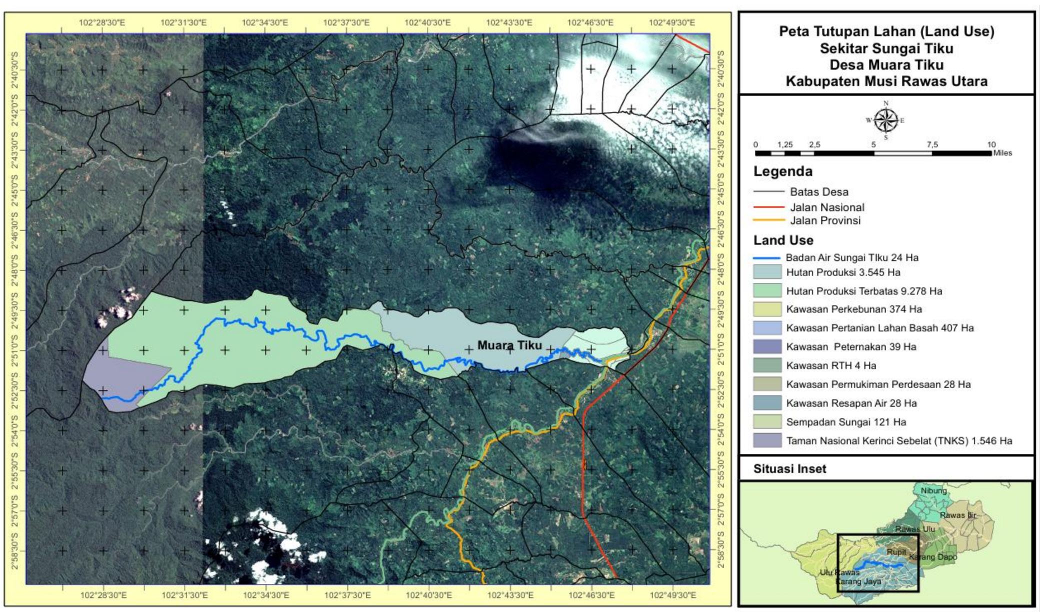

Figure 2. Land use types in the Tiku Subwatershed

Table 1. Land use type in the Tiku Subwatershed

No	Land Use	Area (ha)	Percentage (%)
1	Body of Water	24	0.16
2	Production Forest	3.545	23.03
3	Limited Production Forest	9.278	60.27
4	Plantation Area	374	2.43
5	Livestock Area	39	0.25
6	Ricefield	407	2.64
7	Residential Area	28	0.18
8	Water Catchment Area	28	0.18
9	Green open space	4	0.03
10	River Border	121	0.79
11	National Parks	1.546	10.04
Total		15.394	100

Table 2. Characteristic of physical parameters of Tiku river water

No.	Parameter	Unit	Class II Quality Standards*	Measurement in Tiku River		
				Upstream	Middle	Downstream
1	Temperature	°C	Normal ±3	27.1	27.3	26.4
2	TDS	mg/l	1.000	78.3	98.3	100.3
3	TSS	mg/l	50	34.3	31.2	27.9

* Source: Presiden RI (2021)

3.2. Physical Parameters

The results of the analysis of the physical parameters of the Tiku River water in Table 2 show that the water temperature, Total Dissolved Solids (TDS) and Total Suspended Solids (TSS) levels at all upstream, middle and downstream observation points are still within the thresholds set by Government Regulation Number 22 of 2021 (Presiden RI, 2021) concerning the Implementation of Environmental Protection and Management for class II water quality standards. The highest temperature was recorded in the middle of the river at 27.3 °C, while the lowest temperature was downstream at 26.4 °C. The respective TDS values were 78.3 mg/L (upstream), 98.3 mg/L (middle), and 100.3 mg/L (downstream), far below the maximum threshold of 1,000 mg/L. This shows that the level of dissolved substances in river water is still low and has not been polluted by dissolved chemical compounds such as salt, minerals or organic residues originating from domestic and agricultural activities. Furthermore, the TSS value which reflects the suspended solids content shows figures of 34.3 mg/L (upstream), 31.2 mg/L (middle) and 27.9 mg/L (downstream), all of which are still below the maximum limit of 50 mg/L. This indicates that sedimentation activities and soil runoff into river bodies are still under control.

Ecologically, this good physical quality reflects the important role of the limited production forest land cover and national parks that dominate the Tiku River Sub-watershed area, because they are able to reduce erosion and restrain surface runoff which carries sediment and dissolved substances into the river. Previous research shows that good vegetation cover in upstream river areas has the ability to reduce the amount of sediment entering water bodies, as well as improving overall water quality (de Mello *et al*., 2018; Shah *et al*., 2022). However, the trend of increasing TDS values from upstream to downstream indicates the potential for accumulation of dissolved materials due to human activities such as agriculture, livestock and settlements along river flows (Brontowiyono *et al*., 2022; Prakoso *et al*., 2023). Therefore, even though the current physical condition of the water is still relatively good and meets the standards for class II designation (for example for water recreation, fisheries and agriculture), integrated land use monitoring and management is still needed to maintain the stability of river water quality in the long term.

Apart from having an impact on the aquatic ecosystem, the physical quality of the Tiku River water which is still within standard limits also has positive implications for the agricultural sector in the surrounding area. Water with low TDS and TSS values generally does not cause problems for irrigation, because the dissolved substances and suspended particles do not clog irrigation channels or damage soil structure and plant roots (Anyango *et al*., 2024). A decrease in TDS and TSS content also indicates water quality that can support optimal plant growth, because it does not cause excess salt accumulation in the soil (salinity), which can inhibit nutrient absorption. Therefore, this condition needs to be maintained through sustainable land management and control of agricultural waste, so that there is no increase in pollutant loads which could reduce river water quality in the future, while maintaining agricultural productivity in the Tiku River Sub-watershed (Chabib *et al*., 2025).

3.3. Chemical Parameters

Based on the results of the analysis of the chemical parameters of the Tiku River water, in general the water quality at the three sampling points (upstream, middle and downstream) is still within safe limits in accordance with class II water quality standards according to Government Regulation Number 22 of 2021 concerning the Implementation of Environmental Protection and Management. The Biochemical Oxygen Demand (BOD) parameter was recorded to be below the threshold of 3 mg/l, with respective values of 1.93 mg/l (upstream), 1.28 mg/l (middle), and 1.43 mg/l (downstream), which indicates a low content of organic matter which requires oxygen to biodegrade. Chemical Oxygen Demand (COD) levels also show values far below the maximum limit of 25 mg/l, indicating that the chemical organic pollution load is also low.

Dissolved oxygen (DO) concentrations at all locations were recorded as very good, namely above 7 mg/l, higher than the minimum standard of 4 mg/l, which shows that water conditions support the life of aquatic biota. Nitrate and nitrite concentrations are also still very low and far below the specified threshold (10 mg/l for nitrate and 0.06 mg/l for nitrite), so the risk of eutrophication is still relatively low. The pH value of the water at the three locations ranges from 6.5 to 6.9, which is slightly below the ideal value of neutral pH (7.5) according to class II quality standards, but still within the tolerance range for aquatic life. The only parameter that exceeds the standard is chloride, which at the central location reaches 0.24 mg/l, higher than the threshold of 0.03 mg/l, and can be an indicator of the influence of domestic or agricultural activities. This needs to be a concern to prevent a continuous increase in chloride levels and endanger the balance of the aquatic ecosystem.

Table 3. Characteristic of chemical parameters of Tiku river water

Number	Parameter	Unit	Class II Quality Standards*	Measurement in Tiku River		
				Upstream	Middle	Downstream
1	BOD	mg/l	3	1.93	1.28	1.43
2	COD	mg/l	25	9.23	9.32	8.53
3	DO	mg/l	4	7.95	8.31	7.95
4	Chloride	mg/l	0.03	0.04	0.24	0.04
5	Nitrate	mg/l	10	1	1	1
6	Nitrite	mg/l	0.06	0	0	0
7	pH	Unit	7.5	6.6	6.5	6.9

* Source: Presiden RI (2021)

The water quality of the Tiku River which is classified as good based on chemical parameters such as BOD, COD, DO, nitrate and nitrite has a positive impact on the surrounding agricultural sector, especially for irrigation activities. Low BOD and COD content indicates minimal dissolved organic waste, so the water does not have the potential to cause plant root rot or reduce soil quality. Previous research also shows that water with low BOD and COD can support plant growth better, because this water does not pollute the soil or cause anaerobic conditions that can damage plant roots (Liu *et al*., 2024). High dissolved oxygen (DO) content also supports the balance of soil microorganisms which is beneficial for agricultural land fertility (Baiyin *et al*., 2021). High DO levels in water also support plant root respiration, which is very important for plant growth and development (Ma'Mun *et al*., 2021). Additionally, controlled nitrate levels support plant growth without the risk of nitrogen toxicity (Yang *et al*., 2023). Previous research emphasizes that moderate nitrate levels support optimal photosynthesis processes in plants, which in turn increases agricultural yields (Wen *et al*., 2024).

However, chloride content that exceeds the threshold at the midpoint requires caution, because long-term accumulation of chloride can have a negative impact on soil structure, reduce water absorption by plants, and disrupt the growth of agricultural vegetation (Wang *et al*., 2023). High chloride levels are known to cause excessive soil salinity, which disrupts the ability of roots to absorb water and nutrients, adversely affecting plant productivity (Zhang *et al*., 2025). Therefore, regular monitoring of water quality and management of activities around rivers is essential to ensure the sustainability of agricultural productivity in the area, by identifying potential pollution risks early and implementing appropriate control measures.

3.4. Biological Parameters

Based on the results of the analysis of the biological parameters of the Tiku River water in Table 4, it can be seen that the *Escherichia coli* (E. coli) and total coliform values at all sampling locations (upstream, middle and downstream) show conditions that are still within the thresholds set out in Government Regulation Number 22 of 2021 concerning the Implementation of Environmental Protection and Management for class II water quality standards. The E. coli values at the three locations were 99, 89.3, and 97 MPN/100 ml respectively, much lower than the maximum limit set at 1,000 MPN/100 ml. Likewise, the total coliform content is in the range of 902–948 MPN/100 ml, which is still safe compared to the maximum limit of 5,000 MPN/100 ml.

Table 4. Characteristic of biological parameters of Tiku river water

No.	Parameter	Unit	Class II Quality Standards*	Measurement in Tiku River		
				Upstream	Middle	Downstream
1	E.Ccoli	MPN/100 ml	1000	99	89.3	97
2	Total Coliform	MPN/100 ml	5000	948	902	947

* Source: Presiden RI (2021)

These results indicate that Tiku River water is biologically safe from dangerous fecal microbial pollution, so it does not pose relatively serious health risks when used for recreational activities, agricultural irrigation or freshwater fisheries. The presence of low numbers of microorganisms also indicates that there is no significant contamination from domestic or livestock waste that can pollute water bodies. Previous research shows that low levels of pathogenic microbes such as E. coli and total coliforms in water bodies indicate safe water quality for various purposes, and that regular monitoring is very important to anticipate changes in water quality caused by increased human activities around river basins (Adhikari *et al*., 2020; Alegbeleye & Sant'Ana, 2023).

The biological quality of Tiku River water, which is still within safe limits according to class II quality standards, has positive implications for the agricultural sector, especially in irrigation activities. The low E. coli and total coliform content indicates that the water is relatively free from pathogenic microbial contamination that can cause disease in plants or contaminate agricultural products, in accordance with findings showing that irrigation with microbially contaminated water can damage plants and reduce the quality of agricultural products (Obayomi *et al*., 2024). In addition, the use of clean water for irrigation is also important for maintaining soil fertility and soil microbial ecosystems that support agricultural productivity, as explained in research that links water quality to soil health and agricultural yields (Nepal *et al*., 2024). Therefore, the biological condition of the Tiku River which meets quality criteria has an important potential in supporting the sustainability of safe and healthy agricultural practices in the area around the Tiku Watershed (DAS).

3.5. Water Quality Status

Tables 5 shows the water quality status of the Tiku River in all sampling points (upstream, middle, and downstream) of the river, are in the lightly polluted category. The IP value in the upstream and downstream sections is 1.15, while in the middle section it shows a higher figure, namely 3.90. Although the entire location is still classified as lightly polluted (IP > 1 – 5), higher values in the middle indicate an increase in pollutant load, which most likely comes from anthropogenic activities around the area, such as settlements, intensive agriculture, or waste from plantation activities.

Table 5. Calculation of water quality status for the upstream Tiku River using the IP method

Parameter	Standard	Upstream			Middle			Downstream		
		Results	Ci/Lix	New Ci/Lix	Results	Ci/Lix	New Ci/Lix	Results	Ci/Lix	New Ci/Lix
Temperature	22-28	27.1	0.70	0.70	27.3	0.77	0.77	26.4	0.47	0.47
TDS	1000	78.3	0.08	0.08	98.3	0.10	0.10	100.3	0.10	0.10
TSS	50	34.3	0.69	0.69	31.2	0.62	0.62	27.9	0.56	0.56
BOD	3	1.93	0.64	0.64	1.28	0.43	0.43	1.43	0.48	0.48
COD	25	9.23	0.37	0.37	9.32	0.37	0.37	8.53	0.34	0.34
DO	4	7.95	0.12	0.12	8.31	0.11	0.11	7.95	0.12	0.12
Chloride	0.03	0.04	1.33	**1.62**	0.24	8.00	**5.52**	0.04	1.33	**1.62**
Nitrate	10	1	0.10	0.10	1	0.10	0.10	1	0.10	0.10
Nitrite	0.06	0	0.00	0.00	0	0.00	0.00	0	0.00	0.00
pH	7.5	6.6	0.60	0.60	6.5	0.67	0.67	6.9	0.40	0.40
E. coli	1000	99	0.10	0.10	89.3	0.09	0.09	97	0.10	0.10
Total coliforms	5000	948	0.19	0.19	902	0.18	0.18	947	0.19	0.19
PI				1.15			3.90			1.15
Pollution Quality Status				Light			Light			Light

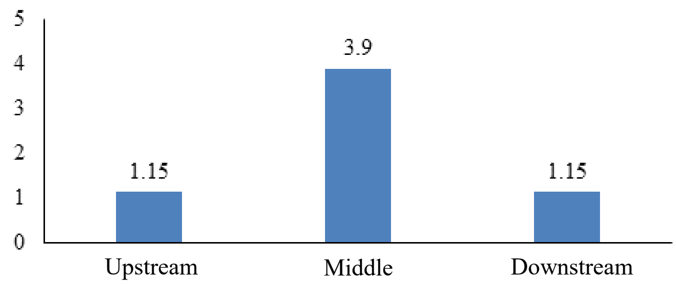

Figure 3. Tiku River water quality status using the IP method

This result is in line with Santika (2024) findings on the Beji River in Pondok Village, which showed an IP value of 1.91 and was included in the lightly polluted category. Santika emphasized the importance of mitigation based on community participation, such as equal distribution of population, controlling population growth in dense areas, providing waste disposal facilities, and building waste water treatment plants (IPAL) to reduce water pollution. In contrast, Agustin (2024) research on the White Gajah River showed better results, with an IP value of 0.72 which was categorized as meeting quality standards. This condition is supported by DO, temperature, pH and TDS parameters which are still in accordance with Class II water quality standards (Presiden RI, 2021). These findings suggest that rivers in areas with low anthropogenic pressure tend to have better water quality.

The lightly polluted conditions in all segments of the Tiku River show that even though the water quality has not yet reached the heavily polluted category, integrated pollution management and control measures are still needed. Especially in the middle part of the river, more attention is needed to potential pollutant sources which cause a significant increase in the Pollution Index (IP) value. As explained in previous research, the increase in IP in rivers can be influenced by factors such as domestic waste, agriculture and industrial activities that are not well managed (Suriadikusumah *et al*., 2021). This control is important to maintain water quality so that it continues to support various needs, such as raw water sources, habitat for aquatic biota, as well as use for agricultural irrigation and domestic activities of local communities. Poor water quality can have a negative impact on the agricultural sector, such as reducing the availability of clean water for irrigation, which in turn can reduce agricultural yields (Marselina *et al*., 2022). The trend of increasing IP in the central part can also be an early indicator that without mitigation efforts, water quality may continue to decline to more severe levels of pollution in the future, as found in Ejiohuo *et al*. (2025) showing that without appropriate control measures, water quality can decline drastically in a relatively short time.

Even though most of the physical, chemical and biological parameters are still below the class II quality standard threshold in accordance with Government Regulation Number 22 of 2021, the presence of organic and microbiological pollutants still requires attention. This condition has the potential to have a negative impact on agricultural activities around rivers, especially if river water is used as a source of irrigation. Pollutant sources come from a combination of point sources, such as domestic and small business waste, and non-point sources, such as agricultural runoff and land erosion. If no intervention is carried out, this pollution load has the potential to increase and threaten the function of aquatic ecosystems. Therefore, a targeted pollution control strategy is needed, based on pollutant sources, and equipped with supporting measures to ensure the sustainability of water quality in the future. These control recommendations include:

1. Point source control:
   - Improving the domestic wastewater management system, such as building communal wastewater treatment plants (IPAL) in villages around the river.
   - Implementation of liquid waste quality standards for small/medium businesses operating around sub-watersheds.
2. Control of non-point sources (Non-Point Source):
   - Implementation of environmentally friendly agricultural practices, such as the use of balanced fertilizer, integrated pesticide control, and the creation of vegetation buffer zones on river banks.
   - Erosion control through soil and water conservation techniques on sloping land.
3. Supporting steps:

- Regular monitoring of water quality at critical points to detect changes in water quality early.
- Education and outreach to the public regarding the impacts of water pollution and their role in controlling pollution.
- Strengthening coordination between agencies in monitoring and enforcing laws related to environmental pollution.

4. CONCLUSION

The research results can be concluded that the Pollution Index (IP) value ranges from 1.15–3.90, with all observation points being in the lightly polluted category. This condition indicates that water pollution in the Tiku Sub-watershed is mainly influenced by domestic waste from settlements on the riverbanks, fertilizer and pesticide residues from agricultural activities, as well as liquid waste discharge from local economic activities. To overcome this problem, it is necessary to improve the sanitation system in villages around the river, implement environmentally friendly agricultural waste management practices, and regularly monitor water quality at points identified as critical locations. The results of this research provide a scientific basis for formulating water resource management policies in the Tiku Sub-watershed area, especially in determining priorities for handling pollution and conservation strategies to maintain the sustainability of the function of aquatic ecosystems.

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