



Study of Sebuku River Water Quality and Public Perception of PT ABC's Mining Activities

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Abstract

The Sebuku River has an important role for the life of flora, fauna, and local communities in Nunukan Regency, North Kalimantan Province. Mining activities in this area raise concerns about potential water pollution. This study aimed to evaluate the impact of mining activities on the water quality of the Sebuku River. Sampling was carried out by purposive sampling at five observation stations between ST-1 and ST-5 based on predetermined coordinate points. The parameters tested included temperature, TSS, pH, DO, BOD, COD, NO₃, PO₄, CN⁻, and fecal coliform. The analysis method referred to SNI and the results are compared with class II river water quality standards in Appendix VI of Government Regulation of the Republic of Indonesia Number 22 of 2021. The results of the analysis showed that the TSS level of all stations exceeded the quality standard as the majority of respondents who stated that it was cloudy, but the level tended to decrease downstream. The highest COD parameters were detected in ST-2. This is supported by the value of the Pollution Index (PI) that indicated it as the primary pollution source from mining activities. The rest of the parameters are still within the permissible limits. Overall, the water quality of the Sebuku River is still classified as moderate based on the value of the Water Quality Index (WQI).

Introduction

Mining is a sector closely tied to the exploitation of natural resources, including both renewable and non-renewable resources. While mining contributes positively to economic development through job creation, poverty alleviation, increased household income, and revenue for local and national governments via taxes and royalties, it also poses significant environmental risks. These include land degradation, biodiversity loss, damage to flora and fauna, erosion, sedimentation, and pollution (Ekka et al., 2023; Okorundu et al., 2022; Kolawole et al., 2023; Rashmi et al., 2022).

One of the most significant environmental impacts of mining is the pollution of river water, often characterized by elevated Pollution Index (PI) levels that exceed environmental quality standards (Indrianto et al., 2023; Tiwari et al., 2015; Krodkiewska et al., 2022). Such pollution commonly originates from mining residues known as tailings. In gold mining (Au) operations, tailings may contain dissolved heavy metals such as copper (Cu), tin (Sn), zinc (Zn), nickel (Ni), iron (Fe), and mercury (Hg) (Rahmadani & Alawiyah, 2022; Okewale & Grobler, 2023; Barcelos et al., 2020; Cacciuttolo et al., 2023; Asare & Afriyie, 2021). However, the specific

elements present depend on the geothermal processes involved in gold formation and may vary from site to site.

Geographically, the island of Kalimantan is rich in gold (Au) deposits. Mining activities in this area are often linked to the degradation of river water quality, as seen in the Sebuku River, located in Nunukan Regency, North Kalimantan. Spanning approximately 115 km, the Sebuku River serves as a central waterway connecting Nunukan City with the Sebuku subdistrict.

PT ABC is one of the gold mining companies operating along the Sebuku River. The company routinely monitors the river's water quality quarterly, assessing physical, chemical, and biological parameters by Class II river criteria (Sigua et al., 2000; Chapman, 2021; Smith et al., 2018; Davis et al., 2003; Mohamed, 2003). This monitoring is vital, as the river supports aquatic transport and serves as a livelihood source for communities, particularly shrimp fishermen in the Sebuku subdistrict. Recently, local communities have raised concerns about the river's murky and polluted appearance, exacerbated by the presence of trash and driftwood. Community perceptions of water quality vary based on individuals' access to information and their level of environmental awareness. These perceptions significantly influence how communities perceive the state of their environment (Lo & Jim, 2010; Liu et al., 2010; Dogaru et al., 2009). In response to growing environmental concerns, Indonesian regulations have become increasingly stringent. Mining companies are now required to conduct comprehensive environmental assessments that encompass both abiotic and biotic aspects, as well as social considerations. PT ABC has implemented environmental monitoring since the operational production phase (2014–2022) and continues to manage the environment during the post-mining phase (2023–2025).

Previous studies on the environmental impact of mining have documented similar trends. Fery et al. (2023) examined the Barito River in Murung Raya Regency. They reported contamination by lead (Pb), total suspended solids (TSS), and zinc (Zn), all of which exceeded Class II water quality standards as outlined in Government Regulation No. 22/2021. The average PI of 1.41 indicated light pollution. The 2023 Performance Report (LKjIP, 2023) of the Nunukan Environmental Agency also recorded deteriorating water quality in several rivers, including the Sebuku River, due to high levels of TSS, chemical oxygen demand (COD), and fecal coliform. This degradation poses risks to residents who rely on river water for their daily needs.

To date, no specific scientific studies have been conducted on the direct relationship between mining operations and water quality in the Sebuku River. Therefore, this study aims to (1) assess the impact of mining activities on river water quality, (2) determine the PI and WQI values, and (3) analyze community perceptions regarding water clarity, odor, safety, and the overall influence of mining on the Sebuku River's condition.

The study was conducted during the post-mining phase in the Sebuku River region, an area that has yet to undergo scientific evaluation. The research findings are expected to contribute to evidence-based environmental management in post-mining regions and provide valuable insights for stakeholders seeking to ensure sustainable environmental governance that encompasses both abiotic, biotic, and socio-cultural components.

Methods

This study employed a survey method using purposive sampling and quantitative descriptive analysis to assess the water quality of the Sebuku River in Nunukan Regency, North Kalimantan Province. The results of water quality testing were compared with the environmental quality standards as stipulated in Government Regulation of the Republic of

Indonesia No. 22 of 2021 on the Implementation of Environmental Protection and Management, notably Appendix VI.

The pollution level of the Sebuku River was evaluated using two key indices: the Pollution Index (PI) and the Water Quality Index (WQI). Additionally, this study analyzed community perceptions of the river's water quality. Laboratory testing was conducted on ten parameters, eight of which are mandatory for WQI assessments as defined in Ministerial Regulation of the Environment and Forestry No. 27 of 2021. These parameters include Total Suspended Solids (TSS), pH, Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Dissolved Oxygen (DO), nitrate (NO₃), phosphate (PO₄), and fecal coliform. Two additional parameters, temperature and cyanide (CN⁻), were included, with cyanide being particularly relevant due to its direct association with PT ABC's mining activities during the production phase.

Water sampling was conducted at five stations along the Sebuku River as follows: a) ST-1: Located in the upstream area and served as the control station, situated at coordinates 3°56'08.2"N, 117°12'16.6"E; b) ST-2: Positioned 1 km downstream from ST-1 at the mixing zone, at coordinates 3°56'50.3"N, 117°14'51.7"E; c) ST-3: Located 1 km downstream of ST-2, representing the first self-purification point, at coordinates 3°57'48.2"N, 117°17'12.8"E; d) ST-4: Represented the second self-purification point at coordinates 3°57'40.4"N, 117°21'34.3"E; e) ST-5: The final self-purification station, 1 km downstream from ST-4, is located at coordinates 4°01'26.5"N, 117°22'20.5"E (Figure 1).

Water sampling and laboratory analysis were conducted in accordance with national standards: SNI 8995:2021 for physical and chemical parameters, and SNI 9063:2022 for microbiological parameters. Sampling and testing were performed in four replicates over a one-month period, with a weekly interval, to ensure data reliability and consistency across the testing period.

All laboratory results were tabulated and analyzed using the Pollution Index method, as stipulated in Minister of Environment Decree No. 115 of 2003, which outlines the guidelines for Determining Water Quality Status. The resulting PI values were subsequently converted into WQI values to provide a more comprehensive assessment of the water quality of the Sebuku River.

Pollution Index (PI) was calculated using the following formula:

$$PI_j = \sqrt{\frac{(C_i/L_{ij})_M^2 + (C_i/L_{ij})_R^2}{2}}$$

Where:

C_i : Measured concentration of parameter i

L_{ij} : Concentration of water quality parameters listed in the standards

Interpretation of PI values:

0 ≤ PI ≤ 1.0 : Good (complies with water quality standards)

1.0 < PI ≤ 5.0 : Lightly polluted

5.0 < PI ≤ 10 : Moderately polluted

PI > 10 : Heavily polluted

The WQI was derived from the weighted percentage of quality status:

WQI : \sum (Percentage x weight)
WQI : (100% \times 50) =50.00

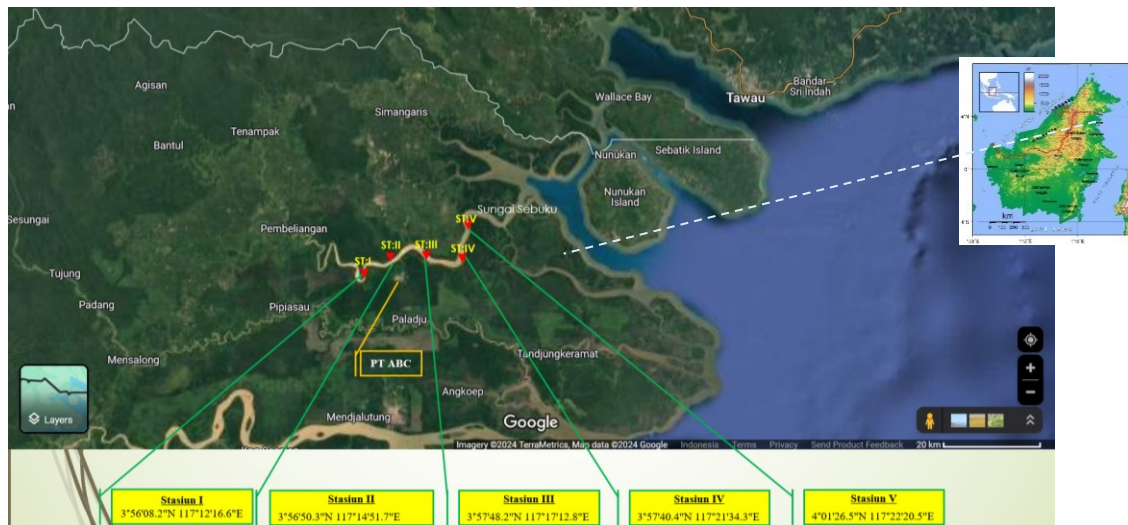


Figure 1. River Water Sampling Point

All members of the target population were included as research respondents, following the Slovin formula (Sugiyono, 2013). The required sample size was calculated using Slovin’s formula with a 5% margin of error, resulting in a minimum sample size of 66 respondents. Based on field data, the total population of individuals living near or frequently interacting with the Sebak River was recorded at 79 people, which is fewer than 100. Therefore, the total number of respondents in this study was 79. The respondents consisted of individuals residing in or regularly interacting with the study area around the Sebak River. This included 27 river fishermen, 13 plantation farmers living near Stations 1 to 5, 2 Navy personnel stationed at the Sebaung Post (river estuary), 8 staff members from the Environmental Agency (DLH) of Nunukan Regency involved in water quality monitoring, 22 members of PT ABC’s environmental monitoring team responsible for quarterly monitoring, 3 speedboat operators, and 4 port security officers from PT ABC.

Results and Discussion

Water Quality of the Sebak River

The water quality at Station ST-1 indicated relatively safe conditions, except for the Total Suspended Solids (TSS) parameter, which exceeded the threshold. The average values of other water quality parameters at ST-1 complied with Class II Water Quality Standards (WQS). The average pH was 6.83, within the acceptable range of 6–9 (Table 1). Dissolved oxygen (DO) was 4.13 mg/L, slightly above the minimum standard of 4 mg/L. Nitrate (NO₃) and phosphate (PO₄) levels were below their respective regulatory thresholds as outlined in Government Regulation No. 22 of 2021. The average COD value of 25 mg/L reached the exact threshold of the Class II WQS, signaling the need for monitoring. TSS at ST-1 averaged 261 mg/L, significantly exceeding the Class II WQS in multiple sampling events. Results at ST-1 were used as baseline data to assess the impacts of pollution, particularly in ST-2, which is located downstream of the mining discharge point.

The high TSS concentration at ST-1 is likely caused by erosion, litter, and floating debris, indicating anthropogenic activity along the riverbanks. According to Mardizal et al. (2024),

heavy rainfall can increase erosion in open lands, resulting in the washing of sediment and dissolved substances into rivers. This aligns with reports by the Nunukan Environmental Agency (LKjIP, 2023), which identified increased TSS due to the conversion of forest land into oil palm plantations along the river. Similar findings were reported by Yudhiman et al. (2023), who observed that land clearing activities led to increased erosion and sedimentation, while land reclamation helped reduce erosion rates.

Field observations revealed that the riverbanks in the upstream area of the Sebuk River consist of soft, sandy-clay soils, which are highly susceptible to erosion during rainfall. These conditions substantially contribute to elevated TSS levels in the river. The Ministry of Public Works and Public Housing, No. 1647 of 2022, reported that podzolic soils in the Sesayap Watershed, ranging from clay to sand, are typically loose at the surface and compact at deeper layers, making them prone to erosion.

Based on the water quality test results of the Sebuk River, significant fluctuations were observed across monitoring stations. At Station ST-2, the mixing of wastewater from residual mining activities resulted in the highest recorded TSS concentration of 265 mg/L, a 4 mg/L increase compared to ST-1, which remained unaffected by pollution. Subsequently, TSS levels began to decrease at ST-3 and ST-4, reaching the lowest point at ST-5. This declining trend indicates the presence of a natural self-purification process in the Sebuk River. A similar finding was reported by Zunaida et al. (2024), who stated that self-purification is influenced not only by the pollution load but also by natural conditions and the dynamics of the aquatic environment.

Nevertheless, TSS levels at ST-5 still exceeded the Class II water quality standard. Elevated TSS due to mining activity is a commonly observed phenomenon and contributes to the deterioration of river water quality. Therefore, corporate commitment and the continuity of environmental impact management and monitoring efforts are crucial. A study by Aldiperdia et al. (2022) on the Manuhing River in Gunung Mas Regency also documented a decrease in pH and an increase in TSS as a direct consequence of mining activities.

COD levels at ST-2 also peaked at 25.50 mg/L, slightly above the standard limit of 25.00 mg/L. This 0.50 mg/L increase indicates potential contamination from industrial activity (Hazanah et al., 2023). However, COD levels declined significantly from ST-3 to ST-5, reaching 16.00 mg/L, lower than both ST-2 and ST-1, suggesting natural degradation of organic compounds. Similar findings were reported by Ani & Harapan (2022), who noted that despite visible waste in the Aek River, water parameters remained within normal limits due to effective biodegradation processes.

DO levels varied across stations, reflecting the influence of anthropogenic factors. DO is crucial for sustaining aquatic organisms (DLH DKI Jakarta, 2020). Low DO indicates poor water quality, which can threaten fish, shrimp, and microbial life. In contrast, high DO signifies a healthy aquatic environment.

Across all stations, the DO ranged from 4.13 to 4.80 mg/L, averaging 4.41 mg/L, which is sufficient to support aquatic life (Paputungan et al., 2022). The presence of many local shrimp fishers corroborates this. Downstream stations (ST-3 to ST-5) exhibited a consistent trend of recovery, characterized by gradual reductions in TSS, BOD, and COD, alongside increasing DO concentrations. According to Islam et al. (2021), a decrease in BOD indicates reduced oxygen demand from microorganisms, allowing DO levels to rise. These findings are supported by a positive correlation among BOD, COD, and DO values (Figure 2).

TSS at ST-5 was nearly halved compared to ST-1 and ST-2, representing the final recovery point. Although still above the Class II WQS, TSS levels exhibited a consistent downward trend (Figure 3). Natural sedimentation processes in the Sebuku River Basin (DAS) appear to be functioning well, reducing suspended solids downstream. Comprehensive management is necessary to sustain river functions, encompassing pollution source control and routine monitoring through collaboration among government, communities, and the private sector.

Water quality test results from ST-1 to ST-5 align with DLH Nunukan’s 2022 and 2023 reports, which stated that most TSS and COD parameters remained below Class II thresholds. Elevated TSS is also a common characteristic in Kalimantan rivers, as seen in the Barito River (Fery et al., 2023). Similarly, Nursaini and Harahap (2022) observed high TSS concentrations in the Barumun River. Recommended interventions include riparian buffer protection, pollution control, periodic water monitoring, and strict regulation of wastewater discharge.

Table 1. Sebuku River Water Testing Results

Parameter	Unit	EQS Class II ^{*)}	Average Repeat Test Results					Average
			ST- 1	ST- 2	ST- 3	ST- 4	ST- 5	
Suhu	°C	0.42	29.83	30.25	29.68	29.38	29.15	29.66
TSS	mg/L	50	261	265	217	197	187	225,25
pH		6-9	6.83	6.94	6.79	6.74	6.73	6.81
BOD	mg/L	3	1.74	2.28	1.54	1.48	1.26	1.66
COD	mg/L	25	25.00	25.50	22.50	18.50	16.00	21.50
DO	mg/L	4	4.13	4.18	4.38	4.58	4.80	4.41
NO3	mg/L	10	0.26	0.23	0.27	0.26	0.23	0.25
PO4	mg/L	0.2	0.09	0.07	0.08	0.06	0.05	0.07
CN-	mg/L	0.02	0.00	0.00	0.00	0.00	0.00	0.00
Fecal Coliform	MPN/10 mL	1.000	7.48	6.30	5.68	3.13	6.43	5.80

^{*)} Government Regulation No. 22 of 2021 concerning the Implementation of Environmental Protection and Management attachment. VI

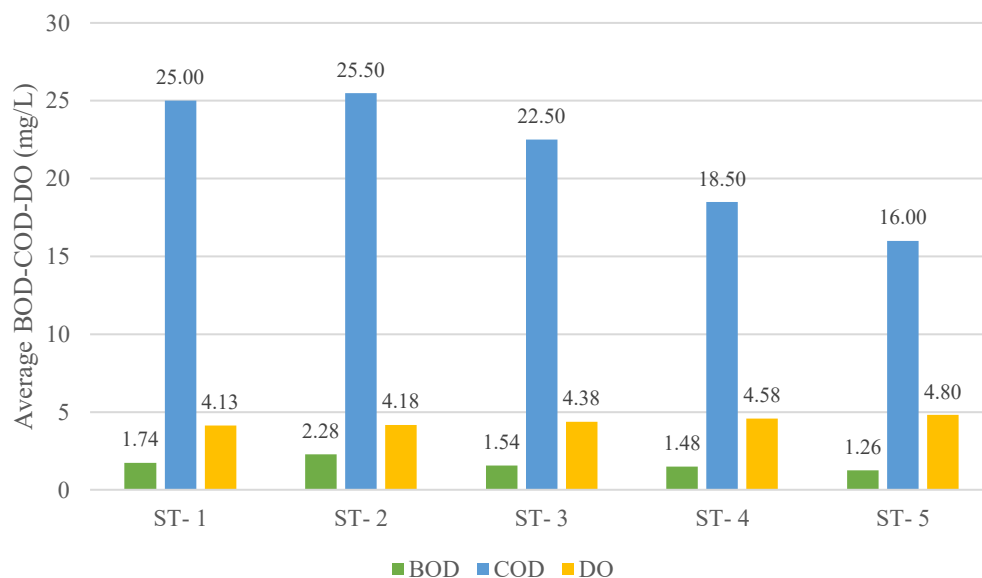


Figure 2. BOD-COD-DO levels across stations

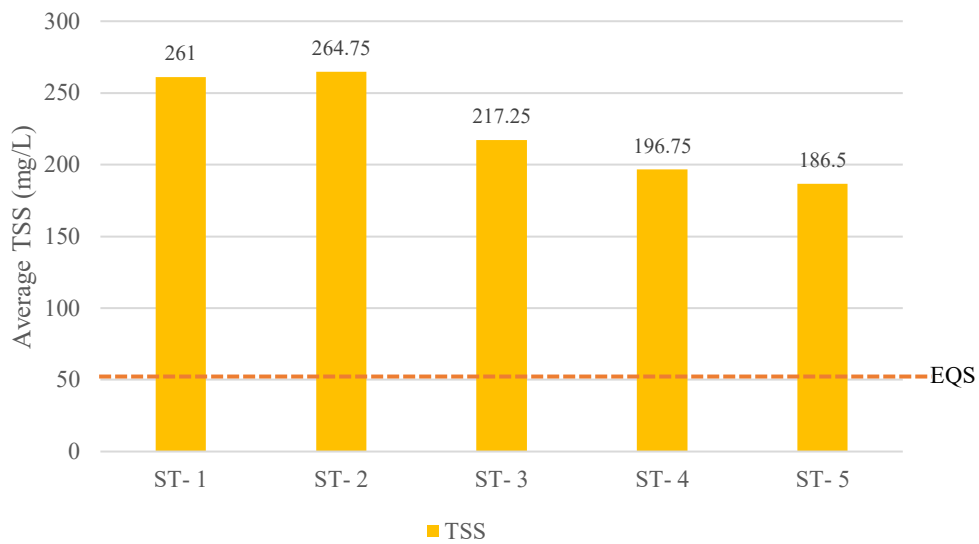


Figure 3. TSS levels across stations

Sebuku River Pollution Index

Based on the methodology outlined in Ministerial Decree No. 115/2003, the average PI values for each station were as follows: 3.20 at ST-1 and ST-2, 2.89 at ST-3, 2.72 at ST-4, and 2.64 at ST-5. These values indicate that all sampling stations are classified into the "lightly polluted" category (PI between 1.0 and 5.0). The overall average PI of 2.93 further confirms this classification. A downward trend in PI values was observed from upstream (ST-1 and ST-2) to downstream (ST-5), as presented in Table 2 and visualized in Figure 4. This pattern highlights both the pollution source and the river's natural recovery capacity. While the PI method is practical for rapid assessments, it only reflects current pollution conditions and does not account for historical contamination. Therefore, historical data are essential for identifying long-term trends. Comparison with PT ABC's quarterly monitoring showed similar PI values, ranging from 1.51 to 1.93, which are also classified as "lightly polluted" based on Ministerial Decree No. 115/2003.

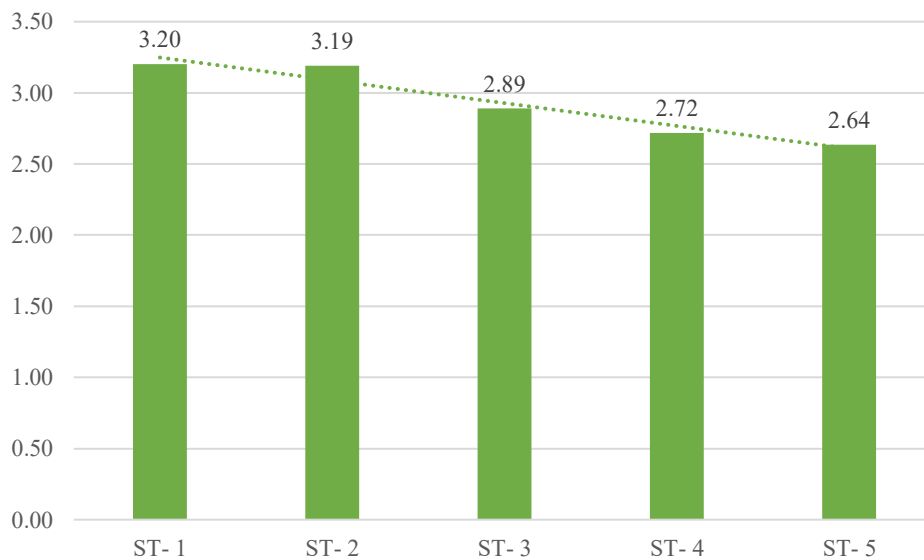


Figure 4. Self-purification Trend Line

Sebuku River Water Quality Index (WQI)

The WQI is a composite metric that summarizes water quality conditions over a specific period (Ministry of Environment and Forestry Regulation No. 27/2021). WQI values were derived from PI data, as shown in Table 3. Analysis of 20 monitoring points indicated that none of the stations met the "clean" water standard. All sites were classified as "lightly polluted," with no stations falling under "moderate" or "heavily polluted" categories.

Based on the weighted scoring system outlined in Ministerial Regulation No. 27/2021, the WQI for the Sebuku River was calculated to be 50.00, placing it in the "moderate" category (WQI range: $50 \leq \text{WQI} < 70$). This aligns with the Environmental Performance Reports (LkjIP, 2023) of Nunukan Regency, which reported WQI values of 54.52 in 2022 and 51.88 in 2023, both within the moderate category. When compared with seven other rivers in Nunukan (Bolong, Sianak, Mentadak, Sebuku, Sembakung, Sebakis, and Menggaris), the Sebuku River exhibited similar WQI values (Table 4). Likewise, the 2023 WQI for Berau Regency was 53.33 (LKjIP Berau-IP, 2023), also classified as moderate.

Table 2. Pollution Index Value

Location	1 st Sampling	2 nd Sampling	3 rd Sampling	4 th Sampling	Average
ST- 1	3.26	3.83	2.20	3.52	3.20
ST- 2	3.76	3.27	1.98	3.80	3.20
ST- 3	3.48	3.25	1.69	3.14	2.89
ST- 4	3.21	3.21	1.44	3.01	2.72
ST- 5	3.03	3.20	1.38	2.93	2.64

Table 3. Water Pollution Index Calculation in Sebuku River

River Names	Sampling Point	Period	TSS (mg/L)	pH	BOD (mg/L)	COD (mg/L)	DO (mg/L)	NO3 (mg/L)	PO4 (mg/L)	Fecal coliform (MPN/10 mL)	CN- (mg/L)	PI	Water Quality Status
Sebuku	Station 1	1	250	6.52	3.61	16	4.5	0.43	0.19	7.6	0	3.26	Light Pollution
Sebuku	Station 2	1	339	6.95	7.22	23	4.5	0.30	0.14	6.5	0	3.76	Light Pollution
Sebuku	Station 3	1	291	6.53	3.11	22	4.4	0.41	0.11	5.8	0	3.48	Light Pollution
Sebuku	Station 4	1	245	6.60	2.56	22	4.7	0.40	0.11	3.0	0	3.21	Light Pollution
Sebuku	Station 5	1	219	6.54	2.17	16	5.3	0.36	0.10	6.4	0	3.03	Light Pollution
Sebuku	Station 1	2	368	6.48	1.67	16	3.5	0.20	0.07	7.8	0	3.83	Light Pollution
Sebuku	Station 2	2	254	6.44	0.56	23	4.0	0.18	0.04	6.0	0	3.27	Light Pollution
Sebuku	Station 3	2	251	6.40	1.72	18	4.3	0.19	0.13	5.6	0	3.25	Light Pollution
Sebuku	Station 4	2	246	6.43	1.81	16	4.4	0.20	0.04	3.0	0	3.21	Light Pollution
Sebuku	Station 5	2	244	6.50	2.22	16	4.5	0.11	0.02	6.6	0	3.20	Light Pollution
Sebuku	Station 1	3	128	7.33	0.28	28	4.8	0.14	0.07	7.2	0	2.20	Light Pollution
Sebuku	Station 2	3	112	7.44	0.33	16	4.6	0.21	0.07	6.4	0	1.98	Light Pollution
Sebuku	Station 3	3	93	7.29	0.28	16	4.9	0.24	0.05	5.6	0	1.69	Light Pollution
Sebuku	Station 4	3	79	7.02	0.83	12	5.0	0.22	0.04	3.2	0	1.44	Light Pollution
Sebuku	Station 5	3	76	7.00	0.31	10	5.1	0.23	0.03	6.4	0	1.38	Light Pollution
Sebuku	Station 1	4	298	6.99	1.39	40	3.7	0.27	0.02	7.3	0	3.52	Light Pollution
Sebuku	Station 2	4	354	6.92	1.00	40	3.6	0.21	0.02	6.3	0	3.80	Light Pollution

Sebuku	Station 3	4	234	6.93	1.06	34	3.9	0.22	0.03	5.7	0	3.14	Light Pollution
Sebuku	Station 4	4	217	6.92	0.72	24	4.2	0.21	0.04	3.3	0	3.01	Light Pollution
Sebuku	Station 5	4	207	6.89	0.33	22	4.3	0.21	0.03	6.3	0	2.93	Light Pollution

Table 4. Sebuku River Water Quality Index Category

Water quality	Number of monitoring that meets water quality	Percentage of Water Quality Fulfillment (%)	Index Value Weight	Index Value per Water Quality
Meets	0	0	70	0,00
Light pollution	20	100	50	50,00
Moderate pollution	0	0	30	0,00
Heavy pollution	0	0	10	0,00
Total	20			50,00
WQI Category				Moderate

Community Perception of Mining Activities on River Water Quality

Based on a survey of 79 respondents, the majority of community members (53.2%) perceived the water clarity of the Sebuku River as "slightly turbid," indicating mild turbidity due to suspended sediments or surface debris. A further 22.8% categorized the water as "very turbid," characterized by visible impurities, suggesting that higher levels of pollution, likely influenced by anthropogenic factors, including gold mining activities, were present. Only 24.1% of the respondents rated the water as "clear." The average clarity perception score of 2.01 reflects a general view of the water as leaning toward turbidity, implying a perceived decline in quality.

Regarding odor, 72.2% of respondents (57 out of 79) stated that the river water had "no odor" (score 3: Never), indicating that odor is not considered a significant issue. Meanwhile, 22.8% reported that the river "occasionally smells" (score 2), possibly during or after rainfall or specific local activities. Only 5.1% noted that the river "often smells" (score 1), which may be due to significant organic or chemical pollution. The average odor perception score of 2.67 suggests that most community members do not perceive odor as a primary concern.

In terms of safety for bathing and washing, 44.3% of respondents considered the river water "fairly safe," though they recommended preliminary treatment. Meanwhile, 35.4% stated the water was "very safe" and could be used without any treatment, indicating confidence in water quality. However, 20.3% of respondents felt the water was "unsafe" for domestic use. The average safety perception score of 2.15 indicates that while the river is generally deemed usable, many still advocate for basic water treatment before household use.

A summary of Community perceptions regarding Sebuku River water quality is presented in Tables 5 and 6. These include perceptions of water clarity, odor, and safety for domestic use.

Table 5. Summary of Community Perception of Sebuku River Water Quality

Variable	1 (Poor)	2 (Moderate)	3 (Good)	Total
Water Clarity	18 (22.8%)	42 (53.2%)	19 (24.1%)	79 (100%)
Water Odor	4 (5.1%)	18 (22.8%)	57 (72.2%)	79 (100%)
Safety for Bathing/Washing	16 (35.4%)	35 (44.3%)	28 (20.3%)	79 (100%)

Table 6. Descriptive Statistics of Perception Scores

Variabel	N	Min	Max	Mean	Std. Dev
Water Clarity	79	1	3	2.01	0.68

Water Odor	79	1	3	2.67	0.57
Safety for Bathing/Washing	79	1	3	2.15	0.73

Community perception data align with laboratory test results, particularly for the physical parameter of water clarity. Most respondents (53.2%) considered the water “slightly turbid,” while 22.8% described it as “turbid,” and only 24.1% viewed it as “clear.” The average clarity score of 2.01 closely borders the “turbid” category, reflecting the community’s sensitivity to visible water pollution.

This perception is supported by laboratory findings, which indicate high TSS concentrations ranging from 187 to 265 mg/L. A positive correlation exists between elevated TSS and reduced water clarity (Sinaga et al., 2024), as suspended solids inhibit light penetration. Lestari et al. (2023) further reported that TSS concentrations above 50 mg/L significantly impair water transparency and aesthetic value. Community perception of turbidity, therefore, serves as a reliable visual indicator that accurately reflects actual water quality data. Asyikin et al. (2024) similarly found that public perceptions of turbidity corresponded to high TSS levels (120–230 mg/L) in the Krueng Seunagan River in Aceh.

Regarding odor, 72.2% of respondents reported no noticeable smell, 22.8% noted occasional odor, and only 5.1% reported frequent unpleasant smells. The average score of 2.67 suggests that odor is not a critical issue. These perceptions are consistent with low BOD values, ranging from 1.26 to 2.28 mg/L, well below the 3 mg/L Class II water quality threshold. A low BOD indicates a limited organic load, reducing the potential for odor. According to Fahrul et al. (2021), foul odors often arise from the decomposition of organic matter and microbial activity, which can sometimes involve specific chemical or mineral compounds. Royani et al. (2021) also observed that odor problems can occur even when BOD levels are within standard limits, depending on the type of chemical compounds present.

Regarding perceived safety for domestic use, 44.3% of respondents considered the water “fairly safe” if treated, 35.4% rated it “very safe,” and 20.3% found it “unsafe.” These findings reflect public caution, although the general acceptance of river water for household use remains relatively high.

Community perceptions of the impacts of mining on river water quality also revealed mixed responses. While 51.9% of respondents believed mining activities had no impact on water quality, 43.0% reported minor effects, particularly during the rainy season, and only 5.1% perceived significant impacts. The average perception score of 2.47 indicates that most respondents considered the influence of mining to be limited or negligible.

Further statistical analysis revealed a significant positive correlation between favorable perceptions of mining operations and improved perceptions of river water quality. Conversely, negative experiences such as increased turbidity or health issues like skin irritation were associated with lower confidence in the cleanliness of river water ($p < 0.01$; $r = 0.664$). These results suggest that effective environmental management in mining operations can help foster public trust in the quality of river water.

Conclusion

In general, the water quality of the Sebuku River is categorized as lightly polluted, with Total Suspended Solids (TSS) identified as the most critical parameter. Both the Biochemical Oxygen Demand (BOD) and pH levels remain within safe thresholds, while the Chemical Oxygen Demand (COD) approaches the standard limit but exhibits a declining trend

downstream. The Pollution Index (PI) classifies the river as lightly polluted, while the Water Quality Index (WQI) categorizes it as of moderate quality.

Community perceptions regarding water clarity, odor, and safety are consistent with laboratory findings, particularly about physical parameters such as TSS. The majority of respondents described the water as "slightly turbid" and "odorless" ($p < 0.01$; $r = 0.664$). Most also considered the water still usable for domestic purposes following basic treatment. These findings suggest that community perception can serve as an early indicator of changes in river water quality.

Recommendations

To improve the water quality of the Seuku River, the following actions are recommended:

Routine Water Quality Monitoring

Continuous monitoring is essential, particularly for key parameters such as TSS, COD, and BOD, to detect early changes in water quality and prevent further pollution.

Stricter Mining Waste Management

Mining companies should implement more stringent environmental management practices to prevent pollutants from entering surface water bodies. Reclamation and rehabilitation of former mining areas must comply with established environmental regulations.

Community Education and Empowerment

Community awareness campaigns should be intensified to inform residents about the risks of water pollution and promote safe and sustainable water usage. Empowering local communities will foster active participation in environmental conservation.

Utilization of Community Perception as a Social Monitoring Tool

Given its strong correlation with laboratory results, community perception can be used as a cost-effective and rapid social monitoring tool to detect changes in water quality at the local level.

River Basin Protection Policies

Local governments are encouraged to strengthen regulatory policies to protect the Seuku River Basin by considering the region's environmental carrying capacity. Cross-sectoral oversight should be implemented to mitigate pollution risks from human activities.

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