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WATER QUALITY CONDITION FROM UPSTREAM TO DOWNSTREAM OF MAHAKAM RIVER, KUTAI KARTANEGARA DISTRICT, EAST KALIMANTAN

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Abstract:
This research aims to ascertain the proclivity of waste in the Mahakam River, identify the category of waste that exhibits the potential to cause pollution, and evaluate the pollution index at the designated site. Water samples were collected at five locations along the Mahakam River in Kutai Kartanegara District, from upstream to downstream. The method of data analysis using the arc gisc software and calculation of the pollution index has been modified to comply with the State Minister of Environment's Decree (KEPMEN LH) No. 115 of 2003. The study's findings indicate an upward proclivity in the total Fecal Coliform waste from the upstream to the downstream of the Mahakam River, with a significant increase observed in the Tenggarong Area. The quality of the waste was measured to be 5400 mg/ltr, surpassing the established environmental quality standards. The Mahakam River exhibits high water quality, up to 4.66 mg/ltr above the established environmental quality standards, although Dissolved Oxygen (DO) waste is primarily located in its upper reaches. The Batuk Area is susceptible to a rise in the pollution index due to Dissolved Oxygen (DO) waste. In contrast, Tenggarong Area is prone to an increase in the pollution index owing to the total Fecal Coliform waste. The pollution levels were measured in five distinct locations along the Mahakam River, namely Batuk Village, Muara Muntai Sub-district, Semayang Lake, Kota Bangun Sub-district, Tenggarong Sub-district, and Jembayan Village. The recorded pollution measures for these locations were 0.599, 0.4576, 0.476, 0.589, 0.526, and 0.583, respectively.

Keywords: Mahakam River, Quality Standard, Waste, Pollution, Proclivity.

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INTRODUCTION

The Mahakam Watershed is situated within the boundaries of the East Kalimantan Province and the North Kalimantan Province. The province of East Kalimantan encompasses a land area of 79,985 square kilometers, constituting a proportion of 93.84%. On the other hand, North Kalimantan has a land area of 5,251 km2 and a population of 6.16% (Ministry of PUPR, 2017). The overall watershed area is 8.2 million hectares, with a river length of 920 kilometers, located in Mahulu District, West Kutai, East Kutai, Kutai Kartanegara, Samarinda City, East Kalimantan Province, and just a tiny portion in Malinau District, North Kalimantan Province (Watiningsih, 2009).

The Mahakam River holds significant importance in sustaining the livelihoods of the individuals of Kutai Kartanegara District. The community relies on this water as a primary resource for daily activities, including but not limited to irrigating rice fields, bathing, and fulfilling the water supply needs of the local water utility company. Therefore, conducting a thorough investigation and

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analysis of the river water's quality is imperative. The study conducted by Annisa and Setyowati (2022) utilized various parameters such as Pb (lead), temperature, pH, TDS, TSS, BOD, and COD. The findings indicate that the water quality status of the Mahakam River within Samarinda City falls under the classification of "lightly polluted," with a value range of 2.106 – 1.65.

According to research conducted by Suyatna et al. (2017), the levels of heavy metals in both water and fish samples collected from the Mahakam Delta were found to be almost below the detection limit, except for Fe (0.02 to 0.72 mg/l), Mn (0.01 mg/l), Cu (0.004 mg/l), and Zn (0.02 mg/l) in the water. While the concentrations of metals detected in six distinct fish species, namely grouper (Epinephelus sp.), kakapo (Lutjanus sp.), croaker (Otoliths sp.), freshwater fish (Nemipterus sp hairpin anchovy (Setipinna sp.), and mullet (Mugil sp.) were observed to be considerably elevated. Although Hg, As, and Se metals remain undetectable, the concentration of other metals such as Cu (ranging from 1,26 until 44,71 mg/kg), Zn (28,7 until 97,54 mg/kg), Mn (6,40 until 69,51 mg/kg), Fe (46,5 until 408,93 mg/kg), Ni (46,5 until 408,93 mg/kg), Pb (0,17 until 1,62 mg/kg), dan Cd (0,02 until 4,02 mg/kg) have been identified.

A study conducted by Sujiman (2022) revealed that the levels of Fe waste at four coal mining locations in Kutai Kartanegara District exhibited an upward proclivity in 2021, reaching a maximum of 6.45 mg/lt, followed by a decline to 0.89 mg/lt, and subsequently a slight increase until September 2020. However, during mining activities involving metallic elements, the concentration of Fe waste spiked to 62.30 mg/lt.

METHODS

The study was conducted in the Mahakam River in Kutai Kartanegara District, East Kalimantan. The data utilized in this research were obtained from various sources and encompassed a range of types displayed as follows. The present study employs primary data, which has been collected from various sampling points situated in distinct regions, including Desa Batuk, Muara Muntai, Semayang Lake, Kota Bangun, Tenggarong, and Jembayan Village, by extracting water samples from the Mahakam River. Subsequently, the water sample underwent a quality analysis at the laboratory of PT. Mutu Agung Lestari, located at Jl. Raya Bogor Km 33 No. 19 is located in Cimanggis, Depok, Indonesia. PT. Mutu Agung Lestari is a laboratory accredited by the National Accreditation Committee. The following formula was used to determine the level of pollution in rivers when analyzing data from water quality using the Pollution Index (IP) according to the Decree of the State Minister of Environment (KEPMEN LH) No. 115 of 2003 Annex II concerning Guidelines for Determining Water Quality Status:

$$Pij = \sqrt{\left(\left(\frac{Ci}{Lij}\right)^2 M + \left(\frac{Ci}{Lij}\right)^2 R\right)/2}$$

Where:

i = The significance of measuring water quality parameters.

Lij = The quality standard value of the water quality parameters adheres to PP No. 82 of 2001 on water quality management and pollution control.

Pij = Pollution Index Designation (J)

(Ci/Lij) M = Value, Ci/ maximum Lij

(Ci/Lij) R = Value, Ci/ average Lij

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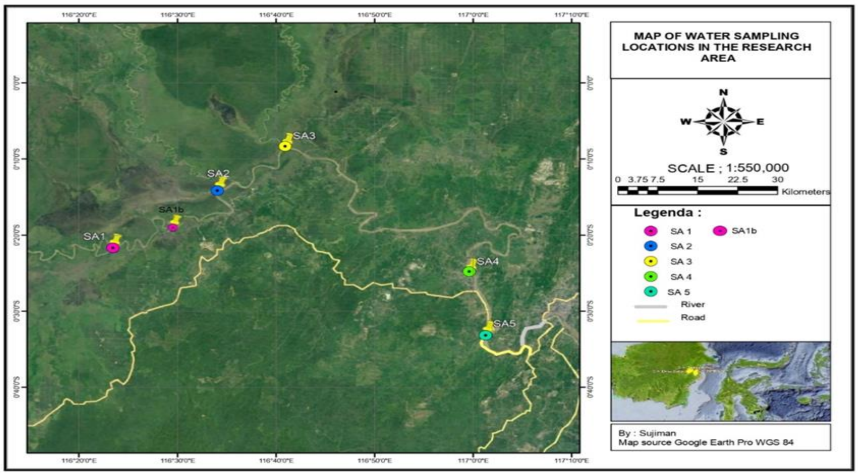
Research Location. The research locations are as follows: 1). Mahakam River of Desa Batuk (SA1) with coordinates 0° 21' 47.70" South, 116° 23' 24.91" East, 2). Mahakam River of Muara Muntai (SA1b) with coordinates 0° 19' 4.22"South, 116° 29' 39.94" East, 3) Mahakam River outlet of Semayang Lake (SA2) with coordinates 0°14'14.21"South, 116° 34' 3.91" East, 4) Mahakam River of Kota Bangun Village (SA3) with coordinates 0° 8' 35.36" South, 116°40'52.77"East, 5) Mahakam River of Tenggarong Sub-district (SA4) with coordinates 0° 25' 0.91" South, 116° 59' 30.32" East, 6) Mahakam River of Jembayan Village (SA5) with coordinates 0°33' 12.47" South, 117° 1' 11.61" East (Google Earth., 2023). Figure 1 depicts the sampling location.



(Google Earth., 2023)

Fig 1. The Map Water Sampling Locations in the Research

RESULT AND DISCUSSION

The present study utilized data collected from six stations during the Mahakam River water quality assessment. These stations were in Desa Batuk, Muara Muntai Sub-district, Semayang Lake, Kota Bangun Sub-district, Tenggarong Sub-district, and Jembayan Village. The data was subsequently analyzed at the water quality laboratory of PT Mutu Agung Lestari. The study findings indicated that the Fecal Coliform values ranged from 240 to 3500 mg/ltr, with the minimum value observed in Desa Batuk and the maximum in Tenggarong Sub-district. The Total Coliform has a concentration range of 350-5400 milligrams per liter. Table 1 displays the data collected during May 2022. The environmental quality standards set by the government are being exceeded solely in Tenggarong, while Batuk location regarding the quality condition of Fecal Coliform and Total Coliform. In certain regions, the environmental quality standards are yet to be met.

Table 1. Quality List of Fecal Coliform and Total Coliform From upstream to Downstream of the Mahakam River

Location	Fecal Coliform (mg/ltr)	Quality Standarts of Fecal Coliform (mg/ltr)	Total Coliform (mg/ltr)	Quality Standarts of Total Coliform (mg/ltr)
Batuk	240	1000	350	5000
Muara Muntai	350	1000	540	5000
Semayang Lake	920	1000	1100	5000

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Kota Bangun	540	1000	920	5000
Tenggarong	3500	1000	5400	5000
Jembayan	1600	1000	2400	5000

The laboratory analysis of Total Dissolved Solids (TDS) quality values from various locations yielded intermediate results ranging from 188 to 340 mg/ltr. The lowest value was recorded in Batuk Village at 188 mgr/ltr, while the highest was observed in Tenggarong City at 340 mgr/ltr. Meanwhile, the Acidity degree (pH) levels ranging from 6.21 to 6.75 and Biochemical oxygen demand BOD values ranging from 2.39 to 2.81 mg/L were observed. The outcomes obtained were within the quality benchmarks established by the governing authorities.

Total Dissolved Solids (TDS) concentrations exhibit variability along the course of the Mahakam River, ranging from its upstream to downstream regions. Although the pH levels remain relatively consistent across all locations, there is variability in the BOD values, which range between 2.39-2.81 mg/L. The outcomes of the TDS, pH, and BOD analyses can be seen in Table 2.

Table 2. List of Mahakam River TDS, pH, and BOD Analysis Findings

Location	Total dissolved solids (TDS) (mg/ltr)	Quality Standards of Total dissolved solids (TDS) mg/ltr	Acidity degree (pH) *(Insitu)*	Quality Standards of Acidity degree (pH) (Insitu) minimum	Quality Standards of Acidity degree (pH) (Insitu) maximum	Biochemical oxygen demand (BOD)	Quality Standards of Biochemical oxygen demand (BOD)
Batuk	188	1000	6,54	6,00	9,00	2,39	3,00
Muara Muntai	210	1000	6,73	6,00	9,00	2,52	3,00
Semayang Lake	262	1000	6,75	6,00	9,00	2,63	3,00
Kota Bangun	244	1000	6,64	6,00	9,00	2,58	3,00
Tenggarong	340	1000	6,21	6,00	9,00	2,81	3,00
Jembayan	328	1000	6,43	6,00	9,00	2,74	3,00

The TSS quality has exhibited a graded decline from upstream to downstream. However, it has yet to attain a high level and remains below the environmental quality threshold of 16-21 mg/ltr. The concentrations of COD, DO, and sulfate exhibited fluctuations within the ranges of (14.2-19.2) mgr/ltr, (4.33-4.66) mgr/ltr, and (4.03-5.10) mgr/ltr, respectively. Table 3 displays the results of the TSS, COD, DO, and sulfate analyses.

Table 3. List of Mahakam River TSS, COD, DO, and Sulphate Analysis Findings

Location	Total suspended solids (TSS) mg/ltr	Quality Standards of Total suspended solids	Chemical oxygen demand (COD) mg/ltr	Quality Standards of Chemical Oxygen Demand	Dissolved oxygen (DO) *(Insitu)* mg/ltr	Quality Standards of Dissolved oxygen (DO)	2- Sulfat (SO_4) mg/ltr	Quality Standards of (2- Sulfat (SO_4) mg/ltr

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		(TSS) mg/ltr		(COD) mg/ltr		(Insitu) mg/ltr		
Batuk	16	50	14,2	25,0	4,66	4,00	4,03	300
Muara Muntai	18	50	15,4	25,0	4,57	4,00	4,33	300
Semayang Lake	19	50	16,7	25,0	4,46	4,00	4,60	300
Kota Bangun	18	50	15,7	25,0	4,55	4,00	4,40	300
Tenggarong	21	50	19,2	25,0	4,33	4,00	5,10	300
Jembayan	21	50	17,3	25,0	4,41	4,00	4,92	300

The nitrate levels in the water between Batuk Village and Jembayan Village exhibit variability, ranging between 1.29 to 1.86 milligrams per liter. Similarly, the nitrite concentration in the water is recorded at 0.0015 milligrams per liter. Table 4 displays the analysis outcomes for N as Nitrate and N as Nitrite.

Table 4. List of Mahakam River N as Nitrate and N as Nitrite Analysis Findings

Location	Nitrat (as N) mg/ltr	Quality Standarts of Nitrat (as N) mg/ltr	Nitrit (as N) mg/ltr	Quality Standarts of Nitrit (as N) mg/ltr
Batuk	1,29	10,00	0,0015	0,06
Muara Muntai	1,41	10,00	0,0015	0,06
Semayang Lake	1,57	10,00	0,0015	0,06
Kota Bangun	1,46	10,00	0,0015	0,06
Tenggarong	1,86	10,00	0,0015	0,06
Jembayan	1,64	10,00	0,0015	0,06

Proclivity in Waste Quality at Research Location, Waste Proclivity of Fecal Coliform and Total Coliform. Based on water sample analysis results for Fecal Coliform and Total Coliform quality conditions. Each case demonstrates that the quality tends to improve as one moves downstream while remaining within the stated quality requirements. Tenggarong Sub-district and Jembayan Village have been found to have surpassed the quality standards for Fecal Coliform, with levels of 3500 mg/ltr and 1600 mg/ltr, respectively. Total coliform has been observed solely in Tenggarong, surpassing the government's quality standard limit of 5000 mg/ltr with a 5400 mg/ltr concentration. Figure 2 illustrates the prevalence of Fecal Coliform and Total Coliform waste.

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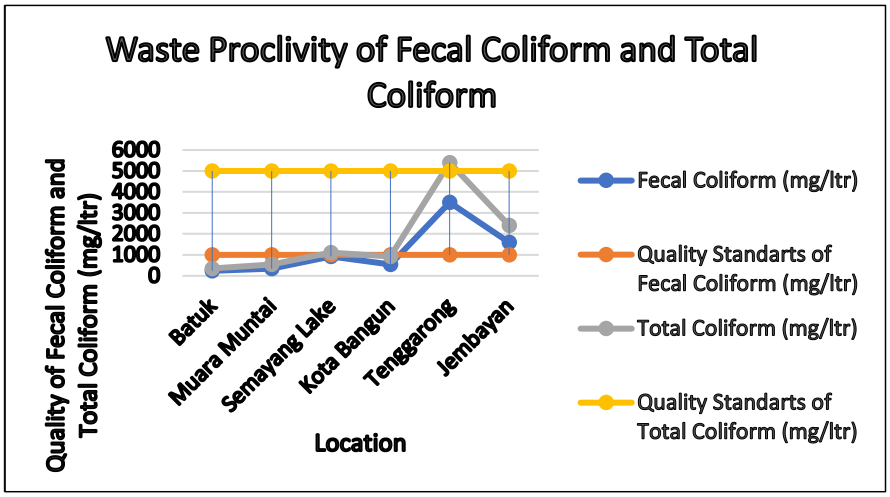

Fig.2. Waste Proclivity of Fecal Coliform and Total Coliform

Proclivity in Waste Quality of Total dissolved solids (TDS). Total dissolved solids (TDS) is a condition that reflects the amount of dissolved solids. The TDS concentration data exhibits variability across different locations. There has been an observed increase in the proclivity of total dissolved solids (TDS) values towards the downstream section of the river. Based on the results of the sample analyses, it was determined that the total dissolved solids (TDS) remained within the government's prescribed quality standard, with a maximum limit of 1000 mg/l. Tenggarong recorded the highest Total Dissolved Solids (TDS) value of 340 mg/l.

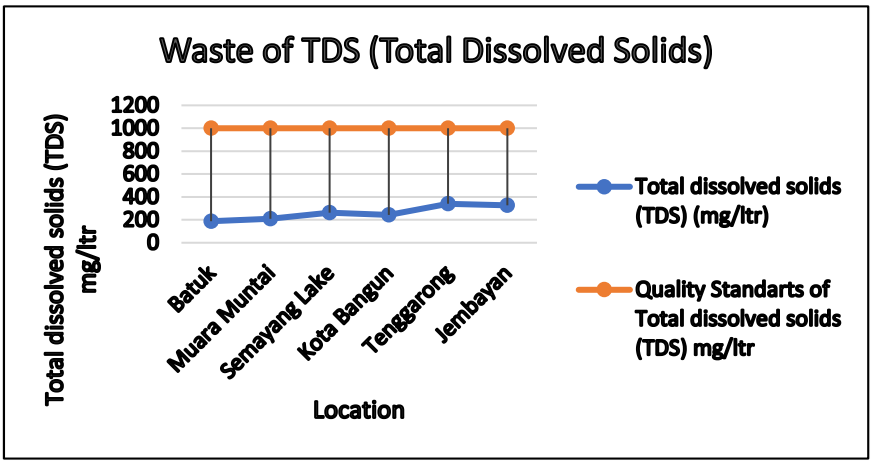

Fig 3. Waste of TDS (Total Dissolved Solids)

Quality Proclivitys of Acidity Degree (pH). Acidity degree (pH) measures the acidity or alkalinity of a substance or solution. The analysis revealed that the entirety of the research site under investigation exhibited a pH level exceeding the minimum threshold of 6 while remaining significantly below the upper limit of 9 as stipulated by the quality standard. The pH values recorded in Tenggarong and Semayang Lake were 6.21 and 6.75, respectively, with the latter exhibiting the highest.

Quality Proclivitys of Biochemical oxygen demand (BOD). The Biochemical Oxygen Demand (BOD) quantifies the extent of biochemical degradation in water. Aerobic microorganisms

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necessitate oxygen for the process of oxidation, which results in the production of inorganic substances. Upon analyzing the data, it is evident that the entirety of the research site remains in a favorable state, as it falls below the established government-mandated maximum Quality Standard of Biochemical oxygen demand (BOD) with a recorded value of 3 mg / ltr. The Tenggarong area exhibited the highest Biochemical Oxygen Demand (BOD) level, measuring 2.81 mg/ltr, while the Batuk area demonstrated the lowest BOD level, measuring 2.39 mg/ltr.

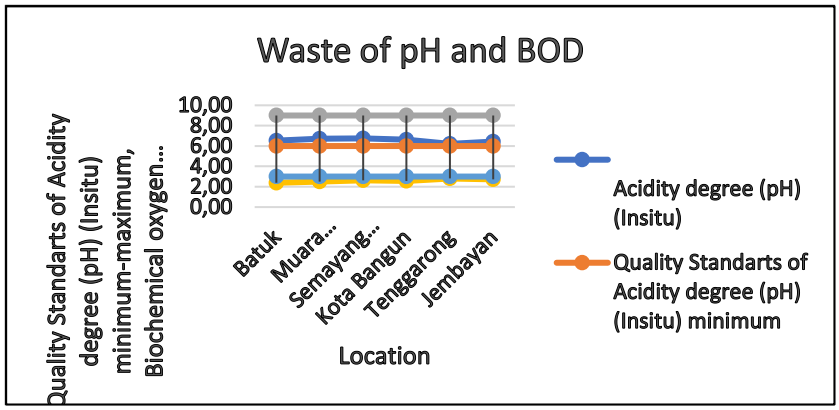

Fig 3. Waste of pH and BOD

Quality Proclivitys of Total Suspended Solid (TSS). Total Suspended Solid (TSS) in water is characterized by the suspension of solid residue comprising organic and inorganic matter, significantly affecting water's turbidity level and overall quality. The gradient of TSS quality from upstream to downstream has exhibited an increase, however not significantly, such that it remains below the established quality benchmark. The findings from the water quality analysis indicate that all research sites remained within the Total Suspended Solids (TSS) Quality Standard, with a maximum value of 50. Tenggarong and Jembayan exhibited the highest TSS values, measuring 19 mg/l. While, Batuk exhibits the lowest TSS value, measuring at 16 mg/ltr.

Quality Proclivitys of Chemical Oxygen of Demand (COD). Chemical Oxygen Demand (COD) refers to the quantity of oxygen required to oxidize organic substances in water. Based on the analyzed data, it has been determined that there is an increasing proclivity in COD values from the upstream to the downstream of the river. Batuk exhibited the minimum Chemical Oxygen Demand (COD) with a recorded value of 14.2 mg/ltr, whereas the maximum COD was observed in Tenggarong with a value of 19.2. The water sample taken from the study location is deemed satisfactory as it falls well below the maximum quality standard of 25 mg/ltr, as stipulated by the governing authorities.

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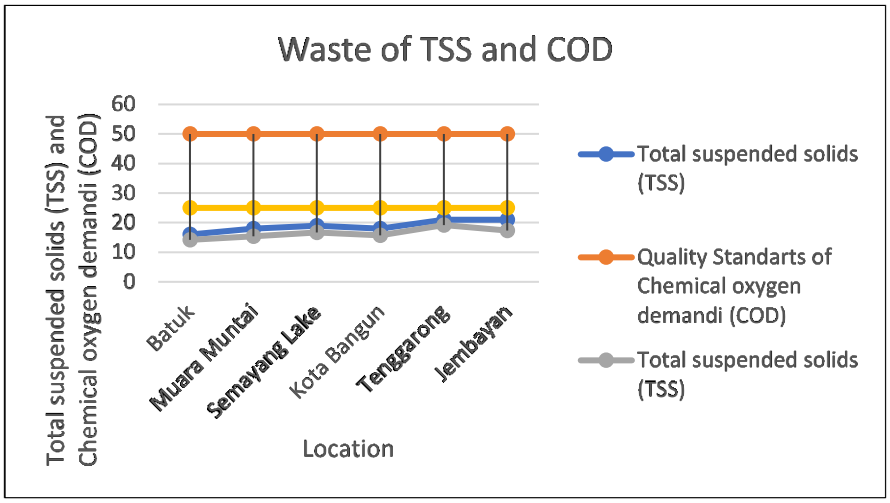

Fig 4. Waste of TSS and COD

Quality Proclivity of Dissolved Oxygen (DO). Dissolved Oxygen (DO) refers to the presence of oxygen that is dissolved in a liquid and is sometimes referred to as oxygen demand. One of the crucial factors to consider when evaluating water quality is this variable. The results demonstrated that the purity of the DO value decreases as the river moves downstream. The location of Batuk exhibited the highest dissolved oxygen (DO) value of 4.66 mg/l, whereas the location of Tenggarong had the lowest DO value of 4.33 mg/l. According to the Quality Standards for Dissolved Oxygen (DO) (in situ), all locations assessed have exceeded the maximum limit beyond the predetermined threshold of 4. Similarly, the state of water sulfate at the study site indicates an elevation in the downstream region of the river, with all research location analyses yielding values exceeding the established maximum threshold of 3 mg/l. Tenggarong exhibited the highest sulfate concentration of 5.10 mg/ltr, while Batuk displayed the lowest value of 4.03 mg/ltr.

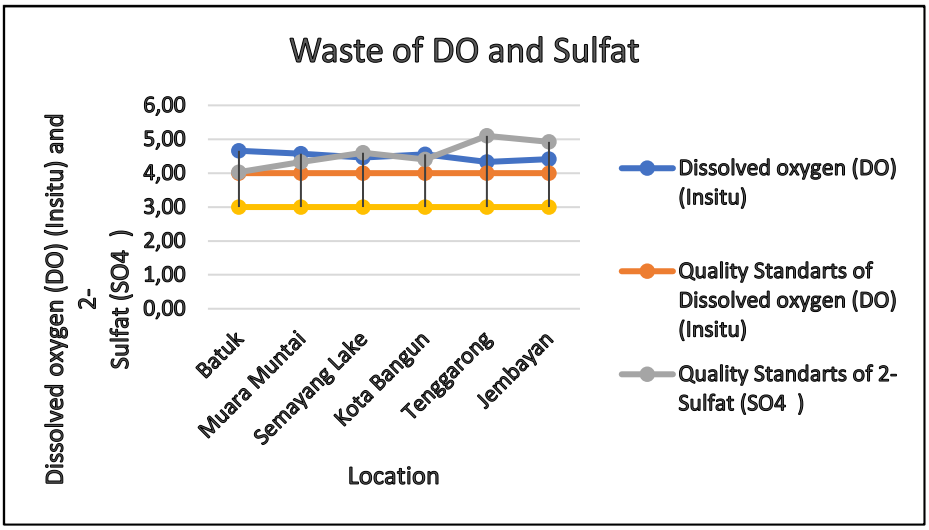

Fig 5. Waste of DO and Sulphate

Quality Proclivity of Nitrate and Nitrite. Nitrate and nitrite are nitrogenous organic compounds that have the potential to impact water quality. Surface water typically contains low

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concentrations of nitrates, usually below 3 mg/l, and nitrates are present at concentrations below 50 mg/l. Nitrite can be produced through two processes: the oxidation of ammonia to nitrate or the reduction of nitrate to ammonia. Elevated levels of nitrites and nitrates in water have been linked to adverse human health effects, including bloody diarrhea, seizures, coma, and potentially fatal outcomes if left untreated. The levels of nitrates in the water between Batuk Village and Jembayan Village exhibit fluctuations and variations. All research locations remain in satisfactory condition according to the water quality standard established by the government, which stipulates a maximum value of 10 mg/l. Tenggarong location exhibited the highest nitrate concentration of 1.84 mg/l, whereas the lowest concentration of 1.29 mg/l was observed in Batuk village. All locations indicate that nitrites' levels remain well below the Nitrite Quality Standard (N) with a maximum threshold of 0.06 mg/l. The observed value for nitrite conditions across all research sites is consistent at 0.0015 mg/l.

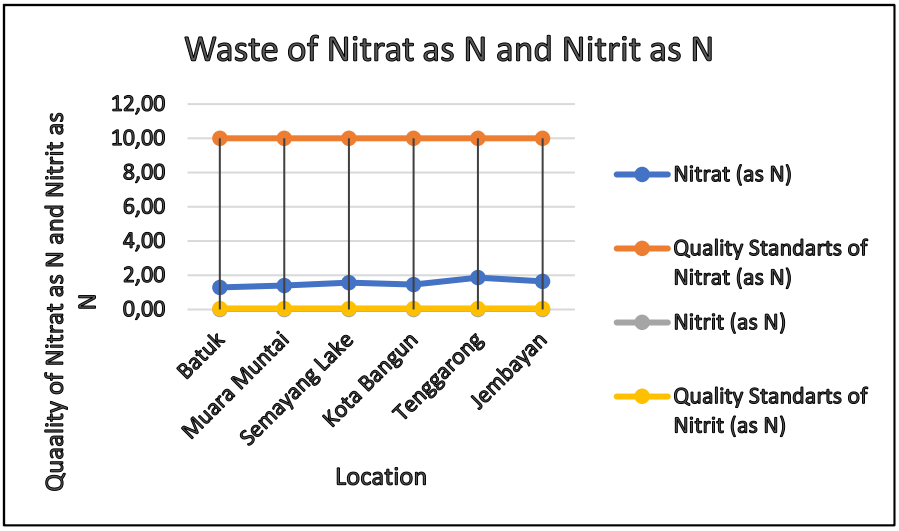

Fig 6. Waste of Nitrate as N and Nitrite as N

Pollution Index. According to KepMen LH No. 115, 2003, the pollution index (IP) calculation results indicate that the water quality of the Mahakam River falls under the unpolluted category, with a pollution index value below 1. The ascending order of the pollutant index calculation results obtained from the six locations is as follows: Batuk Village has a value of 0.599. Muara Muntai Sub-district has a value of 0.4576. Semayang Lake has a numerical value of 0.4765. Kota Bangun has a value of 0.589. Tenggarong Sub-district has a value of 0.526, and Jembayan Village is 0.584. Table 5 presents the computed values of the Mahakam River's IP across six distinct locations.

Table 5. Pollution Index Values in 5 Mahakam River Locations

No.	Location	Pollution Index
1	Batuk	0.5998
2	Muara Muntai	0.4576
3	Semayang Lake	0.4765
4	Kota Bangun	0.5896
5	Tenggarong	0.5260
6	Jembayan	0.5839

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The Pollution Index in the Mahakam River exhibits a fluctuating proclivity from upstream to downstream, with values oscillating between low levels at Batuk Village, increasing to high levels, subsequently decreasing again at Semayang Lake, followed by a rise at Kota bangun Sub-district, and a subsequent decline at Tenggarong Sub-district. However, at Jembayan Village, the Pollution Index experiences a subsequent increase. Figure 7 below depicts the Pollution Index proclivity in the Mahakam River.

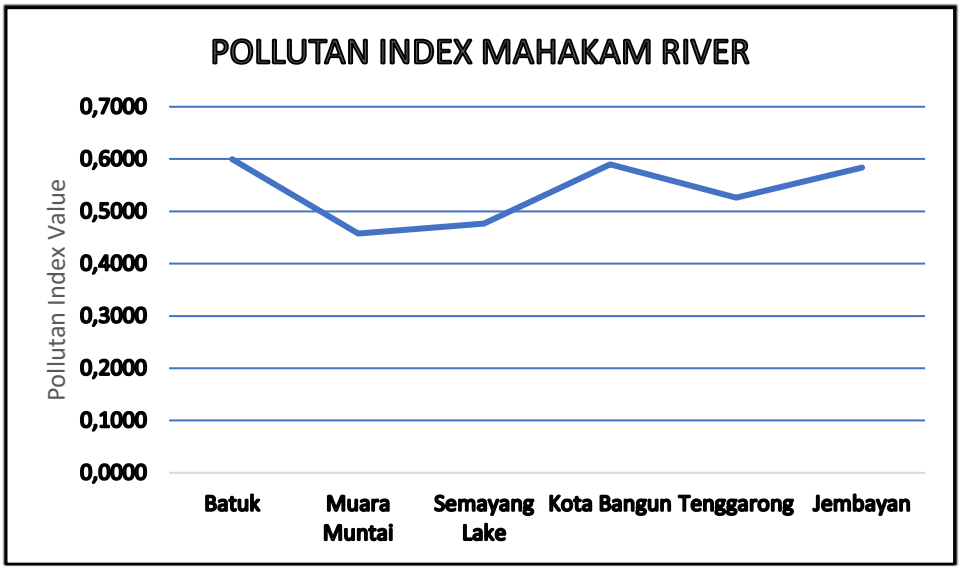

Fig 7. Pollution Index of several areas in the Makaham River

Batuk Village, with a pollution index of 0.599, Kota Bangun, with 0.589, and Jembayan, with 0.583, are the areas with a relatively high pollution index. While the other three regions have low pollution index values, they are still below the threshold.

The pollution index in Batuk Village is relatively elevated due to the oxygen quality demand parameter being 2.39, which falls below the minimum value of 3.00 as per environmental quality standards. Additionally, the quality of dissolved oxygen (DO) elements is 4.66, surpassing the minimum environmental quality standard of 4.00. Phosphate as P is also relatively high, exceeding the environmental quality standard by 0.14 times, which is 0.20. The need for oxygen, measured by dissolved oxygen (DO), and the phosphorus **(P)** concentration are high. Based on the existing IUP (Mining Business Permit) map, Batuk Village has no production, and there are few Plantation Business Permits (Figures 8 and 9), so this parameter is attributable to the presence of Melintang Lake water with low oxygen levels.

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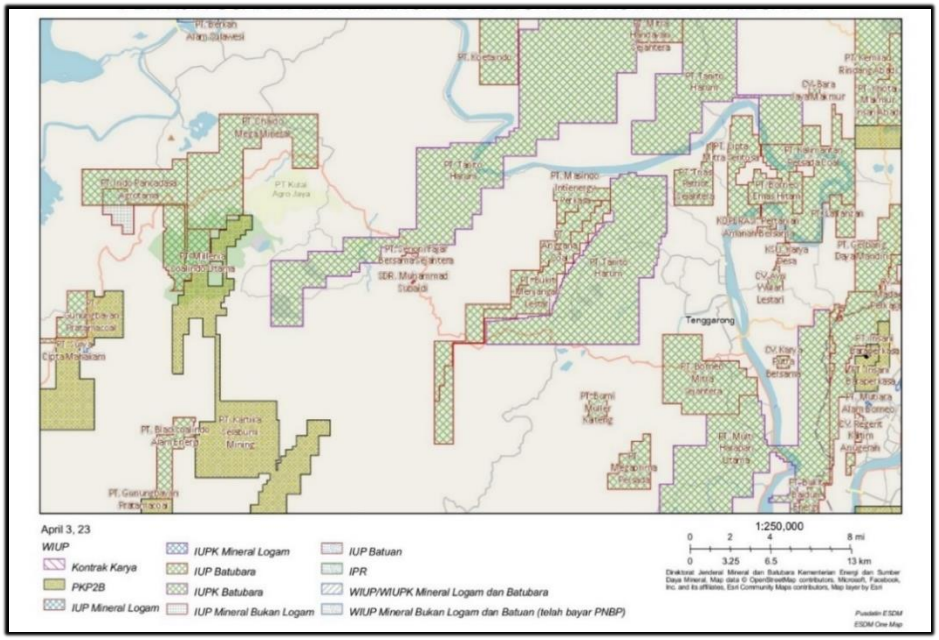
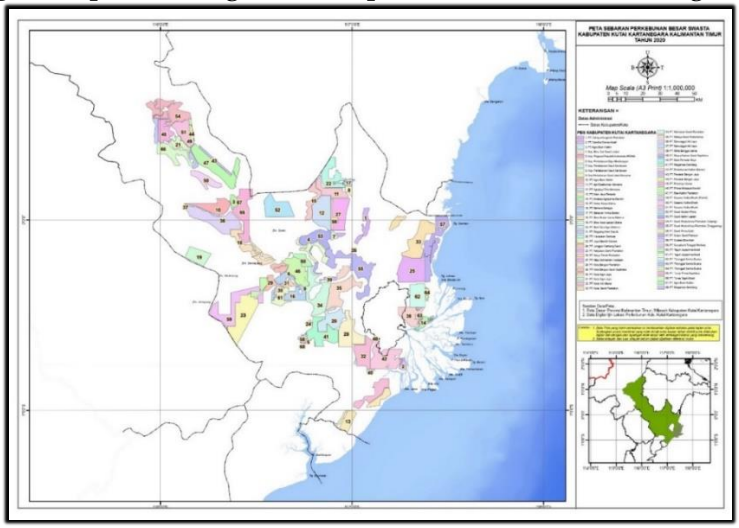


Source: DIRJEND MINERBA., 2023

Fig 8. Map of mining business permits in Kutai Kartanegara District



Source: DISBUN., 2020

Fig 9. Map of plantation business permits in Kutai Kartanegara District

CONCLUSION

The research location with the highest pollution level is in Tenggarong City, with a Fecal Coliform quality value of 1600 mg/ltr, which exceeds the environmental quality standard set by the government, 1000 mg/ltr. In addition, the Total Coliform value is 5400 mg/ltr; this value also exceeds the environmental quality standard of 5000 mg/ltr. In general, the proclivity of waste that can affect the pollution index value at all locations is Biological Oxygen Demand and Dissolved Oxygen. Meanwhile, Fecal coliform and Total coliform were only in the Tenggarong and Jembayan locations. The locations with the highest pollution index were Batuk Village with 0.5998, Kota Bangun District with 0.5896, and Jembayan with a value of 0.5839

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