



Analysis of Water Quality Pollution Index Asahan river in Tanjungbalai City

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ABSTRACT

The Asahan River, located in the Tanjungbalai city area, is used for plantation, agriculture, animal husbandry activities, toilet washing facilities, hospitals, hotels, settlements, and industry causing the decrease water quality of Asahan River. The purpose of this study was to analyze the water quality and status of the Asahan River water quality in the Tanjungbalai City Area and develop a pollution control strategy that needs to be implemented to prevent a decrease in the Asahan River water quality in the Tanjungbalai City Area. Purposive sampling technique as used to determine the sampling station. In this study, there were 6 sampling stations based on the activities of the local community with 3 repetitions of sampling. The data analysis techniques from this study are Water Quality Analysis using the Pollution Index (IP) Method and Water Pollution Control Strategy Analysis. The results of water quality analysis based on the pollution index on Asahan river water in Tanjungbalai City show that the average water pollution index is in the moderately polluted category. The maximum of river water pollution index results were at station 2 is 9,086 and the minimum of river water pollution index results were at station 5 is 6,111. Water pollution occurs due to the parameters of phosphate, detergent, oil and grease, and total coliform which have exceeded the quality standard threshold based on Government Regulation of the Republic of Indonesia Number 21 of the year 2022 concerning Management of Water Quality and Control of Class I Water Pollution.

Introduction

Water is an important part of an ecosystem (Sánchez *et al.*, 2019). A river is open flowing water and gets input from all the castaways originating from human activities in residential areas, agriculture and industry in the surrounding area. Input discharge into rivers will result in changes in physical, chemical and biological factors in the waters (Sahabuddin *et al.*, 2014; Akbar and Rahayu, 2023).

River water quality is also strongly determined by chemical, physical and biological parameters and is related to human needs, especially for agricultural purposes and daily consumption (Li, 2014; AznarSánchez *et al.*, 2019). The condition of a river with a large number of inhabitants can be a cause of decreased quality water and increased pollution of river waters caused by community activities around the river disposing of domestic waste, both liquid and solid waste, directly into river waters (Mahyudin,

Soemarno, Tri. 2015; Hernandi. 2019; Kospa & Rahmadi, 2019; Akbar *et al.*, 2023). Environmental degradation of river waters is strongly influenced by the population subsystem, water resources population subsystem, industry subsystem, pollution (pollution) subsystem, water quality subsystem, tourism subsystem, and agriculture subsystem (Baherem *et al.*, 2014; Widianara *et al.*, 2018). The amount of organic matter discharged into the aquatic environment, then waters will be increasingly polluted with pungent odor (Pohan *et al.*, 2016; Aprilia and Zunggaval, 2019).

Analysis of the water quality of the Asahan River in Tanjungbalai City conducted by the Sumatera II River Basin (2018), showed that Dissolved Oxygen (DO), Biological Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Total Suspended Solid (TSS), Total Dissolved Solid (TDS), Power of Hydrogen (pH) almost entirely exceeds the

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established quality standards. Based on the problem analyzed, the water condition of the Asahan River in Tanjungbalai City has experienced significant pollution, and does not meet the criteria for Water Quality Standard Status for both class I and class II, so it needs to be addressed immediately considering that most clean water sources in Tanjungbalai City depend on rivers Asahan.

The results of Bulan, S (2013), research on the Utara Relationship of Water Quality at Tide and Ebb and the Characteristics of Water Use in the Silau Downstream River to Gastroenteritis in Tanjungbalai District, Tanjungbalai City showed that the quality of the tidewater in terms of physical requirements tastes rancid and is slightly cloudy yellow and the water ebb smells rancid, cloudy yellow. From a chemical point of view, the BOD content of the tide is 10.8 mg/l, COD is 27 mg/l and pH 7, and Coli is 1100 MPN/100 ml. At low tide, the levels of BOD were 11.2 mg/l, COD 25 mg/l, pH 7.3, and E. Coli 240 MPN/100 ml. Quality above the established quality standard.

Based on the problems raised, the researcher intends research to analyze the water quality of the Asahan River in the Tanjungbalai City Area with the value of the physical and chemical parameters of the waters with the standard criteria for water quality in Government Regulation Number 22 of 2021. The research objective was to analyze water quality based on the Pollution Index (IP) method on the Asahan River in Tanjungbalai City. Pollution index is a method or tool that can be used to provide information about water quality (Effendi *et al.*, 2015; Tanjung *et al.*, 2019) and provide an assessment with a single score on the parameters to interpret water quality (Li *et al.*, 2016; Dunca, 2018; Wu *et al.*, 2018).

Materials and Methods

Location and time of research

This research was conducted on September 3, 2022, September 20, 2022, and October 4 2022 at the Asahan River, Tanjungbalai City, North Sumatra Province. The water samples identified were carried out at the Class I Laboratory for Environmental Health Engineering and Disease Control (BTKLPP) Medan. The following map of the research in Figure 1.

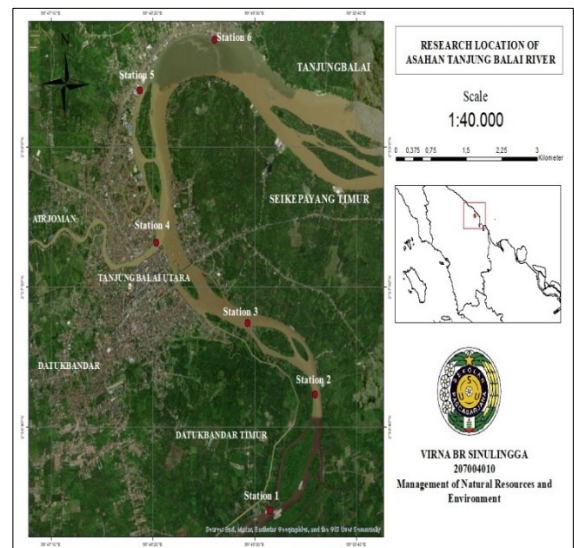


Figure 1. Map of Research Location

Data analysis

a. Station determination technique in sampling

Station determination technique for sampling in this study used a purposive sampling technique. In this study, there were 6 sampling stations based on the activities of the local community with 3 repetitions of sampling.

Station 1

Station 1 is an area close to community-owned oil palm plantation activities. Located in Datuk Bandar Timur sub-district with coordinates 99°49'37,054" E and 2°55',244"N.

Station 2

Station 2 is an oil palm plantation area, populated area, and tourist area, namely Beswesen Island, which is located in Datuk Bandar Timur District with coordinates 99°50'11.964" E and 2°56'54.718" N.

Station 3

Station 3 is an area that contains mangrove forests. Located in North Tanjungbalai district, with coordinates 99°49'23.021"E and 2°57'29.924".

Station 4

Station 4 is an area close to community residential activities and the Silau River watershed which flows towards the estuary. Located in Tanjung Balai Utara District at coordinates 99°48'22,783"E and 2°58'11,282"N.

Station 5

Station 5 is an area close to coconut oil factory activities and residential areas. Located in Teluk Nibung District at coordinates 99°48'10,120" E and 2°59'18,958"N.

Station 6

Station 6 is an area close to residential activities and an ice factory. This location is located in Teluk Nibung District at coordinates 99°49'0.090"E and 2°59'52.795" N.

b. River water quality sampling technique

The water sampling technique is done by taking surface water. The values for the physical, chemical, and microbiological parameters of the waters obtained were compared with the standard criteria for water quality in Government Regulation Number 22 of year 2021.

c. Water Quality Analysis Techniques with the Pollution Index (IP) Method

Analysis of water quality using the pollution index method according to the Decree of the Minister of Environment No. 115/2003 concerning determining the status of water quality, to determine the level of river pollution using the following formula:

$$IP = \frac{\sqrt{\left(\frac{ci}{Lij}\right)_m^2 + \left(\frac{ci}{Lij}\right)_r^2}}{2}$$

- IP = pollution index
- Ci = concentration of water quality parameter i
- Lij = concentration of water quality parameter i listed in the water allotment standard j
- m = Maximum
- r = Average IP water quality value is determined from the result of the maximum value and the average value of the concentration ratio per parameter to the quality standard value.

There are 4 IP index classes:

1. Score $0 \leq Pij \leq 1.0$ Good (good)
2. Score $1.0 < Pij \leq 5.0$ Slightly polluted
3. Score $5.0 < Pij \leq 10$ Fairly polluted
4. Pij score > 10 Heavily polluted

Results

Average results of analysis based on the tested water quality

The results of the analysis based on the tested water quality parameters are compared with the Government Regulation of the Republic of Indonesia Number 22 of year 2021 concerning the Management of Water quality and Control of Class II Water Pollution. The results of analysis water quality Asahan River in Tanjungbalai City can be seen in [Table 1](#).

Based on the results of measuring the temperature of the Asahan River water quality in Tanjungbalai City at stations 1 to 6, the temperature ranges from 28-28.8 ° C. Total Suspended Solid (TSS) Asahan river water in Tanjungbalai City at stations 1 to 6 ranges from 5 - 6.6 mg /L. The results of Total Dissolved Solid (TDS) measurements of Asahan river water quality in Tanjungbalai City at stations 1 to 6 show

Total Dissolved Solid (TDS) values ranging from 19.5 - 40.7 mg/L.

The results of measuring the pH of Asahan River water in Tanjungbalai City show that the pH of the water at stations 1 to 6 is in normal conditions in the range 6 – 9. The results of the analysis of Biological Oxygen Demand (BOD) measurements of Asahan river water in Tanjungbalai City from station 1 to station 6 range from 3.4 to 3.9 mg/L. The results of the analysis of Chemical Oxygen Demand (COD) measurements of the Asahan River in Tanjungbalai City at stations 1 to 6 ranged from 8.3 to 10.8 mg/L.

Dissolved Oxygen (DO) measurements of the Asahan River in Tanjungbalai City at stations 1 to 6 range from 4-7 mg/L. The results of the analysis of phosphoric samples in the Asahan River in Tanjungbalai City at stations 1 to 6 ranged from 0.19 to 0.55 mg/L. The results of the analysis of nitrate measurements in Asahan River water in Tanjungbalai City at stations 1 to 6 showed that nitrate values ranged from 7.03 to 8.77 mg/L. The results of the analysis of free ammonia measurements of Asahan River water in Tanjungbalai City at station 1 to station 6 show that the free ammonia value ranges from 0.02 to 0.07 mg/L.

The results of the analysis of oil and grease measurements of Asahan river water in Tanjungbalai City at station 1 to station 6 show that the value of oil and grease ranged from 1.1-2.9 mg/L. The results of the analysis of detergent measurements of Asahan River water in Tanjungbalai City at station 1 to station 6 show that the detergent value ranges from <333.1 - <500 mg/L. Total coliform measurement analysis of Asahan River water in Tanjung Balai City at stations 1 to 6 showed that the total coliform values ranged from 5400 - 11833.33 CFU/100 mL.

Determination of the water quality status of the Asahan River in Tanjungbalai City is carried out based on the Decree of the State Minister for the Environment Number 115 of year 2003 concerning Guidelines for Determining Water Quality Status. The method used is Appendix II Determination of Water Quality Status Using the Pollution Index Method. The results of the analysis of the Asahan River water pollution index measurement in Tanjungbalai City can be seen in [Table 2](#).

Based on [Table 2](#) the results of the analysis of the water pollution index of the Asahan River in Tanjungbalai City show that the average water pollution index is in the moderately polluted category. The maximum river water pollution index results were at station 2 is 9,086 and the minimum river water pollution index results were at station 5 is 6,111.

Table 1. Average results of analysis water quality Asahan River in Tanjungbalai City

Parameter	Unit	Results of river water quality analysis						Water quality standards (PPRI No. 22 of year 2021)
		1 St	2 St	3 St	4St	5 St	6 St	Class II
Physics								
Temperature	C	28,8	28,1	28,3	28,3	28,3	28,6	Dev 3
(TDS)	mg/L	31	40,7	39,7	19,5	39,3	31,7	1,000
(TSS)	mg/L	5,3	5	6,6	5	6,3	5,6	50
Chemistry								
pH	mg/L	6,6	6,6	6,6	7,3	7,6	7,3	6-9
(BOD)	mg/L	3,6	3,5	3,9	3,3	3,9	3,4	3
(COD)	mg/L	9.60	9.90	10,6	10,3	10,6	9.40	25
(DO)	mg/L	4,6	4,3	4,3	5,9	4,3	5	>4
Phosphate	mg/L	0.32	0.35	0.19	0.55	0.27	0.50	0.2
Nitrate	mg/L	7.03	8.77	7,53	7,45	7,10	7.80	10
Free ammonia	mg/L	0.03	0.02	0.03	0.05	0.05	0.07	0.2
Oil and fat	mg/L	2.60	2.06	2.43	2.50	2.40	1.80	1
Detergent Microbiology	mg/L	<500	<500	< 333,6	< 334,1	< 333,6	< 333,6	0, 2
Total coliforms	CFU/10 0 ml	11833, 33	7300	9566.6 6	11466, 67	6666,6 7	5400	5000

Table 2. Results of analysis of Pollution Index (IP) measurements of Asahan River water in Tanjungbalai City

No	Station	Results of analysis of Pollution Index(IP)	Information
1	Station 1	9,080	Moderately polluted
2	Station 2	9,086	Moderately polluted
3	Station 3	7,087	Moderately polluted
4	Station 4	7,077	Moderately polluted
5	Station 5	6,111	Moderately polluted
6	Station 6	7,082	Moderately polluted

Description: Score $0 \leq P_{ij} \leq 1.0$ Good (good), Score $1.0 < P_{ij} \leq 5.0$ Slightly polluted, score $5.0 < P_{ij} \leq 10$ s Moderately polluted (fairly polluted), score $P_{ij} > 10$ Heavily polluted.

Discussion

Physics Parameters

a. Temperature

Based on the results of measuring the temperature of the Asahan River water quality in Tanjungbalai City at stations 1 to 6, the temperature ranges from 28-28.8 ° C. The temperature values at stations 1 to 6 did not have a significant difference.

The high water temperature is caused by the high intensity of sunlight entering the water body because the sample measurement location is an open area exposed to direct sunlight. The intensity of exposure to solar radiation entering the water body and the density of vegetation around the riverbanks also affect the water temperature river (Marlina et al., 2017).

b. Total Suspended Solids (TSS)

Total Suspended Solid measurement results (TSS) Asahan river water in Tanjungbalai City at stations 1 to 6 ranges from 5 - 6.6 mg /L. Total Suspended Solids Value (TSS) Asahan River in Tanjungbalai City is below the threshold with the Total Suspended Solid concentration value (TSS) is small according to the criteria for class II water quality based on Government Regulation of the Republic of Indonesia Number 22 of year 2021 of 50 mg/l.

The increase in TSS concentration can be caused by natural factors such as sedimentation that occurs

upstream of rivers and domestic waste which is a source of dispersing pollutants (Hamakonda, 2019). Total Suspended Solids (TSS) which is high increases turbidity, reduces brightness, and blocks light penetration into the waters (Walukow *et al.*, 2021).

c. Total Dissolved Solid (TDS)

The Total Dissolved Solid (TDS) value at stations 1 to 6 still meets the class II river water quality standard based on Government Regulation of the Republic of Indonesia Number 22 of year 2021 that the parameter for class II river water quality standard Total Dissolved Solid (TDS) is 1,000 mg/L.

The highest Total Dissolved Solid (TDS) value is at station 2. Activities at this station are community-owned oil palm plantations. High Total Dissolved Solid (TDS) concentrations can be caused by watersheds (DAS) which are dominated by agricultural land originating from the dissolved content of non-agricultural fertilizers even under the same climatological conditions (Swiechowicz, 2002; Merchán *et al.*, 2019).

Chemical Parameters

a. pH

The results of measuring the pH of Asahan River water in Tanjungbalai City show that the pH of the water at stations 1 to 6 is in normal conditions in the range 6 – 9 at class II water quality standards Government Regulation of the Republic of Indonesia Number 22 of year 2021. Increase, pH from stations 1 to 6, with a pH value ranging from 6-8 is still within the threshold of class II river water quality criteria so that river water with a pH parameter of 6-8 can still be used for recreational facilities, freshwater fish cultivation, animal husbandry and agriculture.

The pH indicates the concentration of hydrogen ions in water. pH is used to determine the level of alkalinity and acidity of water. pH affects the toxicity of a chemical compound. Ionizable ammonium compounds are found in waters with low pH (Budiyono *et al.*, 2013).

b. Biological Oxygen Demand (BOD)

The results of the analysis of Biological Oxygen Demand (BOD) measurements of Asahan river water in Tanjungbalai City from station 1 to station 6 range from 3.4 to 3.9 mg/L. BOD values at stations 1 to 6 exceed class II river water quality standards. Based on Government Regulation of the Republic of Indonesia Number 22 of year 2021 requires that the BOD class II river water quality standard is a maximum of 3 mg/L.

The influence of the degradation of organic and inorganic materials originating from the activities of residents around the river which produces waste if not treated properly can cause the river to become shallow. Around the Asahan River in Tanjungbalai City, some trees are quite shady so they can cause fallen leaf and branch litter (organic waste) and domestic waste in the water which is one of the sources of increasing BOD and COD values in water (Ariani *et al.*, 2021).

c. Chemical Oxygen Demand (COD)

The results of the analysis of Chemical Oxygen Demand (COD) measurements of the Asahan River in Tanjungbalai City at stations 1 to 6 ranged from 8.3 to 10.8 mg/L. The value of Chemical Oxygen Demand (COD) at stations 1 to 6 still meets class II river water quality standards. Based on the Government Regulation of the Republic of Indonesia Number 22 of year 2001 requires that the quality standard for class II river water COD parameter is at least 25 mg/L.

The high value of Chemical Oxygen Demand (COD) can cause the amount of oxygen needed by microorganisms to oxidize waste through chemical reactions to be very high (Mardhia and Abdullah, 2018). The concentration of Chemical Oxygen Demand (COD) indicates a greater level of pollution that occurs in a body of water (Naillah *et al.*, 2021). According to Breton (2019), Chemical Oxygen Demand (COD) is the main factor affecting the bacterial community in rivers and there is a negative value relationship between Chemical Oxygen Demand (COD) and Dissolved Oxygen (DO).

d. Dissolved Oxygen (DO)

Dissolved Oxygen (DO) measurements of the Asahan River in Tanjungbalai City at stations 1 to 6 range from 4-7 mg/L. Dissolved Oxygen (DO) values at stations 1 to 6 still meet class II river water quality standards. Based on the Government Regulation of the Republic of Indonesia Number 22 of year 2021 requires that class II river water quality standards, the Dissolved Oxygen (DO) parameter is a minimum of 4 mg/L.

The amount of contaminants in wastewater will cause decrease in dissolved oxygen levels in the water. So it will result in life in water that requires oxygen disrupted and reduced development. In addition, death can also be caused by the presence of toxic substances that also cause damage in plants and aquatic plants (Aprilia and Zunggaval, 2019).

e. Phosphate

The results of the analysis of phosphoric samples in the Asahan River in Tanjungbalai City at stations 1 to 6 ranged from 0.19 to 0.55 mg/L. Table 1 shows that the highest phosphate value is at station 4, which is 0.55 mg/L where the activities in this area are agriculture, the coconut oil industry, and settlements. Based on Government Regulation of the Republic of Indonesia Number 22 of year 2021 requires that the quality standard for class II river water for the phosphor parameter is 0.2 mg /L.

The high concentration of phosphate in river water is predicted to originate from the disposal of domestic wastewater that enters the river without undergoing any prior processing. Detergents contained in wastewater contain surfactants that will combine with polyphosphates so that they can increase the concentration of phosphates in water (Utomo *et al.*, 2018).

f. Nitrate

The results of the analysis of nitrate measurements in Asahan River water in Tanjungbalai City at stations 1 to 6 showed that nitrate values ranged from 7.03 to 8.77 mg/L. Based on Government Regulation Number 22 of 2021 requires that the quality standard for class II river water for the Nitrate parameter is 10 mg/L. Based on Table 1, shows that the highest Nitrate value is at station 2 measurement, namely 8.77 mg/L activities in this area including settlements, mangrove areas, and agricultural land. Dense settlements in the Asahan River can be a cause of high nitrate values. Nitrate is the result of the oxidation of ammonium and ammonia from domestic waste (Yazwar, 2008).

According to Tatanginda *et al.*, (2013), nitrate levels of more than 5 mg/L indicate pollution has occurred, because nitrate levels of more than 0.2 mg/L can cause eutrophication of waters, and in turn can cause blooming as well as a trigger factor for the growth of water hyacinth.

g. Free Ammonia

The results of the analysis of free ammonia measurements of Asahan River water in Tanjungbalai City at station 1 to station 6 show that the free ammonia value ranges from 0.02 to 0.07 mg/L. Free ammonia values at stations 1 to 6 still meet class II river water quality standards. Government Regulation of the Republic of Indonesia Number 22 of year 2021 requires that the quality standard for class II river water for free ammonia parameters is at least 0.2 mg /L.

Ammonia in surface water comes from urine, feces, and the oxidation of organic compounds by microbes. High concentrations of ammonia on

the surface of river water can cause the death of aquatic biota (Windusari and Sari, 2015).

h. Oil and grease

The results of the analysis of oil and grease measurements of Asahan river water in Tanjungbalai City at station 1 to station 6 show that the value of oil and grease ranged from 1.1-2.9 mg/L. The value of oils and fats at stations 1 to 6 exceeds the class II river water quality standards.

Based on Government Regulation of the Republic of Indonesia Number 22 of year 2021 requires that the quality standard for class II river water for oil and fat parameters is at least 1 mg/L. The high concentration of oil and grease is predicted from the additional oil and grease pollutant load originating from the domestic sector (Hermawan and Wardhani, 2021).

i. Detergent

The results of the analysis of detergent measurements of Asahan River water in Tanjungbalai City at station 1 to station 6 show that the detergent value ranges from <333.1 - <500 mg/L. A value of <500 indicates that the measurement result is above the detection limit of laboratory analysis equipment, namely 500 mg/L.

Detergent value at stations 1 to 6 exceeds class II river water quality standard. Based on Government Regulation of the Republic of Indonesia Number 22 of year 2021 requires that the class II river water quality standard for the detergent parameter is 200 mg/L.

Dangerous detergent for fish even though the concentration is small. For example sodium dodecyl benzene sulfonate can damage fish gills, even if only 5mg/l. Fish can last for a month if the detergent reaches 3mg/L. But for organisms that the fish eat it's already dangerous (Langsa and Sirampun, 2020).

Microbiological Parameters

Total Coliforms

Total coliform measurement analysis of Asahan River water in Tanjung Balai City at stations 1 to 6 showed that the total coliform values ranged from 5400 - 11833.33 CFU/100 mL. The total coliform value at stations 1 to 6 exceeds class II river water quality standards. Based on Government Regulation of the Republic of Indonesia Number 22 of year 2021 requires that the quality standard for class II river. Water for detergent parameters is 5000 CFU/100 mL.

According to Widiyanto *et al.*, (2015), contamination of Total coliform bacteria is caused by the presence of waste both originating from

domestic waste and industrial waste, organic waste materials originating from industrial waste and household waste are generally in the form of waste that can rot or be degraded by microorganisms. so that this can result in the development of microorganisms and pathogenic microbes also multiply.

Water Quality Status of the Asahan River in Tanjungbalai City based on the Pollution Index

The pollution index is used to determine the level of pollution relative to the permissible water quality parameters. The pollution index is related to pollutant compounds that are significant for a designation and are developed into several designations for the whole body of water or a part of a river.

The maximum of river water pollution index results were at station 2 is 9,086. The activities at this station were densely populated areas, oil palm plantations and tourist areas. The minimum river water pollution index results were at station 5 is 6,111. The activities at this station is an area close to coconut oil factory activities and residential areas.

Water pollution occurs due to the parameters of phosphate, detergent, oil and grease, and total coliform which have exceeded the quality standard threshold for Government Regulation of the Republic of Indonesia Number 22 of year 2021.

Conclusion

Based on the results and discussion, it can be concluded that the analysis of water quality based on the pollution index of Asahan River water in Tanjungbalai City shows that the average water pollution index is in the moderately polluted category. Water pollution occurs due to the parameters of phosphate, detergent, oil and grease, and total coliform which have exceeded the quality standard threshold based on Government Regulation of the Republic of Indonesia Number 21 of 2022 concerning Management of Water Quality and Control of Class I Water Pollution.

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