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Regional Case Study

Analysis of Water Quality Status in Tuntang River, Semarang Regency in 2022

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Abstract
Tuntang River is a river located in Tuntang District, Semarang Regency. The study was conducted to determine the quality of river water, status of river water quality and sources of river pollution in the Tuntang River in the Upstream Segment so that steps can be taken to tackle pollution in the Tuntang River in the Upstream Segment. This research was conducted during the dry season, samples were taken during the January-June 2022 period. The quality status was assessed using the Pollution Index (PI) method. The results of the study of 2 sample points were at lightly polluted status based on Class II Quality Standards according to Government Regulation Number 22 of 2021. Based on calculations using the PI method at Point 1 were in normal conditions. Meanwhile, point 2 is in a moderately polluted condition. In the analysis using Geography Information System (GIS) there are several sources of pollution, namely, in the domestic sector, plantation sector, agricultural sector (rice fields and fields), livestock sector, and mining sector.

Keywords: River pollution; water quality status; GIS; pollution index

1. Introduction

Water is a compound needed by living things for metabolic processes in the body. Even though water is a renewable resource, an activity is needed to maintain the renewal of this resource (Siregar & Kiswiranti, 2019). Likewise with river water which is widely used by living things. The river is a natural feature that stretches across the mainland. Rivers can be used as a provider of fresh water, agriculture, animal husbandry, power generation, and as an effluent for industrial activities (Novianti et al., 2022). As a result, rivers have the potential to cause pollution impacts that can harm living things, especially humans, which can result in a decrease in the health status of people in the riverbank areas (Daramusseng & Syamsir, 2021).

River pollution, if not resolved, will add to the pollutant load every year that it will reduce the quality of river water as the population increases (Akhirul et al., 2020). For this reason, an analysis is needed to reduce the rate of pollutant load each year. One such analysis is to identify pollutant sources by using a Geographic Information System (GIS) to map the environmental conditions around the river and calculate the pollution load (Asim & Rao, 2021). With GIS, it is easier to carry out environmental mapping activities around the river, such as mapping the location of settlements, the location of farms, the location of industrial areas, and others. In addition, GIS can also combine several physical, economic, social, and spatial data criteria, so that the interrelationships of several of these criteria can be identified (Maimunah et al., 2022).

Semarang Regency consists of many rivers that stretch from south to north. Among the many rivers, there are 6 main rivers that represent rivers in the Semarang Regency area, including the Babon River, Kaligarang River, Bodri River, Suruh River, Galeh River, and Tuntang River (Sadewo et al., 2022). In Semarang Regency there are many sectors around the riverbanks, including residential, agricultural, industrial, domestic, and animal husbandry (Fauzi et al., 2018). The Tuntang River Basin starts from outlet Rawa Pening in Semarang Regency until the Java Sea on the coast of Bonang District, Demak Regency with a length of 139 km (Lestari et al., 2021). Tuntang River is used by the people around to irrigate agriculture, plantations, tourist attractions, fisheries, drinking water companies and power plants (Piranti et al., 2018). Tuntang River is located quite far from the city center, but it is not impossible that the river can be polluted by surrounding settlements, rice fields, fisheries, or natural vegetation (Kusumastuti et al., 2021).

Settlements around the river can cause an increase in the organic content of the river (Djoharam et al., 2018). In addition, agricultural activities such as use of pesticides which drift along with the flow of water can cause pollution in rivers (Al Idrus, 2018). The high content of organic matter can cause health problems for people who use the Tuntang River. Inorganic substances that are washed away by the flow of the river can be caused by dissolved sedimentation in the upstream area of the river. In addition, mining activities can also increase the content of inorganic substances in rivers (Bouty et al., 2022).

Based on previous research, most studies have examined pollution in Lake Rawa Pening which flows into the Tuntang River as studied by Piranti (2018) or pollution of the Tuntang River downstream in the Demak district as investigated by Septiningtyas (2022). However, there is rarely research that examines pollution in the upstream Tuntang River. In fact, in the upstream part there is water tourism which is crowded with visitors during the dry season. If no study is carried out, it is feared that it will affect the health of the visitors. For this reason, it is necessary to search for sources of pollution in the Tuntang River in order to control the rate of pollution in the river.

Tuntang River also caused flooding in the Demak Regency area due to siltation in the river area caused by the carrying of sediments in the upper reaches of the river or in its tributaries (Cakranegara et al., 2018). The large number of steep areas around the Tuntang River is also the cause of landslide sedimentation from the river. Along the Tuntang River there are several settlement points where the domestic waste from the settlements flows directly into the Tuntang River. The purpose of this study is to determine the quality status and sources of pollution in the Tuntang River so that it can provide information regarding policy makers in regulating and controlling pollution more precisely in preventing further pollution which can result in a decrease in the degree of public health in the areas along the Tuntang River, especially in tourist attraction in the upstream region in segment 1.

2. Methods

This study uses secondary data in the form of river water quality data in the first period of 2022 which represents the dry season, where the data was obtained from the Semarang Regency Environmental Service, the sample was taken in June 2022. The data is in the form of results of biological tests (fecal coli and total coli), physics (TDS and TSS), and chemicals (pH, BOD, COD, and DO). Sampling was carried out according to the guidelines of SNI-6989.57:2008. For testing river water samples, using the guidelines SNI-6989.72:2009 at the Laboratory of the Semarang Regency Environmental Office which has been accredited by KAN. The time of this research is from September to December 2022. Meanwhile, the location of this research is in the First Segment of the Tuntang River which is located along the Tuntang, Bawen, and Bringin Districts in Semarang Regency, with a total sample of 2 sample points. Sample coordinate points are shown in Table 1 and Figure 1.

Table 1. Sampling location points on the Tuntang River

Point	Location	District	Coordinate	
			South	East
1	Polosiri Village	Bawen	-7.24865	110.46858
2	Ngajaran Village	Tuntang	-7.21707	110.50040

Data source: DLH Semarang Regency, 2022

The test data is analyzed by comparing the test results with class II based on Government Regulation Number 22 of 2021 about the Implementation of Environmental Protection and Management, namely river water that can be used for recreation, fish farming, animal husbandry, irrigating plants, and other activities according to standard quality class II. Whereas, to determine the water quality status of the Tuntang River used the Pollution Index (PI) calculation which is guided by the Decree of the Minister of State for the Environment No. 115 of 2003 concerning Guidelines for Determining Water Quality Status. The Pollutant Index value is presented in Table 2.

Table 2. Pollutant index value

PI Value	Water State
$0 \leq PI_j \leq 1.0$	Normal
$1.0 < PI_j \leq 5.0$	Lightly Polluted
$5.0 < PI_j \leq 10$	Moderately Polluted
$PI_j > 10$	Heavily Polluted

Data source: Minister of Environment Decree No. 115/2003

Field observations were carried out at each existing sample point to find out directly about the conditions around the sampling point. Based on Iskandar (2007) the farthest distance from the source of pollution in settlements is 500 meters, that is, 30% will enter the river body. For this reason, the researchers set 1 km or about twice the farthest distance determined by Iskandar, because there are several sources of pollution that are not affected by the distance of the pollutant from the river.

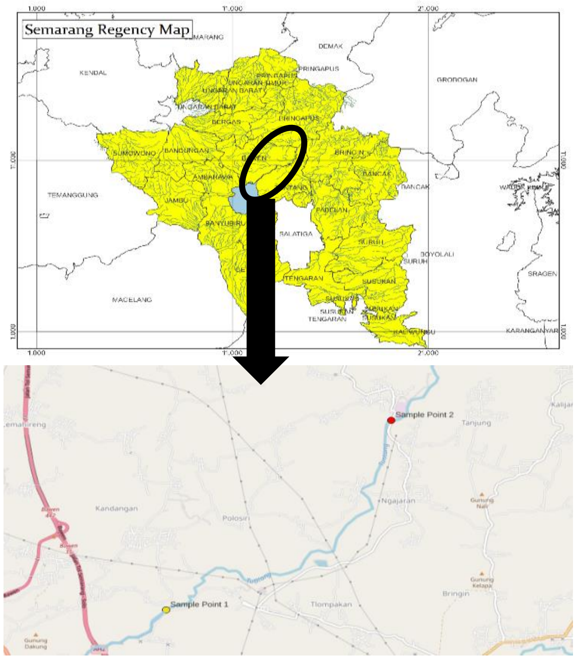

Figure 1. Research sites

This study used a mapping model using a GIS to facilitate the process of analyzing pollution sources. GIS is used for Mapping rivers such as placing sample point locations, mapping the distribution of settlements, knowing the distance between rivers and livestock and mining locations. In the results of mapping using GIS, several results were obtained, including in Figure 3 there is an orange color that describes settlements, Figure 5 has a dark green color that describes rice fields, Figure 6 has a light brown color that describes fields, and Figure 7 has a light green color that describe plantation in Tuntang River basin be it mainstream or tributary.

This study uses the theoretical triangulation analysis method, namely comparing the information obtained with the relevant theoretical perspectives in the research to obtain the truth of these results. This study links the results of air quality tests in the Tuntang River with mapping around the Tuntang River with relevant theory and research over the last 5 years.

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3. Result and Discussion

3.1 Overview of Study Area

Based on observation results, In Asinan Village, on the outskirts of the Tuntang River, there is a private company in the drinking water sector that collects it. Along the Tuntang River there are rice fields which use water from the river to irrigate the fields. There are several points on the Tuntang River that are used as water tourist attractions, one of which is a rafting route and tourist baths. In fact, river water that is used as a water tourist attraction must meet class II quality standards in accordance with Government Regulation Number 22 of 2022 about the Implementation of Environmental Protection and Management, namely river water that can be used for recreation, fish farming, animal husbandry, irrigating plants, and other activities according with the standard quality of class II.

3.2. Quality Status

Based on river water quality data obtained from the Semarang Regency Environmental Service in 2022, there are 2 sample points taken from Tuntang River in the downstream segment to test river water quality, the results can be seen in Table 3.

Table 3. Tuntang river water quality data for 2022

No	Parameters	Test Result		Standard Quality Class II	Unit
		Point 1	Point 2		
A	Physics				
1	Temperature	29*	29.5*	Dev 3	°C
2	TDS	111	110	1000	mg/L
3	TSS	18.7	31.75	50	mg/L
B	Chemicals				
1	pH	8.08	8.26	6-9	-
2	COD	6.08	8.62	25	mg/L
3	DO	6.4	6.89	4	mg/L
4	BOD	1.75*	1.47*	3	mg/L
5	Nitrate	14*	12*	10	mg/L
6	Nitrite	1.7*	1.2*	0.6	mg/L
C	Biologies				
1	Total Coliform	3200	17500*	5000	MPN/100mL
2	Fecal Coliform	1000	5000*	1000	MPN/100mL

**Exceeds the standard quality class II*

Data source: DLH Semarang Regency, 2022

Based on data obtained from the Semarang Regency Environmental Service in 2022, the pollution index (IP) value of the Tuntang River at Point 1 and Point 2 is included in the lightly polluted category, namely Point 1 is 0.51 and point 2 is 3.31. The IP calculation results are presented in Table 4. Table 4 shows that both points are at a value of 1≤ IP ≤ 5 which indicates they are in the lightly polluted category. This score indicates that the Tuntang River can be used for recreation, animal husbandry, irrigating plants, and fish farming. For pollutant indicators, point 2 has pollutant indicators, namely Total Coliform and Fecal Coli.

Table 4. Pollution index calculation results

Point	**Location**	**District**	**Pollution Index**		**Pollutant Indicators**
			Class II	**Quality Status**	
1	Polosiri	Bawen	0.51	Normal	-
2	Ngajaran	Tuntang	3.31*	Lightly Polluted	Total Coliform & Fecal Coli

**Polluted conditions*
Data sources processed individually, 2022.

3.3. Water Quality and Pollution Sources

3.3.1. Temperature

There was an increase in temperature at point 2 which was in Ngajaran Village, which was initially at 29°C to 29.5°C, an increase of 0.5°C from the location of point 1. These two points exceed the standard quality stipulated by Government Regulation Number 22 of 2022 about the Implementation of Environmental Protection and Management. The temperature parameter is in accordance with Government Regulation Number 22 of 2022 about Implementation Environmental Protection and Management, namely at Deviation 3, which means the water temperature must be±3°C from normal water temperature. This increase in temperature can be caused by the shady trees in the river area, the shadier a river area, the more normal the temperature of the river (Widiatmono et al., 2020). This is not in accordance with the results of temperature measurements in the Tuntang River, based on field observations, at points 1 and 2 surrounded by shady trees, however, the temperature of the river water still exceeds the class II standard quality.

3.3.2. TDS (Total Dissolved Solids)

Point 1 and point 2 were met with a decrease in the score of the TDS parameter by 1 unit or permanent trend. The TDS content in two sample points is still below the class II standard quality. TDS is solids smaller than 2 μm which is carried away by river currents (Ruseffandi & Gusman, 2020). This is because the Tuntang River does not have many residential or industrial activities. There is an andesite stone mining activity which is quite far from the mainstream of Tuntang River which can be seen in Figure 2. In Figure 2 it is quite visible that andesite stone mining is located at a radius of 1 km in Tuntang River area, around there are also tributaries of Tuntang River. In addition, residential areas are only found at a few points without crowding the entire Tuntang Riverbank, as shown in Figure 3 in orange. However, that does not mean that residential areas will not have an impact on pollution in the Tuntang River. However, based on river water quality measurements, the TDS score at point 2 tends to be permanent. This is caused by a Self-Purification process in rivers that can purify river water from pollutants without human intervention (Nugraha et al., 2020).

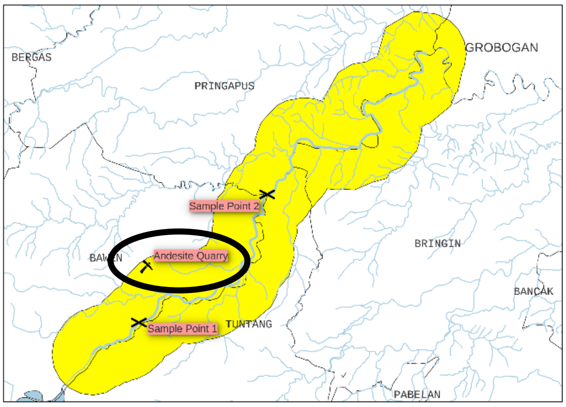

Figure 2. Andesite mining location

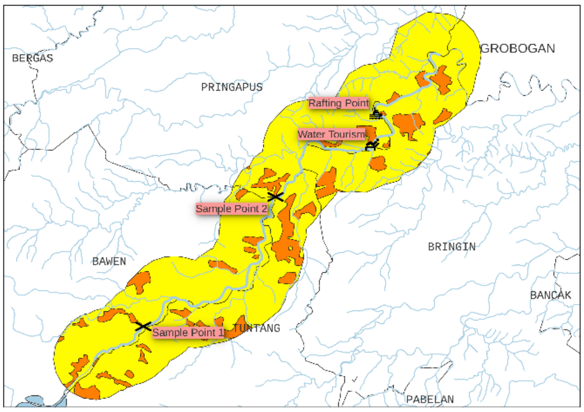

Figure 3. Settlements on the Tuntang River

3.3.3. TSS (Total Suspended Solids)

TSS is total suspended solids, namely solids that are carried by river flow which is the size smaller than 0.45 µm (Harahap et al., 2017). The TSS score at point 2 is higher than point 1 which is upstream. At point 2 the score is 31.75, while point 1 is at 18.7, the difference is 13.05 from the two sample points, almost double from point 1. This is caused by settlement activities around the banks of the Tuntang River, especially in the range of sample point 1 up to sample point 2 where there is land used form of large settlement as shown in Figure 3. This can result in erosion of land that is suspension-sized into the river flow which allows an increase in the score of TSS parameters in the river (Sukmono, 2018). although point 1 and point 2 are still below the class II standard quality, which is at 50 mg/L.

3.3.4. Degree of Acidity (pH)

The Tuntang River at point 1 and point 2 tends to have a weak base, namely at a score of 8.08 at point 1 and 8.26 at point 2 the increase is not too large, namely 0.18. The pH score at these two points is still at the class II standard quality based on Government Regulation Number 22 of 2021 about Implementation of Environmental Protection and Management. pH increased at point 2 from point 1 can be caused by an increase in the surface temperature of river water CO2.

Levels in the water will go up then the river water pH will tend to increase (Kurniati et al., *2020)*. In addition, a very low pH ($pH < 6$) can result in an increase in the content of toxic heavy metals in river water which can disrupt the ecosystem in the river. Meanwhile, a pH that tends to be strongly alkaline ($pH > 9$) can result in disruption of ammonium and ammonia. Ammonia concentration will increase with increasing pH in river water which will harm organisms around the river (Rahman. 2019).

3.3.5. Chemical Oxygen Demand (COD)

COD score in the Tuntang River at point 1 was 6.08 mg/L, still below the class II standard quality that is 25 mg/L. At point 2 is still below the class II standard quality, the COD score is 8.62 mg/L, an increase of 2.54 from sample point 1. The increase in CO levels is caused by residential activities around the Tuntang River as shown in Figure 3 which produces organic waste which flows into the Tuntang River. In addition, livestock husbandry and livestock slaughtering activities also affect the increase in COD levels at point 2. It can be seen clearly in Figure 4, that there are livestock farming and animal slaughtering activities in the upstream area of the Tuntang River which is still in the river's vital point area.

There are rice fields, fields, and plantations along the Tuntang River, especially in the area between point 1 and point 2 as shown in Figure 5, Figure 6 and Figure 7. Three activities can produce agricultural waste in the form of organic and inorganic substances derived from used pesticides, fertilizers, or other chemicals. If the COD content is high, it will have an impact on health because high COD concentrations indicate that there are organic contaminants and microbes such as pathogens that can infect humans (Hamidah & Rahmayanti, 2020).

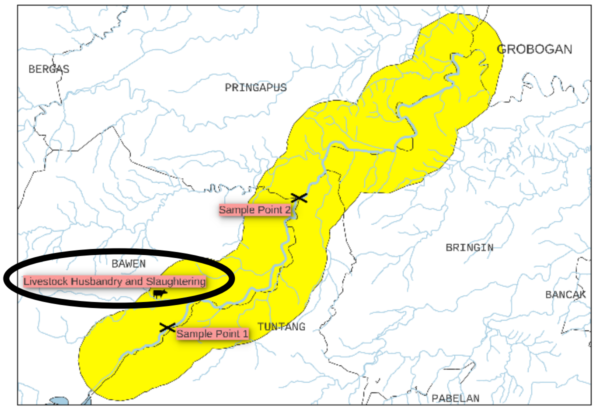

Figure 4. Livestock on the Tuntang River

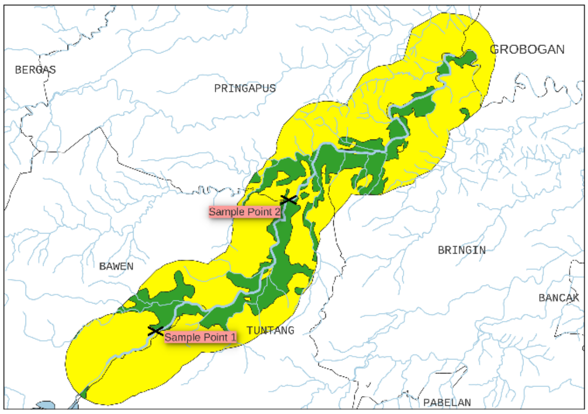

Figure 5. Rice field area on the Tuntang River

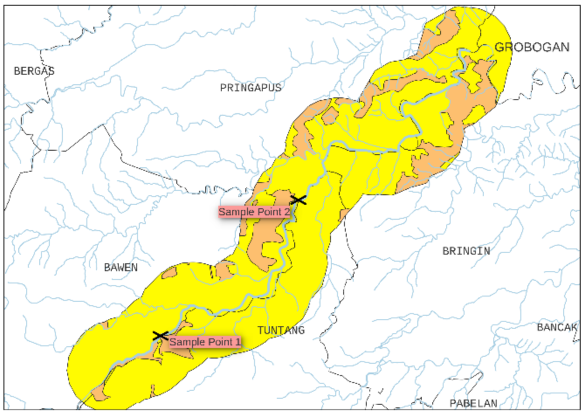

Figure 6. Field area on the Tuntang River

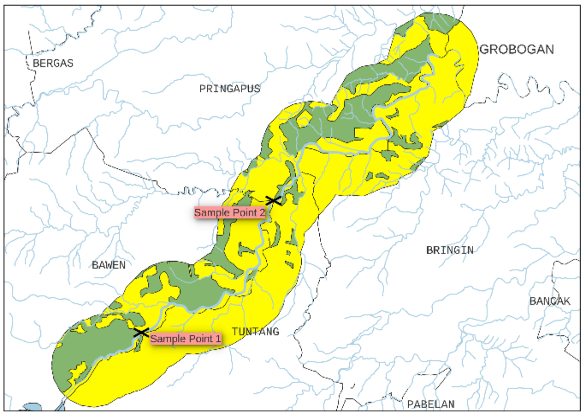

Figure 7. Plantation area on the Tuntang River

3.3.6. Dissolved Oxygen (DO)

Based on river water quality data obtained from Semarang Regency Environmental Service for 2022, at point 1 the DO level was 6.4, lower than point 2, which was 6.89. In contrast to other parameters, the DO content in a river cannot be less than the applicable standard quality. In this case of the Tuntang River, using class II standard quality, DO should not be less than 4 mg/L. DO content that is less than the standard quality in waters can affect self-purification process, namely the process of natural purification of polluting substances caused by human activities around the river by the river itself without any interference from humans (Sumantri & Rahmani, 2020). In addition, low levels of DO also affect the existing ecosystems in rivers, especially in fish life. DO can affect growth, repair damaged tissue, and smooth the reproductive process (Sugianti & Astuti, 2018). Increase in DO levels at point 2 is due to the decreased BOD levels at point 2, because the increased DO levels is affected by BOD levels in the river.

3.3.7. Biological Oxygen Demand (BOD)

Laboratory test results on the Tuntang River at point 1 have a BOD score of 1.75 mg/L. Meanwhile, at point 2 the BOD number is 1.47 mg/L, still below the class II standard quality stipulated in Government Regulation Number 22 of 2022 concerning Implementation of Environmental Protection and Management, namely at score of 3 mg/L. Based on these data, there is a decrease in the BOD score from point 1 to point 2, which is as much 0.28 mg/L. The lower the BOD score indicates that the river is in good condition. However, based on the calculation of the pollution index in Table 2, it shows that there are other contaminants that affect the water quality of the Tuntang River.

3.3.8. Nitrates

The nitrate rate at point 1 was 14 mg/L exceeding the class II standard quality, at point 2 it decreased by 2 mg/L, namely 12 mg/L, both points exceeded the class II standard quality. Nitrates can be formed by natural activities as well as from human activities. Nitrate that comes from nature is the result of the nitrogen cycle, nitrate that comes from human activities is the use of nitrogen fertilizers in agriculture, organic waste from domestic activities, and industrial waste (Putri et al., 2019). This is supported by evidence in Figure 3, Figure 5, Figure 6, and Figure 7, which shows a lot of activity in settlement, rice fields, fields, and plantations, so can affect nitrate content at point 1 and point 2 at Tuntang River (Hutagalung et al., 2022). However, at upstream point 1 there are no livestock, just rice fields and plantations. However, at under point 1 there are livestock and animal slaughter like shown in Figure 4. However, at point 2 nitrite content decreases 2 mg/L. This can be caused by a self-purification process in the river which allows the river to neutralize the source of the pollution step by step.

3.3.9. Nitrite

The nitrite content at point 1 was 1.7 mg/L, almost three times the standard quality for class II, which was 0.6 mg/L. Meanwhile, at point 2 it decreased by 0.5 mg/L to 1.2 mg/L. However, at point 2 it still exceeds the class II standard quality that approved by Government Regulation Number 22 of 2022 about the Implementation of Environmental Protection and Management, namely on the TSS parameters, Total Coliform, Fecal coli, and BOD. The high nitrite at point 1 and point 2 is caused by settlement activities that produce organic matter originating from public bathing, washing, and toilet activities along the river (Rahayu et al., 2018). This is consistent with the situation around the Tuntang River in Figure 3, where there are settlements that have the potential to pollute the river with domestic waste originating from settlements activities.

3.3.10. Fecal Coli and Total Coli

The Total Coli rate at point 1 is 3,200 MPN/100 mL, still below the class II standard quality, which is 5,000 MPN/100mL, meaning it is still safe to use for water tourism activities. Meanwhile, point 2 experienced an increase of almost seven times from point 1, which was 17,500 MPN/100mL. This amount is very dangerous for health when used for tourism activities on the Tuntang River. Fecal Coli at point 1 was 1000 MPN/mL, right with the class II standard quality of 1000 MPN/mL. At point 2 the number of fecal coli was 5000 MPN/mL, five times more than point 1 and the class II standard quality. Fecal coli at this amount is not recommended for use as drinking water or for water tourism activities.

The high number of Total Coliform and Fecal Coli is caused by domestic activities around the river as shown in Figure 3 where there are many settlements that live along the Tuntang River area and the tributaries. The number of Fecal Coli is an indicator of the number of pathogens, one example of these bacteria is *E. coli* and *Enterobacter aerogenes*, the more Fecal Coli in a river, the worse the quality of the river (Anggraini & Wardhani, 2021). Meanwhile, the amount of Total Coli in a river will disturb Tuntang River water users because Total Coli is synonymous with human waste and dirty rivers (Yohannes et al., 2019).

In Figure 3 there are water tourism activities and spot rafting downstream of point 2. In fact, at point 2 the nitrite content was 1.2 mg/L, exceeding class II standard quality, which were used for recreation, fish farming, animal husbandry, irrigating plants, and other activities in accordance with class II standard quality. Nitrites that enter through the mouth can cause health problems, especially digestive problems (Emilia, 2019). Nitrite that enters the body will react with Iron (II) Hemoglobin to form Methemoglobin (MetHb) which causes Methemoglobinemia disease (Mudan et al., 2020)

4. Conclusions

The quality status based on the calculation of the Pollution Index (PI) of the Tuntang River at point 1 is in the good category, which is at value of 0.51. Meanwhile, at point 2 it is in the lightly polluted category with a PI value of 3.31, with pollutant parameters namely Nitrate, Nitrite, Total Coliform, and Fecal Coli. The water quality of the Tuntang River at point 1 on the 11 parameters tested is below the class II standard quality. Meanwhile, at point 2 there are parameters that exceed the class II quality standards on the parameters Nitrate, Nitrite, Total Coliform, and Fecal Coliform, which means that the Tuntang River is not suitable for establishing a water tourism object because it can cause health problems to humans. Based on the results of mapping using GIS, along the Tuntang River in Semarang Regency there are several potential sources of river pollution, including the domestic sector, the plantation sector.

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