The effect of industrial waste on the water quality of Padang River in the industrial area of Tebing Tinggi

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Abstract. Padang River is one of the rivers in Tebing Tinggi Municipality which is used as a source of raw water used by local water supply company (LWSC) Tirta Bulian, Tebing Tinggi. This river flows through residential areas, factories and sand dredging. With this activity, the waste is immediately disposed of into the water body, causing a negative impact on the quality of its waters. This study aims to analyze the quality of Padang River water in the industrial segment as a result of the pollution load by industrial wastewater with indicators of BOD, COD, TSS, DO, temperature and pH. The research method used descriptive analysis with a quantitative approach to the condition of river water quality. Wastewater generated from the activities of the three industries contributed to the potential actual pollution load of the Padang River in the form of BOD, COD and TSS values of 6.9 kg/day, 19.19 kg/day and 6.11 kg/day, respectively. The existence of a fairly large difference in discharge between the rainy and dry seasons also affects the water quality of the Padang River. In general, water quality during the rainy season is better than during the dry season.

1. Introduction

The river as a water source is one of the natural resources that has a multipurpose function for human life and livelihood. The function of rivers is as a source of drinking water, a means of transportation, a source of irrigation, fisheries, and so on. In its development, rivers can be managed and utilized for human life. Padang river is one of the rivers in Tebing Tinggi Municipality which is used as a source of raw water used by local water supply company (LWSC) Tirta Bulian, Tebing Tinggi. This river flows through residential areas and factories. With this activity, the waste is immediately disposed of into the water body, causing a negative impact on the quality of its waters.

Wastewater in Tebing Tinggi is produced by industry and household activities. Not all of the wastewater produced by industries in Tebing Tinggi have Wastewater Treatment Plant (WWTP), so there are still many industries that dump their waste directly into the city drainage channels, which eventually pollutes the rivers in Tebing Tinggi. In 2010 Tebing Tinggi Sanitation Strategy, it is explained that for industrial waste treatment it is carried out with a WWTP which meets the current standards for only 1 (one) unit at ADEI Crumb Rubber Industry Company which is managed by the
company itself with a capacity of 2,961 m$^3$/day. For industrial waste, a separate WWTP is very much needed considering that this industry is very much needed a separate WWTP considering that this industry is a very large waste producer.

The results of research conducted by Dahlia Simamora on the Study of Macrozoobenthic Diversity in the Padang River Flow of Tebing Tinggi, it is said that the macrozoobentor diversity index at station I (without activity) and II (community activity) is classified as lightly polluted waters while stations III and IV (factory activities) are classified as moderately polluted waters [1]. From the background description, the problems are how is the quality of Padang River water in the industrial segment as a result of the influence of the pollution load by industrial wastewater and what are the recommendations for controlling Padang River water pollution [2, 9, 10].

The purpose of this study was to analyze the quality of Padang River water in the industrial segment as a result of the influence of the pollution load by industrial wastewater with indicators of BOD, COD, TSS, DO temperature and pH as well as to recommend strategies for controlling Padang River water pollution. The benefits expected from this research are: as a reference for similar research on river water quality, become an input for industrial wastewater treatment policies, and to provide input for the Tebing Tinggi government in making policies in the field of river water pollution control.

2. Materials and methods

2.1. Rivers crossing Tebing Tinggi

There are two main functions of rivers naturally, namely flowing water and transporting eroded sediments in the watershed and its channels [3, 4, 5]. Table 1 shows the rivers cross Tebing Tinggi.

| No | River Name      | Length (m) |
|----|----------------|------------|
| 1  | Padang River   | 15,940.71  |
| 2  | Bahilang River | 4,981.71   |
| 3  | Kelembah River | 6,373.10   |
| 4  | Sibarau River  | 3,931.84   |
| 5  | Sigiling River | 35,008.97  |

2.2. Research sites

The research was conducted in the Padang River which is located in the Industrial Area of Tebing Tinggi because it is a very potential river which is used as a source of raw water for LWSC, agricultural irrigation and other human activities.

Location I  : 03° 20’ 6.87” N – 99° 10’ 2.08” East Longitude
Location II : 03° 20’ 13.54” N – 99° 10’ 8.53” East Longitude
Location III: 03° 20’ 28.72” N – 99° 10’ 13.36” East Longitude
Location IV : 03° 20’ 49.07” N – 99° 10’ 34.15” East Longitude

The basis for determining the monitoring point is that there are differences in characteristics and activities at each monitoring point.

Water sampling was conducted in November 2017 for 3 (three) weeks. This is due to unstable environmental conditions and repetition of 3 weeks, which are expected to approach the actual conditions with 9 (nine) times taking with the following details: week I was held on May 14, 16, 2018, week II was held on 21, 23, 25 May 2018 and week III was held on 1, 3, 5 June 2018.
2.3. Water sampling method
The method used in water sampling is composite sample, which is by taking water samples from several points using a plastic sample bottle for physical and chemical parameters with a sterile bottle at one monitoring point.

2.4. Monitor point determination method
Determination of water monitoring points, was carried out by purposive sampling, namely by paying attention to various considerations of industrial waste inputs that take place in the watershed and the impact on the river so that water quality can be known before entering the research area and changes in water quality caused by industrial activities. Taking sample points in the river is carried out at a location where the river water is truly homogeneous or well mixed.

3. Discussion
In this research, the scope of the research was carried out at the Padang River, starting at T1 = Adei Company to T4 = Palm Oil Mill, as shown in figure 1 and Table 2.

The results of the industrial wastewater quality test showed that only the pH parameter met the quality standard, while the other 2 parameters, namely BOD and COD, exceeded the specified quality standards. BOD levels reached 181.44 mg/l from the quality standard of 100 mg/l. This shows that the performance of the Industry A Wastewater Treatment Plant is still not optimal for treating wastewater so that the BOD and COD parameters meet the set quality standards.
Table 2. Sample location.

| Location | Description |
|----------|-------------|
| ST1 Station | On the upstream side before the Rubber I industrial outlet location, to determine the quality of the water before it is affected by wastewater |
| ST2 Station | On the downstream side after the Rubber industry I location and before the Rubber industry II outlet. The distance between ST1 and ST2 is 2 km |
| ST3 Station | On the downstream side after the Rubber II industrial location and before the Palm Oil Mill industrial outlet |
| ST4 Station | Downstream after the palm oil mill industrial outlet represents a point where water quality changes by industrial activity |
| OT1 Station | Wastewater discharge outlet from WWTP of rubber industry I |
| OT2 Station | Wastewater discharge outlet from WWTP of rubber industry II |
| OT3 Station | Wastewater disposal outlet from WWTP of palm oil mill |

3.1. Industry

From the data from the results of testing the quality of wastewater from the three industries as shown in Table 3 can be used to determine the pollution load of each parameter [11-20].

Table 3. Concentration and industrial pollution load in the Padang River.

| No. | Industry Name | BOD | COD | TSS |
|-----|---------------|-----|-----|-----|
|     |               | $C_{Aj}$ (mg/L) | APL (kg/day) | $C_{Aj}$ (mg/L) | APL (kg/day) | $C_{Aj}$ (mg/L) | APL (kg/day) |
| 1   | Industry A    | 181.44 | 5.81 | 380.5 | 12.18 | 55 | 1.76 |
| 2   | Industry B    | 5.376 | 1.03 | 33.49 | 6.43 | 21 | 4.03 |
| 3   | Industry C    | 2.688 | 0.06 | 25.88 | 0.58 | 16 | 0.38 |
|     | Total         | 6.9  | 19.19 | 6.11 |

The actual pollution load (APL) from industry is influenced by the discharge and concentration of pollutants in wastewater [9, 10]. For the BOD parameter, industry A contributed the most loads, namely 5.81 kg/day, while industry B was 1.03 kg/day and industry C was 0.06 kg/day. This is because the BOD concentration ($C_{Aj}$) in industrial wastewater A (181.44 mg/L) is much higher than the BOD concentration in industry B (5.376 mg/L) and C (2.688 mg/L).

Likewise, APL for COD parameters, industry A contributed the most, namely 12.18 kg/day, while industry B was 6.43 kg/day and industry C was 0.58 kg/day. This is because the concentration of COD in industrial wastewater A (380.5 mg/L) is much greater than the concentration of BOD in industry B (33.49 mg/L) and C (25.88 mg/L). For the pollution load originating from Total Suspended Solid (TSS), industry B is the biggest contributor, namely 4.03 kg/day. Meanwhile, industry A and C were 1.76 kg/day and 0.38 kg/day, respectively.

3.2. Padang River water quality

From the observations at the research location, the main use of Padang River water by the surrounding community is for irrigation of the fields, both technical and non-technical irrigation. Data on the results of measuring the quality of water in the Padang River are shown in Tables 4 and 5.

In the rainy season there is an increase in river water discharge which causes dilution by rainwater. On the other hand, in the dry season, the water discharge is much reduced so that it affects the concentration of substances in the water flow. The discharge spike in May on ST4 was caused by rainy weather conditions during sampling, so the possibility of additional water sources entering which caused the river to dilute.
Table 4. Results of Padang River water quality analysis in May 2018.

| No | Parameter | Unit | Test Result |
|----|-----------|------|-------------|
|    |           |      | ST1  | ST2  | ST3  | ST4  |
| 1  | BOD$_5$   | mg/L | 3.648| 5.453| 19.97| 7.219|
| 2  | COD       | mg/L | 22.07| 50.57| 25.88| 48.71|
| 3  | DO        | mg/L | 8.03 | 5.84 | 5.49 | 7.6  |
| 4  | TSS       | mg/L | 52   | 70   | 19   | 42   |
| 5  | Temperature | °C  | 25   | 26   | 26   | 25   |
| 6  | pH        |      | 8    | 7.7  | 7.6  | 8.2  |

Debit (m$^3$/s) 0.242 0.265 0.353 1.057

Table 5. Results of Padang River water quality analysis, July 2018.

| No | Parameter | Unit | Test Result |
|----|-----------|------|-------------|
|    |           |      | ST1  | ST2  | ST3  | ST4  |
| 1  | BOD$_5$   | mg/L | 27   | 49   | 29   | 75   |
| 2  | COD       | mg/L | 42   | 83   | 42   | 125  |
| 3  | DO        | mg/L | 6.24 | 7.2  | 6.8  | 0.0*)|
| 4  | TSS       | mg/L | 34   | 25   | 18   | 37   |
| 5  | Temperature | °C  | 27   | 26   | 27   | 27   |
| 6  | pH        |      | 6.5  | 6.5  | 7.0  | 8.2  |

Debit (m$^3$/s) 0.242 0.011 0.025 0.046

If the water quality of the Padang River at the four observation stations is related to the Water Quality criteria based on the class according to PP No. 82 of 2001, for the rainy season the parameters of temperature, DO and pH meet all the water class criteria. BOD parameters do not meet the criteria for class II. At the ST1 and ST2 points, the BOD concentration still meets the class III quality standard, ST4 meets the class IV criteria and ST3 does not meet all the water class criteria. Meanwhile, COD parameters meet class II quality standards except at point ST2. The TSS parameters on ST1 and ST2 meet the criteria for class I, while those for ST3 and ST4 meet the criteria for class III.

In the dry season, the BOD parameter values at all observation points do not meet all the water class criteria. The COD parameter values at points ST1 and ST3 meet the criteria for class IV and ST4 does not meet the criteria for all classes. For temperature parameters, TSS and pH meet all classes. The water quality conditions for the parameters at the upstream (ST1) for the dry and rainy seasons have actually exceeded the class II water quality standards. This shows that before being influenced by wastewater from industrial activities, activities in the upstream part have caused a decrease in river water quality.

3.3. River water quality status with pollution index (IP) method

In calculating the status of water quality, it only uses parameters BOD, COD, pH and DO with quality standards for the status of water quality in the Padang River using Class II water designation criteria. The results of the calculation of the Pollution Index Value according to Minister of Environment Regulation No. 115 of 2003 concerning Guidelines for Determining Water Status [7, 8].

From the results as shown in Table 6, the condition of the Padang River water quality in May (rainy season) can be categorized as lightly polluted with a Pollution Index (PI) value between 1 - 5. Although the PI value has increased, it is still in the lightly polluted category.

Even though the BOD and COD values exceed the quality standards designated for Class II water, the excess values of these quality standards are not significant enough in changing the level of pollution from the original upstream condition (ST1) which is included in the lightly polluted category. Waters with low levels of pollution have dissolved oxygen (DO) > 5 ppm and BOD levels ranging from 1 - 10 ppm. This is in accordance with the DO conditions of water which averages > 5 ppm assuming the specific gravity of water is equal to the specific gravity of fresh water (= 1 mg/l) [6].
Table 6. Water quality status.

| Time     | No | Location | Pollution Index | Water Quality Status |
|----------|----|----------|-----------------|----------------------|
| May 2018 | 1  | ST1      | 1.11            | Lightly Contaminated  |
|          | 2  | ST2      | 2.03            | Lightly Contaminated  |
|          | 3  | ST3      | 3.75            | Lightly Contaminated  |
|          | 4  | ST4      | 2.28            | Lightly Contaminated  |
| July 2018| 1  | ST1      | 3.84            | Lightly Contaminated  |
|          | 2  | ST2      | 5.28            | Moderately Contaminated|
|          | 3  | ST3      | 4.37            | Lightly Contaminated  |
|          | 4  | ST4      | 5.99            | Moderately Contaminated|

3.4. Padang River water pollution control

Based on the results of observations, the results of testing the quality of river water and industrial wastewater, interviews and literature studies, descriptions of aspects and indicators of water pollution control in the Padang River are made as presented in Table 7.

Table 7. Pollution control analysis.

| No | Aspects                      | Indicator                                                                                                                                                                                                 |
|----|------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1  | Padang River Condition       | 1. In general, the water quality of the Padang River does not meet the Class II water criteria because at all points and seasons the BOD parameters exceed the quality standard.  
2. The status of the river water quality is light to moderate.  
3. At some point in the dry season, the carrying capacity of the Padang River for the BOD parameter has been exceeded.  
4. In the upstream area, before it was affected by industrial wastewater, there were parameters that exceeded the class II water quality standard. |
| 2  | Role of government           | 1. The existence of regulations regarding quality standards and permits for liquid waste disposal.  
2. There are efforts to supervise industrial activities.  
3. There are river water quality monitoring activities, although not yet periodically.  
4. There is a center for complaints about pollution cases at environmental agencies.  
5. Coordination between agencies in controlling river water pollution is still lacking.  
6. Information and supporting data relating to the Padang River and its pollution control are still incomplete.  
7. The granting of industrial permits has been based on RT / RW but not based on tamping capacity and river carrying capacity. |
| 3  | Role of industry             | 1. The three industries already have WWTP installations and liquid waste disposal permits.  
2. Three industries have environmental management documents.  
3. There are industries whose wastewater still does not meet quality standards. |
| 4  | Role of public               | 1. The existence of the Forum for Environmental Care at the sub-district level.  
2. People still throw garbage in the Padang River. |
From the description above, a SWOT analysis was carried out for each indicator as presented in Table 8.

**Table 8. SWOT analysis based on the assessment of each indicator of Padang River water pollution**

| Strength (S)                                                                                                           | Quality | Score | Total |
|-----------------------------------------------------------------------------------------------------------------------|---------|-------|-------|
| 1. The existence of conservation in the water catchment area / upstream of the Padang River.                            | 0.33    | 2     | 0.67  |
| 2. The use of rivers for plant irrigation, so that the quality standard requirements are looser                        | 0.33    | 2     | 0.67  |
|                                                                                                                        | 1.00    | 6     | 2.00  |
| Weakness (W)                                                                                                          |         |       |       |
| 1. Water quality does not meet Class II water criteria                                                                  | 0.25    | 3     | 0.75  |
| 2. In the upstream area before being affected by industrial wastewater, there were parameters that exceeded Class II water quality standards | 0.17    | 2     | 0.33  |
| 3. In the dry season, the capacity of the Padang River for the BOD parameter has been exceeded                         | 0.17    | 2     | 0.33  |
| 4. The status of the river water quality is light to moderate                                                          | 0.17    | 2     | 0.33  |
| 5. Only one monitoring point for water quality and not periodically                                                   | 0.25    | 3     | 0.75  |
|                                                                                                                        | 1.00    | 12    | 2.49  |
| Opportunity (O)                                                                                                       |         |       |       |
| 1. There are regulations regarding quality standards                                                                    | 0.27    | 3     | 0.82  |
| 2. There is a community participation forum through the Environmental Care Forum (ECF) & there is a pollution complaint center at the Environmental Services Offices | 0.18    | 2     | 0.36  |
| 3. There are industries that participate in the environmental program                                                  | 0.18    | 2     | 0.36  |
| 4. The three industries already have environmental documents in the form of environmental documents                     | 0.18    | 2     | 0.36  |
| 5. There is an activity program for supervision and monitoring of industrial activities by Environmental Services Offices | 0.18    | 2     | 0.36  |
|                                                                                                                        | 1.00    | 9     | 2.26  |
| Threat (T)                                                              |         |       |       |
| 1. Industries dispose waste water that have not met quality standards                                                   | 0.20    | 2     | 0.40  |
| 2. Incomplete database regarding the source of pollution and river                                                    | 0.20    | 2     | 0.40  |
| 3. The issuance of a permit for industrial liquid waste disposal has not been adjusted to the river's capacity        | 0.20    | 2     | 0.40  |
| 4. In certain locations there are people throw garbage in the river                                                   | 0.20    | 2     | 0.40  |
| 5. Lack of coordination between stakeholders                                                                           | 0.20    | 2     | 0.40  |
|                                                                                                                        | 1.00    | 10    | 2.00  |

From the results of the strategy analysis (S - T), there are several strategies that support efforts to control water pollution in the Padang River, namely:

a. A technical study on the determination of water class and the holding capacity of the Padang River as the basis for river pollution control policies. The implementation of the tamping power policy for river pollution loads can be carried out, among others:
   - Require a study of river holding capacity in environmental management documents for every industry that has the potential to discharge waste water into the Padang River.
   - To limit the number and production capacity of new industries that have the potential to increase the pollution load for certain parameters that exceed the carrying capacity of rivers.
   - Limitation of production capacity for existing industries so as not to increase the pollution load to the Padang River.
b. Increasing the frequency of industrial activity supervision and monitoring activities

c. Increase the number of monitoring points and the frequency of monitoring the water quality of the Padang River

d. The existence of law enforcement sanctions and local appreciation to the industry in environmental management

4. Conclusion

Wastewater generated from the activities of the three industries contributes to the potential actual pollution load of the Padang River in the form of BOD, COD and TSS values of 6.9 kg/day, 19.19 kg/day and 6.11 kg/day, respectively. Based on the results of the SWOT analysis of the indicators of Padang River Water Pollution Control, a water pollution control strategy is produced, namely: study of water class determination and its allotment power, increasing the frequency of industrial activity monitoring and monitoring activities, increasing the number of monitoring points and monitoring frequency of Padang River water quality, as well as law enforcement and local appreciation of the industry in environmental management.

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