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Analysis of the Contribution of TSS, pH, Fe, and Mn Parameters to the Pollution Load Capacity of Coal Mines in the Oal River, South Sumatra

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Abstract: The Oal River, which is located in Muara Enim Regency, received input from coal wastewater, one of which came from PT. X. Coal mining in the vicinity of the location adds to the burden of water pollution in the Oal River due to wastewater disposal activities. The increase in the concentration of coal waste and the pollution load that enters the Oal River water body will have an impact on the reducing capacity of the pollution load. This study aimed to provide information on the condition of the pollution load-carrying capacity of the Oal River. Mass balance application is used in this study to determine the carrying capacity of water pollution loads at water sources. The characteristics of the Oal River water with the parameters TSS, pH, Fe and Mn have not yet passed the quality standards for river water and wastewater, both according to PP No. 22 of 2021 and South Sumatra Governor Regulation No. 8 of 2012. The Oal River still has the capacity to accommodate TSS, pH, Fe, and Mn parameters.
Keywords: Coal, Oal River, Wastewater

1. Introduction

The existence of water in river bodies can be utilized as a fulfillment of human life needs and as a medium for aquatic biota life. The rivers are often used as a disposal sites for domestic, agricultural, urban, industrial, livestock and mining waste. The amount of disposal site that flows into the river makes pollution of water bodies unavoidable.

The Oal River is a tributary of the Enim River and is classified as a class II river. The geographical location of it is in Muara Enim Regency and is closely related to community activities considering that many rivers in urban areas in Indonesia are used as sources of raw water for drinking water needs. It receives coal wastewater input from several companies. Coal mining in the vicinity of the location adds to the burden of water pollution in the Oal River due to wastewater disposal activities.

The pollution of coal waste in the form of Acid Mine Drainage (AMD) causes environmental problems, namely decreasing water quality to a certain level [1]. The water quality of a river can be studied based on physical, chemical, and aquatic biological parameters, where the higher the level, the more polluted the river water [12].

The wastewater treatment system for coal mining activities in Muara Enim Regency generally uses active control methods to neutralize pH, and reduce the concentrations of iron (Fe) and manganese (Mn) in acid mine drainage. Neutralization of pH, Fe, and Mn is done by mixing quicklime or mixing Calcium Oxide (CaO) directly into the acid mine drainage in the settling pond [2].

Acid mine drainage should not be channeled directly into river water bodies because it can damage river ecosystems and pollute the environment [3]. The concentration increase of coal waste and the pollution load that enters the Oal River's water body will have an impact on the decreasing capacity of the pollution load, so it is necessary to carry out efforts to manage wastewater to achieve a level of water quality under predetermined quality standards [4].

Determination of the carrying capacity of pollution loads according to the Decree of the State Minister for the Environment No. 110 of 2003 can be known by using the mass balance method [5]. The mass balance method uses the calculation of the mass balance of components of pollution sources to determine the average concentration of downstream originating from pollutant sources (point sources) and non-point sources.

Previous research on pollution load carrying capacity was conducted by [12] in the Surabaya River using the mass balance method, the results obtained show that the quality of river water in the Surabaya River for TSS and phosphate parameters at each point has exceeded the quality standard, while the parameters COD, BOD, DO, pH, Temperature, and Nitrate for each point is still within the specified threshold.

The research on the analysis contribution of TSS, pH, Fe, and Mn parameters to the pollution load carrying capacity of the Oal River requires to be carried out considering that the Oal River has the potential to be polluted by the presence of sources of pollution in the area and there has been no research on the pollution load carrying capacity of the Oal River. The results of this study were expected to provide information regarding the condition of the pollution load-carrying capacity of the Oal River.

2. Material and Methods

2.1. Materials

This study used a quantitative approach with descriptive methods sourced from field data taken directly by researchers. A quantitative approach is used in analyzing water quality and the capacity to carry river water pollution loads, as well as comparing it with the quality standards for coal mining wastewater based on South Sumatra Governor Regulation No. 8 of 2012 [6]. The data collection techniques are:

1. Field observation, this observation aims to determine the conditions around the riverbanks and the things that affect the river pollution load so that it can determine the point.
2. Determination of Sections/Segments is made based on 3 sections, namely upstream, middle, and downstream of the Oal River in Muara Enim Regency.

2.2. Methods

2.2.1. Sample collection and preparation

Field research was carried out in September 2022 in the Oal River, Muara Enim Regency, South Sumatra Province. This location was chosen because it is estimated to be directly affected by coal mining activities with a fairly large mining area. TSS and pH parameters were measured in situ. While the analysis of iron (Fe) and manganese (Mn) was carried out at UNILAB Jakarta. The research location on the Oal River is divided into three observation stations (downstream, middle, and upstream).

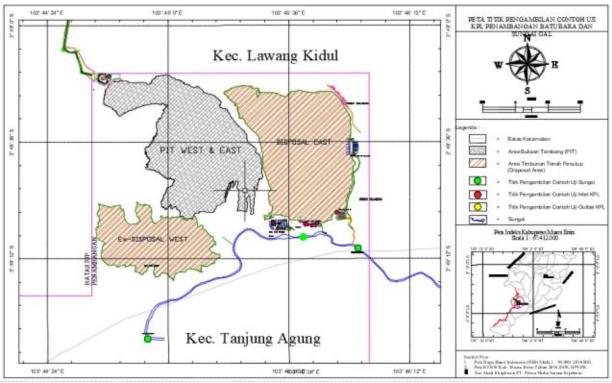

Figure 1. Oal River Research Location Map

2.3. Experimental variable and analytical procedures

Measurement of pH and TSS uses a water checker type Cyberscan CON 11. How to use the tool is to insert the tip of the water checker sensor into the water sample being measured, wait a few moments then look at the TSS and pH values listed on the water checker screen. While the analysis of Fe and Mn metal content was carried out in the laboratory using the spectrophotometric method. The spectrophotometric method measures the amount of adsorbent that absorbs waves according to the spectra of Fe and Mn metals. The instrument used is Atomic Absorption Spectroscopy (AAS) type ICE-3500 AA System.

2.4. Data Analysis

After obtaining data on concentration values for TSS, pH, Fe, and Mn parameters in the upstream, middle and downstream areas of the Oal River, the data were processed using Microsoft Excel using the mass balance method based on Minister of Environment Decree No. 110 of 2003 then analyzed the capacity to find out how much pollutant load can still be channeled into the Oal River.

Table 1. Wastewater Quality Standards for Coal Mining Activities

No	Parameter	Ministry of Environment Decree No. 113 of 2003	South Sumatra Governor Regulation No. 8 of 2012
1	Total Suspended Solid (TSS)	400 mg/L	300 mg/L
2	pH	6-9	6-9
3	Ferrum (Fe)	7 mg/L	7 mg/L
4	Manganese (Mn)	4 mg/L	4 mg/L

Determination of the carrying capacity of water pollution loads at water sources using the mass balance method based on Minister of Environment Decree No. 110 of 2003, the steps that must be taken are:

1. Measure the concentration of each constituent and flow rate in the stream before mixing with pollutant sources.
2. Measure the concentration of each constituent and the flow rate of each pollutant source stream
3. Determine the average concentration in the final stream after the stream mixes with the pollutant source by calculating :

$$CR = \frac{\Sigma Ci\ Qi}{\Sigma Qi} = \frac{\Sigma\ Mi}{\Sigma\ Qi} \qquad (1)$$

Information :
CR : Average concentration (mg/l)
Ci : Parameter concentration in stream i-th (mg/l)
Qi : Flow Rate i-th (m/s)
Mi : The mass of the parameters in the i-th flow (mg/l)

3. Results and Discussion

The process of the main coal mining activities at PT. X consists of several stages of activities, namely land clearing, stripping of topsoil and overburden, mining, transportation, stockpiling, and post-mining reclamation. On the other hand, coal mining activities result in a decrease in water quality due to the accumulation of coal excavated products and increased erosion. Overburden stripping activities will also affect surface runoff and surface water quality. Furthermore, the transportation of overburden using a dump truck caused spillage of material along the road, which is carried away by water when it rains, causing an increase in TSS and a decrease in light penetration and eventually the river water becomes cloudy. The Dumping or stockpiling of overburden will result in piles of soil in the dumping area that are easily eroded.

The coal mining activities are directly affiliated with the changes in surface water quality and quantity. Open pit coal mining will be in the form of a basin so that mining activities are always faced with problems of groundwater, river water, and rainwater. The runoff in the mine area is channeled into settling ponds located outside the pit area through drainage channels around the mine as well as on the left and right sides of the mine's road and coal haul road before being discharged into natural drainage, which ends on the river in the mining area.

The mining activities cause runoff water because rainwater that falls on the piles of coal does not experience infiltration into the ground. Runoff water originating from the mining area contains suspended solids and several dissolved substances so it needs to be managed properly. The results of the observations from water quality data on the Oal River, Muara Enim Regency, South Sumatra Province show that the water quality in the Oal River has changed as a result of water pollution. This is indicated by the decline in water quality to a certain level which can cause water to not function according to its designation. The water quality of the Oal River, seen from the parameters TSS, pH, Fe, and Mn, indicates that there has been a decrease in quality because there are several water quality parameters that have exceeded the quality standards required in PP No. 22 of 2021 class II river water. Complete data is presented in Table 2.

Table 2. Table of results of water quality measurements in the Oal River

Parameter	Quality standards	Results		
		Upstream	Middle	Downstream
Total Suspended Solid (TSS)	50 mg/L	20 mg/L	35 mg/L	30 mg/L
pH	6-9	6,7	6,5	6,5
Ferrum (Fe)	-	0,2 mg/L	0,5 mg/L	0,5 mg/L
Manganese (Mn)	-	0,03 mg/L	0,1 mg/L	0,07 mg/L

Based on the table above it can be seen that the concentration of TSS in the upstream of the river is 20 mg/L. While in the middle and downstream of the river with TSS concentrations of 35 mg/L and 30 mg/L respectively. This could be due to the influence of direct sewage input in the middle area of the Oal River.

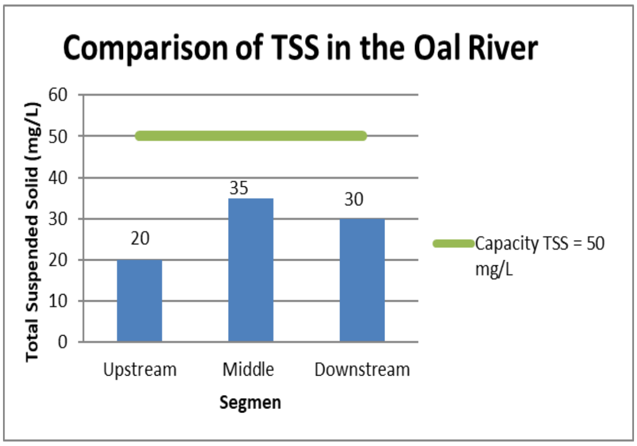

Figure 2. Comparison of TSS in the Oal River

pH is the degree of acidity or alkalinity of a solution, expressing the negative logarithm of the concentration of H ions with a base number of 10. Based on Table 2 above it can be seen that the concentration of pH has decreased from upstream to the middle of the river with a value of 6.7 to 6.5. However, there was no change in pH between the middle of the river and the downstream of the river. A decrease in pH concentration can occur due to the process of respiration and decomposition of organic substances in water [8]. The pH in the upstream, middle, and downstream of the Oal River is relatively stable and still in the good category so it is still possible for aquatic biota to live.

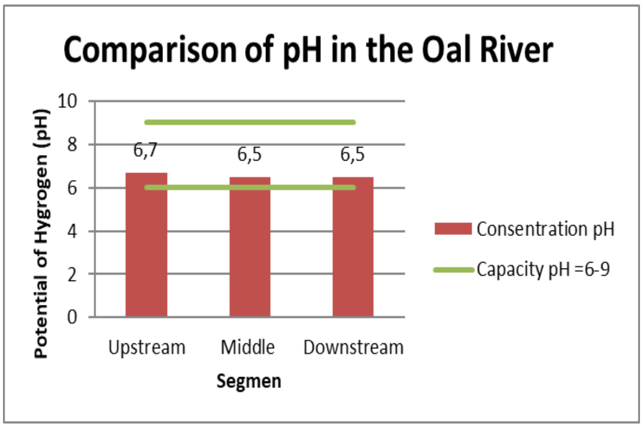

Figure 3. Comparison of pH in the Oal River

Based on the table above, it can be seen that the concentration of Fe in the upper reaches of the river is 0.2 mg/L, while in the middle and lower reaches of the river it is 0.5 mg/L. There is no quality standard related to the value of Fe concentration in class II river water quality standard which refers to Government Regulation No. 22 of 2021. The high and low content of Fe metal can be influenced by factors other than pollutant sources. Dynamic water movement can be a factor in the high concentration of Fe in the water because currents can carry Fe at the bottom of the water. [9] states that iron can dissolve in soil and water.

When raining, rainwater carries the Fe content from the soil to the river, which increases the Fe content in the river. The coal contained different minerals and inorganic elements as ions dissolved in runoff water. Sulfur also undergoes a reaction with water and/or oxygen, thereby releasing sulfate into the environment. This reaction caused the soil and water to become acidic and increased the concentration of Fe. A pH level below 7 can dissolve metals.

If the concentration of dissolved iron in water exceeds the limit, it will cause various problems, namely technical problems in the form of corrosive deposits, physical problems in the form of color, odor, and unpleasant taste, as well as health problems in the form of nausea, damage to the intestinal wall and irritation to the eyes and skin. PP No. 22 of 2021 has not yet set a maximum limit for Fe content in river water, but in South Sumatra Governor Regulation No. 8 of 2012, the quality standard for Fe in mining wastewater is 7 mg/L. From Figure 4.7, the levels of Besi (Fe) in the Oal River are still within safe limits so they are not dangerous. On the other hand, Fe is also an important mineral needed by plants as a source of nutrients.

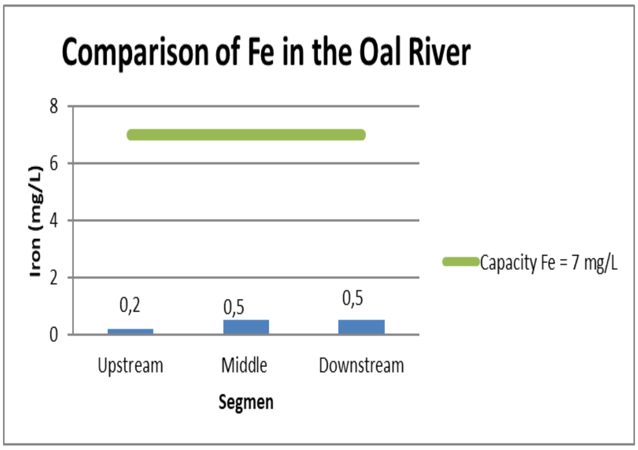

Figure 4. Comparison of Fe in the Oal River

Mn is a metal cation that has chemical characteristics similar to iron. The low manganese content is caused by the lithology/rocks that make up the stockpile which has a low element content. If water containing manganese is left exposed to air or oxygen, manganese oxidation reactions will occur slowly forming colloidal precipitates or lumps from unexpected manganese oxidation.

The concentration of Mn in the Oal River increased from 0.03 mg/L to 0.1 mg/L in the middle of the river and again decreased to 0.07 mg/L in the lower reaches of the river. Fluctuations in the Mn value can be caused because in the soil itself there is an Mn content that allows it to be carried into the river [9]. In addition, the interaction between metals also affects the speed and extent to which metal deposition occurs.

Changes in manganese compounds in nature based on pH conditions at valence 2 will generally dissolve in water. Therefore, in the water treatment system, manganese compounds by oxidation are converted to compounds that have a higher valence oxidation method that are insoluble in water so that they can be easily separated physically. The manganese content in the water that exceeds the limit can cause negative effects such as creating a fishy metallic taste and smell in drinking water, leaving a brownish color on white clothes and laundry, causing liver dysfunction, and others.

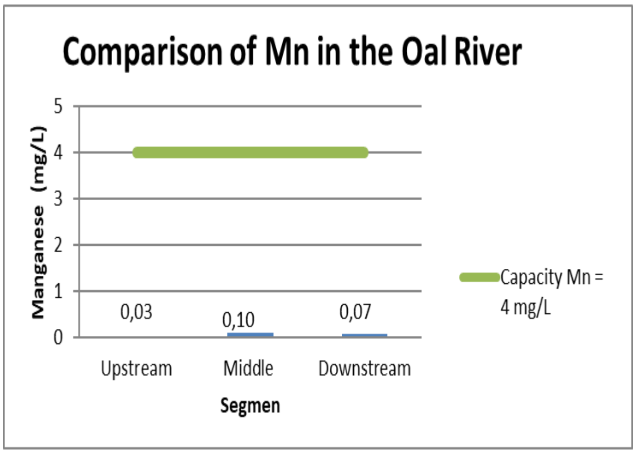

Figure 5. Comparison of Mn n the Oal River

Then based on the calculation results of the pollution load capacity of the Oal River using the mass balance method is presented in the following Table 3.

Table 3. Calculation results for the capacity of the Oal River

Point	Water Discharge (m^3/s)	TSS (mg/L)	pH	Fe (mg/L)	Mn (mg/L)
Upstream	1,38	20	6,7	0,2	0,03
Middle	1,5	35	6,5	0,5	0,1
Downstream	1,62	30	6,5	0,5	0,07
CR	4,50	24,83	6,03	0,70	0,42
BM X		50	6-9	-	-
Capacity (Kg/day)		604,16			
Capacity		**Good**	**Good**	**Good**	**Good**

Information :
CR : Average concentration
BM : Quality Standards

Table 3 explains the CR value (average concentration mg/L) in TSS, pH, Fe, and Mn. Based on the results of mass balance calculations, the CR TSS value (average concentration) is 24.83 mg/L. When compared with the value of class II quality standards that have been set in PP no. 22 of 2021, the TSS concentration value in the Oal River has not yet passed the quality standard of 50 mg/L, the Oal River still can contain TSS contamination. The high TSS content in river water can increase the turbidity value which will inhibit the penetration of sunlight into the river water and will ultimately affect the process of photosynthesis in river water [10].

The results of the analysis related to the average pH value in the Oal River using the mass balance showed a result of 6.03. There was a decrease when compared to the pH value in upstream of the river, where the upstream is the initial condition of the water quality of the Oal River. This decrease occurs because acid mine drainage is relatively more acidic. The decrease in pH in the Oal River occurred in the middle and downstream of the river, so the change in pH may occur when river water mixes with wastewater. From Table 3 the pH value in the Oal River is still below the class II quality standard set in PP No. 22 of 2021 so the Oal River still can withstand changes in pH.

Based on the results of mass balance calculations, values can be generated from the average concentrations of Fe and Mn metals which can be seen in Table 3 with respective values of 0.7 mg/L and 0.42 mg/L. Referring to PP No. 22 of 2021 concerning the Implementation of Environmental Protection and Management, it has not yet been regulated regarding the limits on the quality standards for Fe and Mn values in the class II river water quality standards. However, when referring to the Governor of South Sumatra Regulation No. 8 of 2012 concerning Liquid Waste Quality Standards for Industrial, Hotel, Hospital, Domestic, and Coal Mining Activities, the parameter values of Fe and Mn are still far from the established quality standards, where the maximum values set respectively for Fe and Mn are of 7 mg/L and 4 mg/L. Fe and Mn are nutrients needed by plants, but in large quantities, they are toxic [11].

Acid Mine Drainage (AMD) is generally acidic, so it becomes a factor in increasing the solubility of Fe and Mn in water. Metals that are contained and flow with AMD into wastewater are the main causes of river water pollution [13].

4. Conclusion

The characteristics of the Oal River water with the parameters TSS, pH, Fe and Mn have not yet passed the quality standards for river water and wastewater, both according to PP No. 22 of 2021 and South Sumatra Governor Regulation No. 8 of 2012. The Oal River still can accommodate TSS and pH parameters.

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