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Study on Pollutant Load Allocation and Carrying Capacity of the Asam Sub-DAS, Jambi City

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A B S T R A C T
Asam River in Jambi City is one of the tributaries of Batanghari River which is important for Jambi Community. Batanghari River is the main source of raw water for Regional Drinking Water Company (PDAM) to fulfill clean water needs in Jambi City. Currently, Asam River has been polluted by domestic waste from settlements, hotels, offices, and trade. This study aims to examine the allocation of pollutant load to the capacity of Asam Sub-DAS, with emphasis on BOD (Biochemical Oxygen Demand), COD (Chemical Oxygen Demand), and TSS (Total Suspended Solid) parameters. In this study, data processing was carried out using water quality modeling with Qual2Kw model, then 4 scenarios were carried out, namely existing conditions, population predictions for the next 5 years, suitability of class 2 quality standards without pollutant load and suitability of class 2 quality standards trial & error. After the analysis of the 4 scenarios, the development of the Asam Sub-DAS Water Quality Modeling scenario was carried out again so that improving water quality can be achieved by reducing the amount of pollutants produced from pollution sources. The results show that to meet the BOD quality standard, a reduction in pollutant load of 50%-75% is required, while COD and TSS can meet the quality standard with a reduction of 25%.

1. INTRODUCTION

Water pollution occurs when the characteristics of water change due to the entry of hazardous contaminants, making it unfit for human consumption and unsupportive of life such as fish. Domestic, industrial, livestock, and hospital waste can reduce water quality and threaten organisms in the surrounding area.

Asam Sub-DAS, part of Batanghari DAS in Jambi City, is a source of raw water for PDAM. This sub-DAS crosses Kota Baru, Jelutung, and Pasar Jambi Districts with a length of 13.98 km and an area of 2,930 Ha. The Asam River is threatened by pollution from residential, office, hotel, and trade waste. Data from the Jambi City Environmental Service in 2023 showed a decline in water quality downstream, BOD and COD parameters increased to exceed the class 2 river water quality standards according to PP No. 22 of 2021. Figure 1 shows the water quality of the Asam River.

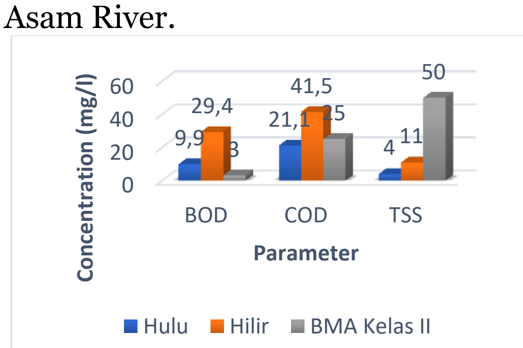


Figure 1 Water Quality of Upstream-Downstream Asam River in 2023

Based on Figure 1, the river's natural ability to purify itself is limited, especially if pollution exceeds its capacity. Therefore, an analysis of the river's capacity is needed to regulate the allocation of pollution loads. Determination of this allocation must consider the type of pollution source, location, and river segment, and be supported by data on water quality, hydrology, and morphology of the Asam Sub-DAS. The results of this study are important for preparing a water pollution control plan (PPA) and environmental management policies.

2. METHOD

Determination of Territorial Boundaries

The determination of the research area boundary was carried out with a radius of 500 meters from the river bank. Only households within this radius were counted as sources of pollution (Novitasari, 2015). The research area boundary map was used to map the observed area. Figure 2 shows the boundaries of the research area.

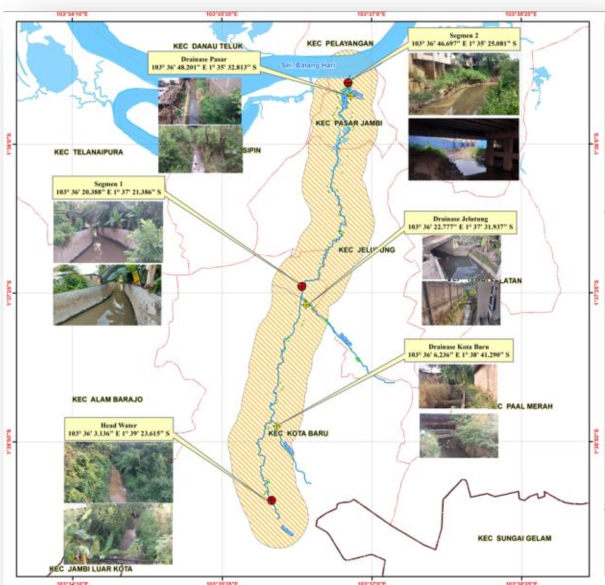


Figure 2. Research Area Boundaries

Field Observation and Sampling

Before sampling, the study area was divided into 3 parts, namely Headwater, Segment 1, and Segment 2. Water sampling was taken at 6 points, namely at Headwater, Segment 1, and Segment 2 and then at the drainage originating from Kota Baru District, Jelutung District, and Pasar Jambi District to be samples from *point sources* . This sampling was carried out simultaneously with the collection of river profile data such as width, depth, and cross-section of the Asam River. Water samples were then tested in an accredited private environmental laboratory in Jambi City, and then the results were input into the Qual2Kw modeling, and analyzed.

Water Quality Modeling (Qual2Kw)

In the Qual2Kw modeling, input data is required in the form of primary and secondary data, primary data consists of the results of acid river water quality tests and *point source water quality data* whose samples were taken directly at the research location. For secondary data used, namely meteorological data. The meteorological data consists of 8 parameters, namely: Air temperature , Dew point *temperature* , Wind speed *,* Shade *,* Cloud cover *,* Solar *,* Light *and* heat . Each parameter has a value with certain units and provisions. Meteorological data can be accessed through the site https://power.larc.nasa.gov/ in the Data *Access Viewer* . On this site, 4 types of meteorological data can be downloaded that are needed, namely Air temperature *,* Dew point temperature *,* Wind speed *and* solar. Other meteorological data can be downloaded through other sites such as https://www.accuweather.com/ or data from BMKG (Meteorology, Climatology, and Geophysics Agency) (Manalu, 2023).

Modeling was conducted to analyze the impact of pollutant load on water quality in the Asam River. The data used include BOD, COD, TSS parameters measured at several points along the river (headwater, segment 1, segment 2, and three points in the drainage channel). Four modeling scenarios were used, namely:

- Existing Scenario: Using existing pollutant load data.
- Projection Scenario: Using projection data for the next five years.

- No Pollution Scenario: Calculates natural recovery capacity without pollutant load.
- Control Scenario: Optimizing pollutant load reduction to achieve quality standards.

Next, the Development of Water Quality Modeling Scenarios for the Asam Sub-DAS was carried out as an effort to improve the water quality of the Asam River. This study focuses on improving water quality resulting from reducing pollution loads, with the assumption that the conditions resulting from the efforts made remain as they are currently. Improvements in water quality from upstream to downstream of the Asam River are predicted through water quality model simulations in the Asam Sub-DAS with the following four scenarios:

1. Conditions without reduction of pollution load,
2. Reduction of pollution load by 25%,
3. Reduction of pollution load by 50%,
4. Reduction of pollution load by 75%.

Based on KLHK (2017), to determine the potential pollution load from household sources, the following equation can be used:
PBP = Population x Emission factor x city equivalence ratio x alpha
Which one :

- Population emission factors: BOD = 40 gr/person/day, COD = 55 gr/person/day
- City equivalent ratio (*discharge load*):
  City = 1 , Suburbs = 0.8125, Interior = 0.625
- Alpha (α): Load transfer coefficient (*delivery load*)
  - The value of $\alpha = 1$,
    is used in areas that are located between 0 and 100 meters from the river,
  - The value of $\alpha = 0.85$,
    is used for locations that are between 100 – 500 meters from rivers and
  - The value of $\alpha = 0.3$,
    is used for locations that are more than 500 meters from the river.

3. RESULT AND DISCUSSION

Research Area

The research area in this study is divided into three parts, namely *headwater* , segment 1, and segment 2. The existing conditions of water quality in these parts are described as follows.

Headwater is the starting point of the simulation located at the upstream of the river, precisely in Kenali Asam Bawah Village, Kota Baru District. Data from the headwater is used to calculate the flow, mixing, and impact of pollution with the *Qual2Kw simulation* . The water quality at this point shows organic and chemical pollution, with a pH of 5.88 (below the standard of 6–9), DO 5.88 mg/l, BOD5 29.11 mg/l, and COD 32.6 mg/l, all of which exceed the quality standard. TSS 13.43 mg/l is still within normal limits. This indicates that there is pollution upstream that affects the water quality in the next segment.

Segment 1 covers four sub-districts in Kota Baru District with an area of 464.89 hectares. The majority of the land is used for settlements (85%), while 13% is shrubs. Water quality in this segment shows a decline due to pollution from upstream and settlement activities. The DO value is only 1.21 mg/l (very low), BOD5 20.18 mg/l, and COD 39.7 mg/l, which exceeds the quality standard. However, pH 6.85 and TSS 7.33 mg/l are still within normal limits. This decline in quality is due to pollution from settlement activities.

Segment 2 covers nine villages in three sub-districts, namely Kota Baru, Jelutung, and Pasar Jambi, with a total area of 637.2 hectares. In this segment, 65% of the land is used for settlements, 20% for businesses, and 15% for bushes. Water samples were taken in Jelutung Village and Sungai Asam. The results showed DO 2.41 mg/l (still low), BOD5 12.25 mg/l, and

COD 19.45 mg/l, which exceeded the quality standards. TSS 29.67 mg/l is still within normal limits. Pollution in this segment decreased compared to Segment 1, but was still affected by pollution from upstream and local activities.

1. Qual2Kw Modeling

a) Scenario 1

Scenario 1 represents the actual (existing) conditions. The data used includes discharge data, water quality of the Asam River, meteorological data, water quality *point sources* from drainage entering the river , and diffuse sources of pollution . This simulation aims to calculate the pollution load entering the Asam River under existing conditions.

Scenario 1 also serves to calibrate and validate the river water quality model, so that the model can be used in the next scenario . The results of river water quality modeling using QUAL2Kw from Scenario 1 are presented in Figure 3. It can be observed that the model has approached the input data (marked with a black box). The COD, BOD, pH, DO, and TSS values of the Asam river show stability in each segment. The next step is to validate using the *Root Mean Square Percent Error* (RMSPE) method. The simulation results on the Qual2Kw output WQ worksheet are presented in Table 1. Based on the calculation results in Table 2, the error value for each parameter in the model is below 1, so it can be concluded that the model is acceptable.

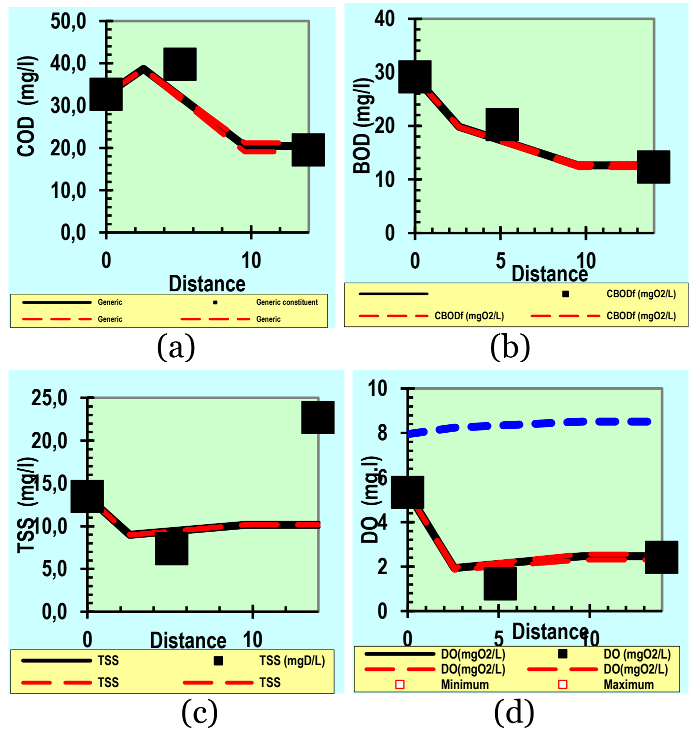


Figure 3 Results of water quality simulation in scenario 1 using Qual2Kw for parameters (a) COD, (b) BOD, (c) TSS, and (d) DO

Table 1 Simulation Results *Worksheet* WQ Output Qual2Kw data scenario 1

Segmen	pH	BOD	DO	TSS	COD
Headwater	5.88	29.11	5.33	13.43	32.60
Segment 1	6.12	19.08	2.01	8.44	38.67
Segment 2	6.45	11.42	2.69	21.71	19.69

Source: Qual2Kw Simulation, 2024

Table 2 *Root Mean Square Percent Error* (RMSPE) Scenario 1 for each parameter

No	Sampling Point Name	pH		COD		BOD		TSS		DO	
		Observation Result Value	Qual2Kw Simulation Result Value	Observation Result Value	Qual2Kw Simulation Result Value	Observation Result Value	Qual2Kw Simulation Result Value	Observation Result Value	Qual2Kw Simulation Result Value	Observation Result Value	Qual2Kw Simulation Result Value
1	Headwater	5.88	5.88	32.6	32.60	29.11	29.11	13.43	13.43	5.33	5.33
2	Segment 1	6.85	6.73	39.7	38.67	20.18	19.08	7.33	8.44	1.21	2.01
3	Segment 2	6.93	6.47	19.45	20.45	12.25	11.42	22.67	21.71	2.41	2.69
		RMSe	0.27	RMSe	0.83	RMSe	0.80	RMSe	0.84	RMSe	0.49

Source: Calculation Results, 2024

b) Scenario 2

Scenario 2 is a simulation considering the projected pollution sources in the next five years. Data on water quality conditions in the upstream river are based on existing data (primary data), while point sources data *and* climatology data use data used in scenario 1. Meanwhile, *diffuse sources pollution data* are obtained from predictions based on population projections in 2029. The purpose of this simulation is to calculate the pollutant load that will enter the Acid River in 2029. This is in accordance with KepMenLH No. 110/2003, which states that the determination of minimum capacity is carried out every five years.

According to the Jambi City Central Statistics Agency, in 2024 the population of this city will reach 641,022 people. With this population, Jambi City is categorized as a large city because its population is between 500,000-1,000,000 people. The need for clean water for domestic use in large cities is estimated at 150 liters per person per day, where around 80% of this consumption is assumed to be domestic wastewater. The calculation of the projected population and the discharge of wastewater produced is as shown in Table 3.

Table 3 Calculation of domestic wastewater in 2029

Segmen	Population (People)	Clean Water Requirements (l/day)	QWastewater (m3 / day)	QWastewater (m3 / sec)
Segment 1	106,393	15,958,878	127.67	0.00148
Segment 2	72,463	10,869,516	86.96	0.00101

Source: Calculation Results, 2024

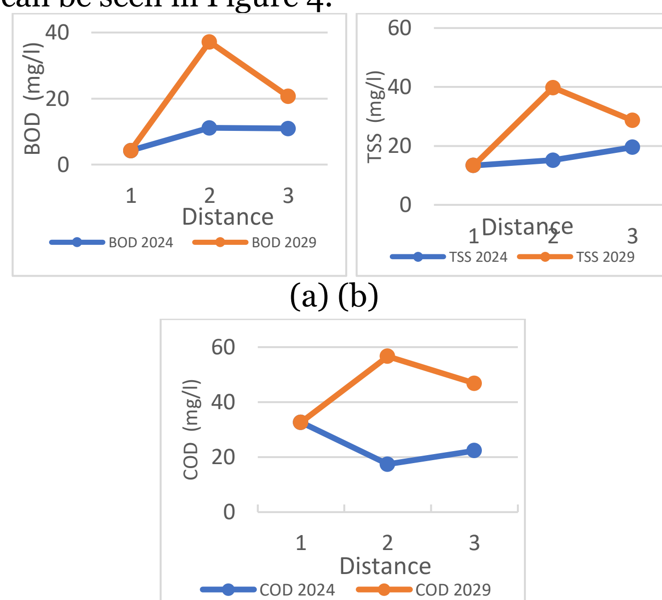
After obtaining the wastewater discharge in 2029, the quality calculations of BOD, COD, and TSS parameters were carried out again using population emission factors. The results of the water quality calculations for *diffuse source pollutant sources* are shown in Table 4.

Table 4. Water Quality Calculation in 2029

Segmen	Population (People)	Q (m^3/sec)	C BOD (mg/l)	C COD (mg/l)	C TSS (mg/l)
Segment 1	106,393	0.00148	1000	1375	950
Segment 2	72,463	0.00101	1000	1375	950

Source: Calculation Results, 2024

After obtaining the water quality results for *the diffuse source* , the QUAL2Kw program is *run* with the latest input data, the next step is to analyze the results displayed on *the source summary worksheet*. This worksheet presents information about the quality of pollutant sources entering the Asam River. These results allow a comparison between the quality of pollutant sources from Scenario 1 and Scenario 2. The results of this comparison show an increase in BOD, TSS and COD values as parameters of pollutant sources entering the Asam River between the data in scenario 1 and the predicted data for 2029 in scenario 2. The comparison between scenario 1 and scenario 2 can be seen in Figure 4.



(a) (b)

(c)

Figure 4. Comparison of Water Quality in 2024 and 2029 (a) BOD, (b) TSS, and (c) COD

The results of the analysis show that there is an increase in the parameter values of BOD, COD, and TSS between 2024 (Scenario 1) and 2029 (Scenario 2). The visualization of the increasing trend of pollutant load shows the need for early management of pollution load to maintain the capacity and water quality of the Asam River in the future.

c) Scenario 3

Scenario 3 is a simulation conducted without involving pollutant sources entering the water body. Water quality data in the upstream part of the river is adjusted to meet class 2 water quality standards. Climatology data uses available information as secondary data. All pollutant source data, both *point sources* and *diffuse sources* , are removed, except for pollutant sources from tributaries which are still adjusted to meet class 2 water quality standards. The purpose of this simulation is to evaluate the *self-purification capability* of the Asam River without any contribution from pollutant sources.

Simulation 3 results in Table 5 show that the Asam River has optimal *self-purification capability in conditions without any contribution of pollution load from external sources, both point sources* and *diffuse sources*. The natural purification process can be seen from the simulation results which show that all water quality parameters meet class 2 quality standards. The BOD value decreased from 4.00 mg/L upstream to 2.69 mg/L downstream, indicating the success of the organic matter biodegradation process. The increase in DO value from 4.00 mg/L to 9.01 mg/L indicates that natural aeration and reoxygenation are functioning well along the river flow.

Other parameters such as TSS decreased from 25.00 mg/L to 13.61 mg/L due to sedimentation of suspended particles, while COD also decreased from 50.00 mg/L to 20.23 mg/L, indicating a reduction in organic and inorganic pollutants. The stability of the pH value in the range of 6.00 to 6.37 ensures conditions that support aquatic life. This simulation confirms that without any pollution load, the Asam River is able to purify itself effectively. However, this ability still requires support through pollution load management to maintain sustainable water quality. The output data from QUAL2Kw in Simulation 3 for all parameters are listed in *the Source Summary* and *WQ Output worksheets* . The trend of the Simulation 3 model can be seen in Figure 5.

Table 5 WQ Output QUAL2KW scenario 3

Segmen	BMA *	pH	BMA	BOD	BMA*	DO	BMA*	TSS	BMA*	COD
Headwater	6-9	6.00	3	3.00	4	4.00	50	50.00	25	25.00
Segment 1		6.14		2.84		6.82		20.16		23.24
Segment 2		6.37		2.69		9.01		13.61		20.23

*Class 2 Water Quality Standards PP No. 22 of 2021

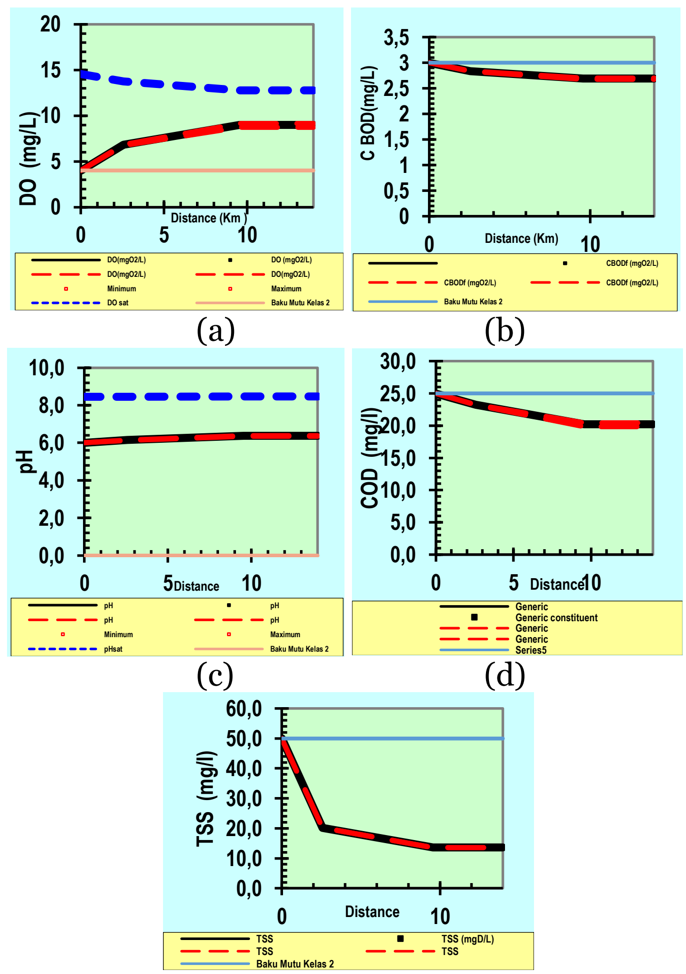
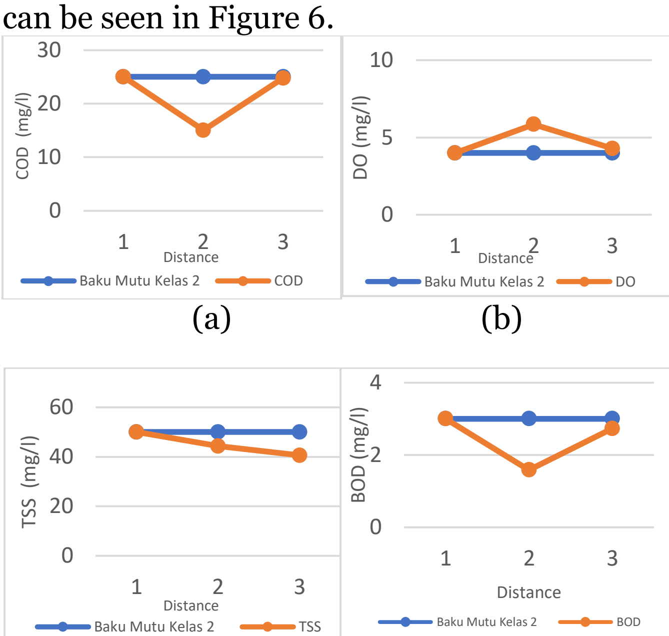


Figure 5 Simulation of scenario 3 of the *self-purification capability* of an acidic river without pollution sources , (a) DO, (b) BOD, (c) pH, (d) COD, (e) TSS.

d) Scenario 4

This scenario is based on water quality parameters that meet the quality standards for class 2 water bodies according to PP No. 22 of 2021. In the existing conditions in Scenario 1, there are several river water quality parameters that exceed the class 2 quality standard limits. Scenario 4 is carried out by applying the *trial and error method* to adjust the value of pollutant sources, both from point sources and non-point sources. Trial and error is considered complete if the river water quality data and pollutant sources in the output worksheet have met the class 2 BMA value. This simulation aims to determine the amount of pollutant load that is allowed to enter the river.

The results of Scenario 4 show that all river water quality parameters have met the water quality standards of class 2, with better water quality compared to the results of Scenario 1. This occurs because the water quality in the upstream (*headwater*) has been adjusted to meet the quality standards, and the trend line (model) in this simulation is also designed according to the quality standards of class 2. The trend of the simulation model of scenario 4 can be seen in Figure 6.



(a) (b) (c) (d)

Figure 6 Simulation of water quality that meets the quality standards for class 2 water bodies according to PP No. 22 of 2021, (a) COD, (b) DO, (c) TSS, (d) BOD

e) Scenario Development

Based on the results of the four previous water quality scenarios, the data is used to calculate the pollution load capacity of the Asam River. This calculation is done using data from *the Source Summary worksheet* , which includes the results of the pollution load calculation based on the discharge and water quality in each river segment. Development of Water Quality Modeling Scenarios for the Asam Sub-watershed Water quality improvement can be achieved by reducing the amount of pollutants produced from pollution sources. The water quality modeling used in this study is focused on projecting improvements in water quality resulting from reducing the pollution load. Improvements in water quality from upstream to downstream of the Asam River are predicted through water quality model simulations in the Asam Sub-watershed with the following four scenarios:

1. Condition without reduction of pollution load,
2. Reduction of pollution load by 25%,
3. Reduction of pollution load by 50%,
4. Reduction of pollution load by 75%.

The results of the pollutant load calculations from scenario development can be seen in Table 6.

Table 6 Results of scenario development in improving the quality of the Asam River

Parameter	Segmen	Maximum Pollutant Load Quality Standard (kg/day)	Actual Pollutant Load Without Reduction (kg/day)	25% reduction (kg/day)	50% reduction (kg/day)	75% reduction (kg/day)
BOD	Segment 1	787,968	7,617,024	5,443.2	2,592	783.13
	Segment 2	574,128	1,298.63	946.21	746,496	199.71
COD	Segment 1	6,566.4	10,913.81	4,571.78	2,619.41	556.01
	Segment 2	4,784.4	8,023.1	3,845.78	1,973.12	1,616.17
TSS	Segment 1	22,693.4784	3,414.52	2,094,924	1,058,124	280,524
	Segment 2	16,534,8864	11,603.32	2,988.98	3,788,796	802,812

Source: Calculation Results, 2024

Based on Table 6, the maximum pollutant load for BOD is 787.97 kgBOD/day. In conditions without reduction, the pollutant load reaches 7,617.024 kgBOD/day, which far exceeds the quality standard threshold. After reducing the pollutant load by 25%, the load decreases to 5,443.2 kgBOD/day, but remains above the permitted limit. A further 50% reduction reduces the pollutant load to 2,592 kgBOD/day, but still does not meet the quality standard. Only at a reduction level of 75% does the pollutant load approach the quality standard with a value of 783.1296 kgBOD/day, so reducing the pollutant load by 75% is a necessary step to maintain dissolved oxygen levels in water. BOD (*Biochemical Oxygen Demand*) measures the amount of oxygen needed by microorganisms to decompose organic matter in water. The higher the BOD value, the more oxygen is used, which can cause a decrease in the dissolved oxygen (DO) level in water, which is very important for the life of aquatic organisms. Since the strict BOD quality standard (3 mg/l) is set to maintain the oxygen balance in water, a significant decrease in the BOD value is essential. This aims to ensure that the decomposition process of organic matter does not drastically reduce the dissolved oxygen level, so that the water quality continues to support the survival of aquatic organisms (KLHK, 2021).

The Maximum Pollutant Load COD is set at 6,566.4 kgCOD/day. In conditions without reduction, the pollutant load reaches 10,913.81 kgCOD/day, far exceeding the quality standard. With a 25% reduction, the COD load decreases to 4,571.78 kgCOD/day, which is already below the quality standard. A 25% reduction in COD is sufficient to achieve the quality standard compared to BOD. The COD (*Chemical Oxygen Demand*) quality standard of 25 mg/l is higher than BOD because COD includes the oxygen requirement to oxidize all organic materials, both those that can be biodegraded and those that are difficult to decompose. This higher limit provides tolerance for pollution of complex organic materials and stable chemical compounds that do not directly reduce dissolved oxygen (DO) levels, in contrast to BOD which focuses more on the direct impact on aquatic ecosystems through the activity of microorganisms. A 25% reduction in COD is sufficient to reduce the pollution load, considering that COD measures various types of pollutants, not all of which contribute directly to oxygen consumption (KLHK, 2021).

The TSS Pollutant Load is 22,693.48 kgTSS/day. Without reduction, the TSS pollutant load reaches 34,414.53 kgTSS/day, far above the quality standard. With a 25% reduction, the load is reduced to 20,948.24 kg/day, which meets the standard. A further 50% reduction reduces the load to 10,581.24 kg TSS/day. The TSS (*Total Suspended Solids)* quality standard of 50 mg/l focuses on the physical quality of water, especially clarity and photosynthesis ability in aquatic ecosystems. High TSS can reduce water transparency, block sunlight, and affect aquatic life. A 25% reduction in TSS is sufficient to improve water clarity, support photosynthesis, and meet standards for uses such as fish farming and recreation (KLHK, 2021).

The results of the analysis of the pollutant load of the Asam River show similarities and differences with previous studies using QUAL2Kw modeling, such as in the Kahayan, Mahakam, Brantas, and Gajahwong Rivers. In general, the BOD parameter requires the largest reduction, up to 70%-80%, to approach the quality standard. This is due to the nature of BOD which is slow to decompose and selective towards *biodegradable organic matter* . In contrast, the COD parameter is easier to meet the quality standard with a reduction of around 20%-30%, due to the faster and more effective chemical oxidation reaction. The TSS parameter is relatively easier to manage, with a reduction of 25% sufficient to meet the quality standard in most rivers. The Kahayan and Mahakam Rivers show a lower natural purification capacity than the Asam River, so the percentage of reduction required is higher. Thus, this study confirms a similar trend to previous studies, although it shows differences related to pollutant sources and hydrological conditions in the Asam Sub-watershed. The QUAL2Kw approach remains relevant to support water quality management planning in various regions with different pollution challenges (Masduqi, A., & Assomadi, AF (2011); Jumiati, Y., et al (2020); Ghozali, AA, et al, (2024); Hermawan, D., et al (2024)).

Efforts and strategies to control pollution in the acid river in Jambi City

To overcome the pollution that occurs in the Asam River, a comprehensive approach is needed that involves technical, environmental, and community participation aspects. Technically, it is important to improve waste processing infrastructure, both domestic and industrial, as well as to conduct regular monitoring of water quality by testing BOD, COD, and TSS parameters. This is in accordance with the recommendations in the Strategic Plan of the Ministry of Environment and Forestry (KLHK), which emphasizes the importance of calculating the pollution load capacity to avoid ecosystem overloading (KLHK, 2020). In addition, to support sustainable environmental management, efforts need to be made to protect and manage natural resources through planning based on environmental carrying capacity, which is regulated in Jambi City Regulation Number 4 of 2020 (Jambi City Regulation, 2020). From the community's perspective, education about river cleanliness, household waste management, and active participation in planting trees can strengthen environmental supervision and management. This integrated strategic approach will not only reduce the pollution load in the Asam River, but also support the sustainability of the ecosystem in the future.

4. CONCLUSION

COD and TSS parameters in Asam River water are easier to meet standards than BOD. A 25% reduction in COD and TSS is sufficient to achieve quality standards. Meanwhile, BOD requires a reduction of up to 75%. To reduce COD, efficient industrial waste treatment and pollution source management can be applied. TSS can be controlled by erosion control and filtration systems. To reduce BOD, better waste treatment, reduction of organic waste, and restoration of natural ecosystems are needed which aim to restore damaged river environmental conditions, through activities such as planting vegetation, erosion control, and improving water flow. These activities help improve the ecosystem's ability to decompose organic matter and improve water quality.

5. REFERENCES

Central Bureau of Statistics of Jambi City. (2024). Jambi Municipality in Figures 2024. Volume 25. ISSN 0215-3920. Central Bureau of Statistics of Jambi City.

Ermawati, R., & Hartanto, L. (2017) . Mapping of Lamat River Pollution Sources Magelang Regency. Journal of Environmental Science & Technology , 9(2), 92-104.

Ghozali, AA, Yoshua, B., Eviane, D., & Lestari, ADN (2024). Analysis of river carrying capacity using QUAL2Kw: Case study of Gajahwong River segment, Yogyakarta. Journal of Environmental Engineering , 24(1), 27. ISSN: 2716-4470.

Government of the Republic of Indonesia. (2021). Government Regulation of the Republic of Indonesia Number 22 of 2021 Concerning the Implementation of Environmental Protection and Management.

Hermawan, D., Ardianor, Redin, H., & Sinaga, S. (2024). Analysis of maximum pollutant load of palm oil wastewater using the QUAL2Kw model in the Kahayan River, Pulang Pisau Regency. Journal of

Comprehensive Science , 3(3). p-ISSN: 2962-4738, e-ISSN: 2962-4584.
Jambi City Environmental Service, (2024), Asam River Water Quality Report.
Jambi City Regional Regulation Number 4 of 2020 concerning Environmental Protection and Management . Jambi City.
Jumiati, Y., Mislan, D., & Subagiada, K. (2020). Study of determining the carrying capacity of Mahakam River water quality pollutant load using the QUAL2Kw method. Kutai Basin Geoscience, 3 (1), 1-XX.
Komarudin, M., Hariyadi, S., & Kurniawan, B. (2015). Analysis of pollution load capacity of Pesanggrahan River (Depok City Segment) using numerical and spatial models. Journal of Natural Resources and Environmental Management , 5(2), 121-132.
Maghfiroh, L. (2016). Determination of pollution load capacity of Kalimas River Surabaya (Taman Prestasi-Jembatan Petekan Segment) using QUAL2Kw modeling (Final Project, Sepuluh Nopember Institute of Technology).
Manalu, YS (2023). Theory and User Guide for QUAL2KW Application Version 5.1 . Smart Eduplex Courses.
Masduqi, A., & Assomadi, AF (2011). Application of QUAL2Kw model for water quality management of Brantas River. Paper presented at the conference.
Ministry of Environment and Forestry (KLHK). (2020). Strategic Plan for Environmental Pollution Management . Jakarta: Ministry of Environment and Forestry.
Ministry of Environment and Forestry KLHK. (2017). Book of Study on Capacity and Allocation of Pollution Load of Citarum River.
Ministry of State for Environment (KLHK) . (2003). Decree of the Minister of State for Environment No. 110 of 2003 concerning Guidelines for Determining the Capacity of Water Pollution Loads in Water Sources . Jakarta: Ministry of State for Environment
Novitasari, AK (2015). Analysis of identification & inventory of pollution sources in Surabaya River (Thesis, Sepuluh Nopember Institute of Technology).
Pramaningsih, V., Suprayogi, S., & Purnama, I. L. S, (2020), Pollution load capacity analysis of BOD, COD, and TSS in Karang Mumus River, Samarinda . Indonesian Journal of Chemistry , 20(3), 626–637. https://doi.org/10.22146/ ijc.44296.