

## Assessment of Water Quality Status and Pollution Index in Musi River, South Sumatera, Indonesia

Muhammad Rendana<sup>1\*</sup>, Yandriani<sup>1</sup>, Puspa Ayu Pitayati<sup>2</sup>, Muhammad Izzudin<sup>3</sup>, Mona Lestari<sup>4</sup>

<sup>1</sup>Department of Chemical Engineering, Faculty of Engineering, Universitas Sriwijaya, Indralaya, Sumatera Selatan, 30662, Indonesia

<sup>2</sup>Department of Fish Product Technology, Faculty of Agriculture, Universitas Sriwijaya, Indralaya, Sumatera Selatan, 30662, Indonesia

<sup>3</sup>Department of Sociology, Faculty of Social and Political Science, Universitas Sriwijaya, Indralaya, Sumatera Selatan, 30662, Indonesia

<sup>4</sup>Department of Public Health Sciences, Faculty of Public Health, Universitas Sriwijaya, Indralaya, Sumatera Selatan, 30662, Indonesia

\*Corresponding author e-mail: muhrendana@ft.unsri.ac.id

### Abstract

A study area was at the Musi River, located in the southern part of Sumatera Island, Indonesia. This river flows in the southern area with a majorly tropical rainforest climate. For decades, it has become a substantial port used mainly for the transport of rubber, petroleum, and oil palm, which has the potential to threaten the area. Therefore, the objective of this study was to investigate the impacts of these activities by evaluating the water quality status and pollution index in the Musi River. Physicochemical parameters such as pH, salinity, temperature, dissolved oxygen (DO), biological oxygen demand (BOD), chemical oxygen demand (COD), and total suspended solids (TSS) were measured along the river. Results of the study revealed the impact of agriculture and fish farming activities in the upstream area has affected the pH values of the water became slightly acidic. In addition, COD values at all stations were found to be high and made they could not be used for drinking water. TSS values were also found to be high at the downstream stations. According to the pollution index status, the study area was classified from low to moderate pollution.

### Keywords

Human Activities, Pollution Index, Water Quality Status

Received: 4 September 2022, Accepted: 25 November 2022

<https://doi.org/10.26554/ijems.2022.6.4.114-118>

## 1. INTRODUCTION

The primary problem in surface water is the situation of contaminated waters that may diminish the aquatic ecosystem quality (Hasan et al., 2019). Pollutants from the domestic and industrial areas may contribute to the reduction of biological processes and eventually contaminate the water (Vystavna et al., 2018). Water quality generally relies on the ecosystem circumstance and it is assessed according to the physical and chemical properties (Kamboj and Kamboj, 2019). Aquatic pollutants like inorganic and organic matter are transported via rivers from various human activities, including industrial, agricultural, fisheries, and ship or vessel discharge (Kanan et al., 2020).

Musi river basin consists of the organic soil wetland, which is located in the South Sumatera Province, Indonesia. This area is encompassed several ecosystems, such as coastal areas, mangrove forests, wetlands, tidal swamps, and lowlands. These ecosystems are riched in biological diversity and natural resources. The intrusion of seawater into the area is found near the Musi estuarine inlet. The

upstream human activities are found in the area, such as rubber, oil palm, and coconut plantations. These activities have contributed to the deterioration of freshwater input to the basin area, especially for the adjacent rivers, which was also reported in another study (Ewaid et al., 2020; Assar et al., 2019). In addition, the people of surrounding villages in the area mostly use their land for rice cultivation, thus making the area became the main producer of rice in the whole of South Sumatera Province.

Agricultural activities are the fastest-growing economic activities in the South Sumatera region. Meanwhile, aquaculture activities have not vastly developed in the area. To date, the rapid growth of agriculture activities has affected wetland areas because of wastes or effluents of particulate organic material (Mostapa and Weston, 2016; Zedler, 2003; Zhang et al., 2010). Intensive agriculture activities may lead to the water quality degradation of the area as a result of fertilizer and nutrient inputs (Verhoeven et al., 2006).

The objective of this study was to evaluate the variation in surface water quality in the Musi River. The physico-

chemical water parameters analyzed in the study such as pH, temperature, salinity, dissolved oxygen (DO), biological oxygen demand (BOD), chemical oxygen demand (COD), and total suspended solids (TSS). These values were then calculated into a pollution index formula to assess the level of pollution in the area. The outputs of the study can be used to support data regarding the quality and pollution status of the river in the South Sumatra province, specifically providing useful suggestions for river management in the study area.

## 2. EXPERIMENTAL SECTION

### 2.1 Study Area and Sampling Activity

The Musi river lies between latitudes 2 57'0"N and 3 0'0"N and longitudes 104 42'0"E-104 51'0"E (Figure 1). The river is the main freshwater contributor to the Musi Estuary. The river flows from southwestern to northeastern Sumatra and ends in the South China Sea. The length of the river is around 750 km. The water river is applied for prominent needs like transportation, industry, and domestic activities. The annual average temperature in this area is 24 °C, with the average annual precipitation is 2,579 mm.

### 2.2 Physicochemical Analysis

The measurement and analysis of water samples have been performed according to standard methods. In situ field measurements such as pH, salinity, temperature, and dissolved oxygen (DO) were measured by using YSI multi-parameter water quality instrument. The other water quality parameters, such as biological oxygen demand (BOD), chemical oxygen demand (COD), and total suspended solids (TSS), were analyzed at the laboratory according to the standard procedures (APHA, 2016).

### 2.3 Pollution Index Analysis

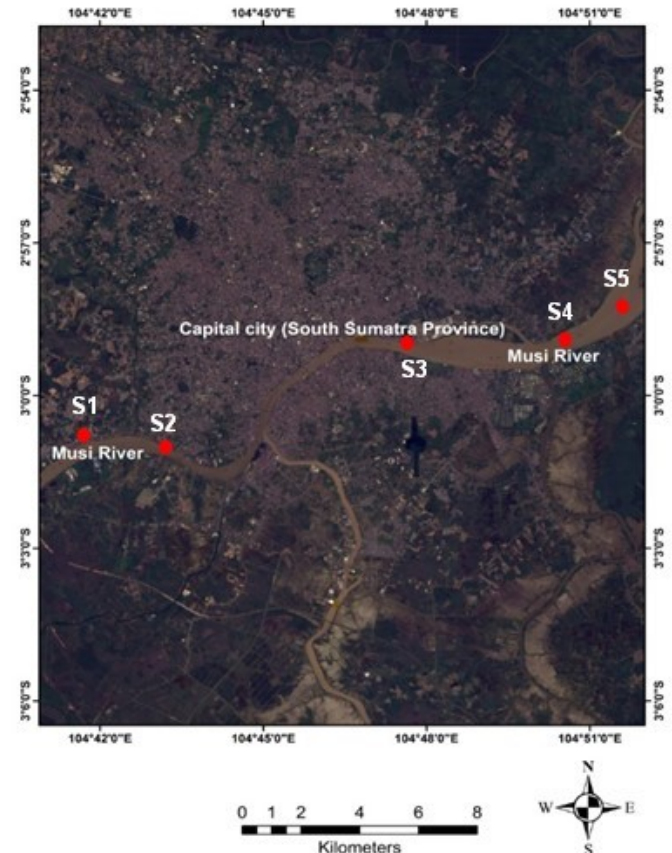
The Pollution Index (PI) was used to determine the level of water pollution against the permitted value of water quality parameters (Martinus et al., 2018). The calculation of PI was made by the following formula from Nemerow and Sumitomo (1970). The result of the calculation was then classified into a scale in Table 1 to determine the water quality status of the study area.

$$PI_j = \left\{ \frac{(\frac{C_i}{L_{ij}})^2 M + (\frac{C_i}{L_{ij}})^2 R}{2} \right\}^{1/2} \quad (1)$$

Where  $C_i$  gave the observed concentration of the  $i$  parameter,  $L_{ij}$  permissible limit of the  $i$  parameter,  $M$  maximum value of  $(C_i/L_{ij})$ , and  $R$  average value of  $(C_i/L_{ij})$ .

### 2.4 Statistical Analysis

Statistical analysis was analyzed by Tukey's Test (HSD) using SAS version 9.4 to determine significant differences in the parameters between sampling stations.



**Figure 1.** Study Area and Sampling Stations of the Studied River (Red dot indicated sampling points along the river flow)

## 3. RESULTS AND DISCUSSION

### 3.1 Water Quality Status and Pollution Index of Musi River

The variation of physicochemical water parameters is shown in Table 2. Salinity was one of the most prominent parameters affecting DO values in water (Ustaoglu and Tepe, 2019). This study has proved that there was a positive correlation between DO and salinity values ( $r=0.662$ ;  $p<0.01$ ). The salinity of the Musi river ranged from 0 to 1.37%. There was no detected salinity on stations 1 and 2. Contrarily, the salinity levels of stations 3, 4, and 5 were high, and they were above the permissible limit of salinity value according to the Indonesian Water Quality Standard (IWQS) and Surface Water Quality Management Regulation (SWQMR) criteria. The highest salinity value at station 5 was located at inshore area about  $\pm 500$  m outside the basin area. Thus, the station might represent a seawater condition. The high salinity values at stations 3 and 4, located a bit farther from the estuary, were possibly caused by brackish water intrusion. Contrarily, stations 1 and 2 were located upstream of the

**Table 1.** The Classification of Pollution Index Value

Pollution Index Values*	Water Quality Status
0<PI<1	Good
1<PI<5	Low Polluted
5<PI<10	Moderate Polluted
PI>10	Severe Polluted

\*Ministry of Environment Indonesia (2003)

Musi River. Thus they showed zero salinity values because they did not mix with seawater.

Water temperature affects the variation and the living condition of the aquatic ecosystem (Kwak et al., 2017). In this study, the water temperature values did not differ significantly ( $p>0.05$ ) among the sampling stations (22-23°C). According to the water quality standard from South Sumatra Governor (2005) and SWQMR (2015), the water temperature value was normal in classes I and II. The water temperature values obtained in the study area were a type of tropical coastal waters (Yuan et al., 2016).

The pH of Musi river ranged from 4.72 to 7.20, with statistical differences between station 5 and the other stations. The pH is a crucial parameter that might affect the toxicity of some compounds by its fluctuations in water (Bhuyan et al., 2017). The pH values of stations 4 and 5 were accepted as class I water quality according to the INWQS and SWQMR. But, stations 1, 2, and 3 were below the permissible limit of pH value. In natural conditions, the pH value in wetland ecosystems was mostly influenced by CO<sub>2</sub> throughout photosynthesis, respiration, and decomposition processes (Moor et al., 2017). However, the slightly acidic pH in this study might be caused by the intensive agricultural activities in the upstream area that deposited too much urea and phosphate fertilizers into the river. The fluctuating pH value could also affect the mangrove growth. The mandatory pH range of freshwater for the mangrove ecosystem was from 5.5 to 8. There was no threat of mangrove species according to the measured pH values in the study.

Dissolved oxygen (DO) was the primary indicator of the ecological health of aquatic ecosystems. DO levels were measured between 4.83 to 7.12 mg/L in Musi River. The lowest DO level was 4.83 mg/L at station 2 when the temperature was the highest at 23°C. Pearson correlation analysis supported the inverse relationship with a high negative correlation between DO and temperature ( $r = -0.548$ ;  $p < 0.05$ ). The level of DO in water should be in a range of 4-6 mg/L for class I water quality criteria based on the SWQMR. In this study, most of DO levels were suitable for class I water quality criteria, but only at station 5, which found a slightly higher than the DO standard value. The high DO level at station 5 might be caused by the deposition of organic materials and fertilizers from the upstream agriculture activ-

ities. When nutrients in fertilizers accumulate in waterways, algae growth increases rapidly, resulting in an ecological imbalance that finally causes in depletion of DO level (Qiu et al., 2019).

The amount of total suspended solids (TSS) was found a higher at the downstream stations than at the upstream stations. The TSS level of upstream stations was 4.50 mg/L, then TSS values were increased towards the downstream stations with 283 mg/L. This situation might be caused by erosion materials from the upper basin of the Musi river and additional organic and chemical materials from agricultural activities that are transported from the surface to the river bed by runoff. The high TSS values at the downstream stations might be caused by animal wastes, manures, and suspended food residues that originated from the upstream stations. For this reason, the TSS levels of stations 3, 4, and 5 were higher and significantly different than the other stations.

Biological oxygen demand (BOD) refers to the amount of oxygen that bacteria consume during the mineralization process (Lee et al., 2016). The BOD value of this study varied from 1.64 (station 3) to 3.17 mg/L (station 2), and measured values from all stations were in the class I water quality according to the SWQMR. The BOD values from the upper to lower basins of the river decreased with significant differences between station 1 and station 5 ( $p < 0.05$ ). Deposition of organic waste materials from agriculture activities into the river could decrease DO levels because of the oxygen consumption by microorganisms. For this reason, the Pearson correlation analysis has shown a higher BOD value associated with a lower DO value ( $r = -0.808$ ;  $p < 0.01$ ). According to IWQS, the BOD value should not exceed 2 mg/L in freshwater in the South Sumatra region. There was a threat of local freshwater fish species if the BOD value surpassed the mentioned-above level.

Chemical oxygen demand (COD) values were normally higher than the BOD values because the COD was also oxidized from biochemically degraded organic substances as well as other substances (Basheer et al., 2017). Musi river, with BOD values ranging from 11.10 to 18 mg/L, surpassed the permissible BOD value according to SWQMR and also IWQS. Stations 1 and 2 had significantly greater COD values than all other stations ( $p < 0.05$ ). This difference is thought to be caused by the deposition of fertilizers, pesticides, and wastes from agricultural activities into the river around those stations. Many studies have reported these activities contributed to negative impacts on water quality (Lagzdins et al., 2018; Matta et al., 2017; Osborn, 2017). The COD values at all stations have exceeded water quality criteria according to WHO (2008) guidelines in Table 2. This situation made the water could not be used for drinking water (COD >10 mg/L). Each physicochemical water parameter measured was calculated to analyze the pollution index (PI) at the Musi river (Table 3). The result of the study revealed stations 1 to 4 were classified as low

**Table 2.** Physicochemical Parameters Values Measured at the Studied River

Parameters	Station 1	Station 2	Station 3	Station 4	Station 5	IWQS Criteria	SWQMR Criteria	WHO Guide-lines
T (°C)	22±0.58 <sup>a</sup>	23±0.58 <sup>a</sup>	23±0.58 <sup>a</sup>	23±0.58 <sup>a</sup>	23±0.58 <sup>a</sup>	28±3	28	<40
pH	5.14±0.03 <sup>bc</sup>	4.72±0.03 <sup>c</sup>	5.52±0.48 <sup>b</sup>	6.11±0.04 <sup>b</sup>	7.20±0.10 <sup>a</sup>	6-9	6-9	6.5-8.0
DO (mg L <sup>-1</sup> )	5.23±0.03 <sup>d</sup>	4.83±0.03 <sup>e</sup>	6.30±0.15 <sup>c</sup>	6.92±0.05 <sup>b</sup>	7.12±0.03 <sup>a</sup>	6	4-6	NA
Salinity (%)	0.00±0.00 <sup>c</sup>	0.00±0.00 <sup>c</sup>	0.13±0.02 <sup>b</sup>	0.12±0.01 <sup>b</sup>	1.37±0.02 <sup>a</sup>	0.01	<0.04	<0.002
TSS (mg L <sup>-1</sup> )	18.00±0.58 <sup>d</sup>	4.50±0.10 <sup>d</sup>	283±13.53 <sup>a</sup>	195±2.52 <sup>c</sup>	262±1.53 <sup>b</sup>	50	80	NA
COD (mg L <sup>-1</sup> )	13.9±0.35 <sup>b</sup>	11.1±0.15 <sup>c</sup>	13.9±0.73 <sup>b</sup>	18.00±0.50 <sup>a</sup>	14.5±0.25 <sup>b</sup>	10	7.07	10
BOD (mg L <sup>-1</sup> )	3.16±0.04 <sup>a</sup>	3.17±0.02 <sup>a</sup>	1.64±0.12 <sup>c</sup>	2.45±0.07 <sup>b</sup>	1.65±0.03 <sup>c</sup>	2	6	2-5

Means followed by different letter from each station are significantly different at  $p \leq 0.05$  for each parameter.

NA: Not available, IWQS: Indonesian water quality standard obtained from the WQS South Sumatera Governor

Regulation No. 16 of 2005, SWQMR: Surface Water Quality Management Regulations, WHO: World Health Organization.

**Table 3.** Pollution Index Values in each Station of the Studied River

Stations	Pollution Index Values	Water Quality Status
1	1.45	Low Polluted
2	1.69	Low Polluted
3	4.75	Low Polluted
4	4.62	Low Polluted
5	8.35	Moderate Polluted

pollution while station 5 was moderately polluted. Station 5 was found to be more polluted than the other stations because of high salinity, TSS, and COD values.

#### 4. CONCLUSIONS

The result of the current study concluded the water quality in the Musi River has been exposed to environmental issues such as intensive agriculture activities. The intensive activities at the upstream area have resulted in a low pH value with high COD and BOD values. In addition, these activities have also contributed to high TSS and COD levels at the downstream stations. As a whole, the study revealed stations 1 to 4 were low polluted, except station 5, categorized as moderately polluted according to the water pollution index calculation. This description states Musi basin has started to be affected by a minor environmental degradation. Thus we suggested periodic monitoring of the water quality status in this area to ensure the anthropogenic activities did not result in deteriorating environmental quality.

#### 5. ACKNOWLEDGMENT

This research was funded by PNBP, Faculty of Engineering, Universitas Sriwijaya, the year 2021 SP DIPA-023.17.2.67751

5/2022 on November 17, 2021, In accordance with Rector's Decree Number: 0390/UN9.FT/TU.SK/2022, on May 13, 2022. This article was a mandatory output for this research funding.

#### REFERENCES

- APHA (2016). *Standard Methods for the Examination of Water and Wastewater*. American Public Health Association
- Assar, W., M. G. Ibrahim, W. Mahmud, and M. Fujii (2019). Assessing the Agricultural Drainage Water with Water Quality Indices in the El-Salam Canal Mega Project, Egypt. *Water*, **11**(5); 1013
- Basheer, A. O., M. M. Hanafiah, and M. J. Abdulhasan (2017). A Study on Water Quality from Langat River, Selangor. *Acta Scientifica Malaysia (ASM)*, **1**(2); 1-4
- Bhuyan, M. S., M. A. Bakar, A. Akhtar, M. B. Hossain, and M. S. Islam (2017). Analysis of Water Quality of the Meghna River using Multivariate Analyses and RPI. *Journal of the Asiatic Society of Bangladesh, Science*, **43**(1); 23-35
- Ewaid, S. H., S. A. Abed, N. Al-Ansari, and R. M. Salih (2020). Development and Evaluation of a Water Quality Index for the Iraqi Rivers. *Hydrology*, **7**(3); 67
- Hasan, M. K., A. Shahriar, and K. U. Jim (2019). Water Pollution in Bangladesh and its Impact on Public Health. *Heliyon*, **5**(8); e02145
- Kamboj, N. and V. Kamboj (2019). Water Quality Assessment using Overall Index of Pollution in Riverbed-mining Area of Ganga-River Haridwar, India. *Water Science*, **33**(1); 65-74
- Kanan, S., M. A. Moyet, R. B. Arthur, and H. H. Patterson (2020). Recent Advances on TiO<sub>2</sub>-based Photocatalysts toward the Degradation of Pesticides and Major Organic Pollutants from Water Bodies. *Catalysis Reviews*, **62**(1); 1-65

- Kwak, J., A. St-Hilaire, and F. Chebana (2017). A Comparative Study for Water Temperature Modelling in a Small Basin, the Fourchue River, Quebec, Canada. *Hydrological Sciences Journal*, **62**(1); 64–75
- Lagzdins, A., R. Sudars, A. Veinbergs, K. Abramenko, L. Grinberga, and I. Siksnane (2018). Evaluating the Status and Trends in Water Quality using Long-term Agricultural Runoff Monitoring Data. *EGU General Assembly Conference Abstract*; 16203
- Lee, J., S. Lee, S. Yu, and D. Rhew (2016). Relationships between Water Quality Parameters in Rivers and Lakes: BOD<sub>5</sub>, COD, NBOPs, and TOC. *Environmental Monitoring and Assessment*, **188**(4); 1–8
- Martinus, Y., W. Astono, and D. Hendrawan (2018). Water Quality Study of Sunter River in Jakarta, Indonesia. *IOP Conference Series: Earth and Environmental Science*, **106**(1); 012022
- Matta, G., S. Srivastava, R. Pandey, and K. Saini (2017). Assessment of Physicochemical Characteristics of Ganga Canal Water Quality in Uttarakhand. *Environment, Development and Sustainability*, **19**(2); 419–431
- Ministry of Environment Indonesia (2003). *Guidelines for Water Quality Standard*. MOEI
- Moor, H., H. Rydin, K. Hylander, M. B. Nilsson, R. Lindborg, and J. Norberg (2017). Towards a Trait-based Ecology of Wetland Vegetation. *Journal of Ecology*, **105**(6); 1623–1635
- Mostapa, R. and K. Weston (2016). Seasonal and Spatial Variability of Selected Surface Water Quality Parameters in Setiu Wetland, Terengganu, Malaysia. *Sains Malaysiana*, **45**(4); 551–558
- Nemerow, N. and H. Sumitomo (1970). *Benefits of Water Quality Enhancement. Report No. 16110 DAJ, prepared for the US Environmental Protection Agency*. Syracuse University, Syracuse, NY
- Osborn, T. (2017). The Conservation Reserve Program: Status, Future, and Policy Options. *The Economics of Agri-Environmental Policy*, **2**; 235
- Qiu, H., M. Ye, Q. Zeng, W. Li, J. Fortner, L. Liu, and L. Yang (2019). Fabrication of Agricultural Waste Supported UiO-66 Nanoparticles with High Utilization in Phosphate Removal from Water. *Chemical Engineering Journal*, **360**; 621–630
- Ustaoglu, F. and Y. Tepe (2019). Water Quality and Sediment Contamination Assessment of Pazarsuyu Stream, Turkey Using Multivariate Statistical Methods and Pollution Indicators. *International Soil and Water Conservation Research*, **7**(1); 47–56
- Verhoeven, J. T., B. Arheimer, C. Yin, and M. M. Hefting (2006). Regional and Global Concerns Over Wetlands and Water Quality. *Trends in Ecology and Evolution*, **21**(2); 96–103
- Vystavna, Y., Z. Frkova, H. Celle-Jeanton, D. Diadin, F. Huneau, M. Steinmann, N. Crini, and C. Loup (2018). Priority Substances and Emerging Pollutants in Urban Rivers in Ukraine: Occurrence, Fluxes and Loading to Transboundary European Union Watersheds. *Science of the Total Environment*, **637**; 1358–1362
- Yuan, X., H. Huang, W. Zhou, T. Yuan, X. Li, Y. Gao, and S. Liu (2016). Long-term Variations in Oxygen in Sub-tropical Coastal Waters: Influence of Sewage Effluent. *Aquatic Ecosystem Health and Management*, **19**(4); 336–344
- Zedler, J. B. (2003). Wetlands at Your Service: Reducing Impacts of Agriculture at the Watershed Scale. *Frontiers in Ecology and the Environment*, **1**(2); 65–72
- Zhang, J., K. Ma, and B. Fu (2010). Wetland Loss Under the Impact of Agricultural Development in the Sanjiang Plain, NE China. *Environmental Monitoring and Assessment*, **166**(1); 139–148