Assessment of Water Quality of Bokor River, Surabaya City as an Effort to Support the Sustainability of Fish Pond Business in the Downstream

Moh Rizal Ngambah Sagara[1], I Wayan Koko Suryawan[2*], Iva Yenis Septiariva[3]
[1]Industrial Engineering Study Program, Bandung College of Technology, Jl. Soekarno Hatta No. 378, Bandung, West Java 40235
[2] Departement of Environmental Engineering, Faculty of Infrastructure Planning, Universitas Pertamina, Jl. Teuku Nyak Arief, RT.7/RW.8, Simprug, Kec. Kby. Lama, South Jakarta City, Special Capital Region of Jakarta 12220
[3]Civil Engineering Study Program, Faculty of Engineering, Universitas Sebelas Maret, Jl. Ir. Sutami No.36, Kentingan, Kec. Jebres, Surakarta City, Central Java 57126
*Corresponding autor: i.suryawan@universitaspertamina.ac.id

Received: 4 June 2022 Accept: 15 July 2022

Abstract

Due to human activities, both domestic and non-domestic, river pollution can occur over time. One of the rivers in Surabaya, which is located in a densely populated area, is Bokor River. Residents use Bokor River for pond activities, so the water's quality must meet these quality standards. This study aims to analyze the suitability of river water quality in Bokor River, Surabaya City, which has met its quality standards for this activity. Water quality measurement is carried out by existing testing with the standard method that is used as a reference in Indonesia. Water quality measurements were determined based on the parameters BOD, COD, DO, TSS, Phosphate (PO4 3-), Nitrate (NO3), and Ammonium (NH4). The measured DO, BOD, phosphate, and ammonia parameters did not meet these quality standards. However, DO parameters in the upstream still meet the quality standard (above 3 mg/L), while after that, they experience a decrease in quality. Meanwhile, nutrient parameters, especially ammonia, do not meet quality standards, as it is known that ammonia can provide toxic properties to fish. In addition, there is an opportunity for eutrophication of this quality. Pollutants entering the Bokor River are point sources and non-point sources, which cannot be located precisely and generally consist of many relatively small individual sources.

Keywords: Water Quality, River, Bokor River, Nutrient

Introduction

The known sources of pollution come from the activities of the surrounding community and are dumped into the Bokor River (Ariella & Moesriati, 2017). The wastewater produced has not been treated to reduce the quality of water bodies. In addition, the habit of people who litter, either by the surrounding community or the people who pass through the water body, further reduces the quality of the Bokor River. The amount of debris in the water can reduce water quality and clog (M. M. Sari et al., 2022). Physical changes have occurred, starting with the watercolor that is not clear. The smell is unpleasant, and the aesthetics are no longer suitable for viewing. The local community began to complain about the physical changes in the Bokor River.

Efforts to prevent quality degradation in managing rivers are significant. River management can be carried out by identifying and predicting water quality by determining critical points on the river (Ali Abed et al., 2019; Tiyasha et al., 2020). This is the basis for conducting river management to improve environmental conditions in rivers. One of the efforts that can be made is to determine the capacity of the river's pollution load. The maximum limit of waste that can be put into the river can be selected so that the river can self-purify (improve the condition of the water naturally) (Lebepe et al., 2022; Tao et al., 2022).

Control by the surrounding community can be carried out after the maximum limit is known. Research on the identification and prediction of the quality of the Bokor River is carried out with the hope that water bodies can be appropriately managed to improve the quality of water bodies, especially for ponds and fish and shrimp farming. Along with the change in the land use of Surabaya from rice fields to settlements, it is necessary to conduct an analytical study related to drainage channels and whether the drainage channels in Bokor River can still accommodate the current water discharge. This research is limited to the Bokor River area of Surabaya, a residential area. This research was conducted to determine the condition of the capacity of the drainage channel in Bokor River to accommodate the current discharge or not. This research is expected to define the next steps so that the channel can be used properly. This study aims to analyze the suitability of water quality in Bokor River Surabaya according to the designation of fish farming/pond.

Material and Method

This study discusses the identification and prediction of the quality of water bodies in Bokor River Surabaya. Bokor River Surabaya passes through 3 sub-districts, namely Mulyorejo, Sukolilo, and Gubeng sub-districts. According to the Surabaya City Regional Regulation Number 2 of 2004, the Bokor River in Surabaya is included in the class III river classification. This Bokor River is used as water for fish and shrimp farming. This research needs to be done so that the water in Bokor River Surabaya gets special attention in maintaining the quality and quantity of water bodies. Water quality identification can be seen from the parameters BOD, COD, DO, TSS, Phosphate (PO4 3-), Nitrate (NO3), and Ammonia (NH3).

In this study, the Bokor River that will be studied starts upstream of the Bokor River, a river fragment from the Mas River before the flood pump, which is approximately 6.5 km long from the total length of the Bokor River, which is 8.9 km. The division of this segment or segment is based on input from tributaries and the availability of places for sampling and sources of pollution. Segments in this study amounted to 3 segments. Each segment is taken 1-2 samples representing the upstream and downstream of each segment depending on the water discharge of the Bokor River. Sampling is used to represent the condition of water bodies in that segment to identify water quality in the Bokor River.

The selection of the sampling location was based on the ease of taking water as a sample. The sampling location is in a place where there is a river bridge for the comfort of taking water as a sample. This applies at every point. The sampling points in this study were four sampling points, where each point was measured for river hydraulic data before sampling river water. The hydraulic data taken are speed, river depth, river discharge, and river cross-sectional width.

Result and Discussion

This study analyzes the Bokor River River with a length of 6.50 km from upstream to the flood pump located in the Keputih Kejawan area. In this case, the river is divided into three segments starting from the upstream (kilometer 6.50), which is a fraction of the Kalimas river in Surabaya, to the downstream (kilometer 0.00), which is in Keputih Kejawan. This river segmentation is carried out for modeling purposes. The division of this segment is based on the classification of water quality characteristics or the presence of input from other channels/rivers. These two things are the basis for determining the segment so that three segments are obtained which can be seen in Table 1.

Table 1. Characteristics of Segment Area in Bokor River Surabaya

Segments	Distance from downstream (km)	Elevation Right		Elevation Left	
		Upstream	Downstream	Hulu	Upstream
A-B	6,5 – 4,5	50	13	9	4
B-C	4,5 – 1,6	13	4	3	3
C-D	1,6 – 0	4	3	3	2

Segments A – B is the first segment in forming the model for Bokor River Surabaya. Segment A – B is the sampling point located upstream of the river, while B is the second sampling point. The distance on this segment A – B is 2 km. This first segment is divided based on the characteristics of river water pollutants. Segments B – C are the second segment in forming the model for Bokor River Surabaya. B is the sampling point located at the intersection of Jalan Pucang and Jalan Klampis, while C is the third sampling point. The distance in segment B – C is 2.9 km. This second segment is the longest segment among the other two segments. This second segment is divided based on the characteristics of river water pollutants and the presence of tributaries that enter the Bokor River.

River water has its own quality and characteristics. This is influenced by the quantity and quality of pollutants that enter the river water. The water quality of the Bokor River River is obtained from primary data and secondary data. Primary data collection is done by analyzing samples taken from several points on a certain day. A sampling at each point is carried out using the function of distance and average speed. Sampling was seen based on river discharge. According to the Indonesian National Standard (SNI) 6989.57:2008, if the river discharge is less than 5 m^3/s, the sample taken is 1 location, namely in the middle of the river and half the depth.

At each point, the river water is put into a 600 ml bottle and a Winkler bottle for testing at the laboratory. When analyzed, samples in Winkler bottles were preserved to not change in quality, namely five drops of manganese sulfate and oxygen reagent. Next, the sample water bottle is put into the cooling box to preserve the sample. This is done to maintain water quality because of the long distance.

In this study, the sampling point is divided into 4 points: in the upstream segment (point 1), then point 2 is in the A-B segment, point 3 is in the B-C segment, and point 4 is in the C-D segment. Sampling was carried out once to obtain hydraulic data and river quality. The data obtained from the sampling results show that several parameters are not following the quality standards used. This can be seen in the graphic image of each parameter.

In the dissolved oxygen (DO) (Figure 1), only one point meets the quality standard, namely point 1. This is due to a small plunge from the sluice gate located a few meters before the first sampling point. With this drop, aeration will occur to increase the DO value. In addition, the upstream of the Bokor River is a fragment of the Mas River, which is of good quality. Based on primary data in research on Kali Mas data, DO data for the Mas River at the point before the upstream of Bokor River is 4 mg/L. Therefore, the DO value in Mas River, upstream of Bokor River Surabaya, greatly affects the DO condition upstream of Bokor River Surabaya.

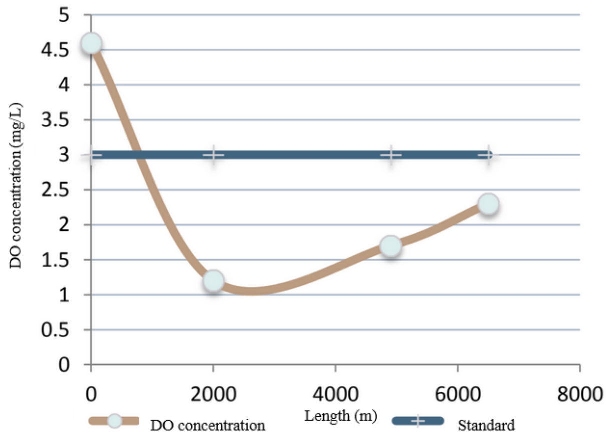

Figure 1. DO Concentration at Study Locations from Each Segment (A-D)

The results of the BOD measurement show a value that exceeds the predetermined quality standard (Figure 2). Where BOD is increasing downstream, the BOD and COD values in the dry season will be higher than in the rainy season. Therefore, if there is rainwater, the BOD and COD values will decrease. This is because rainwater entering the river will dilute organic pollutants (Hou et al., 2019; Kozak et al., 2019; Susilowati et al., 2018).

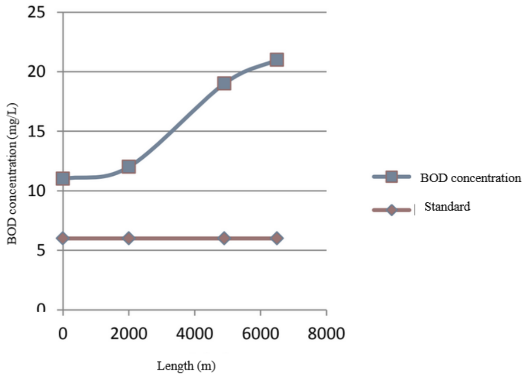

Figure 2. BOD Concentration at Study Locations from Each Segment (A-D)

In contrast to BOD, COD in this study shows a concentration that still meets the quality standard (Figure 3). If seen and compared, the BOD/COD value of the data is about 0.5. This value indicates that most isolated organics are easily degraded (Helmy et al., 2022; Prajati et al., 2021; Suryawan et al., 2021). Therefore, the possibility of self-purification is also quite large. This is because microorganisms in nature will use organic as a carbon source for generations (Afifah et al., 2020; Jiao et al., 2010).

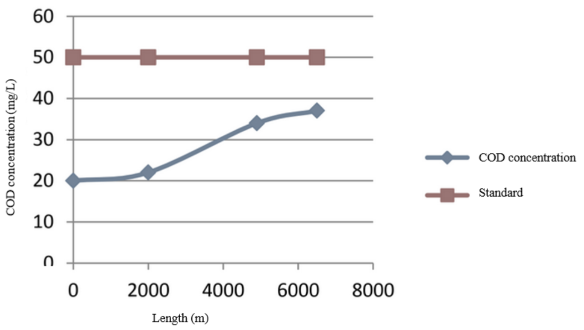

Figure 3. COD Concentration at Study Locations from Each Segment (A-D)

In Figure 4 are the parameters that meet the standard stream quality standards. This indicates that the nitrate and TSS content is not too large in the Bokor River because it is far from the water quality standard limits, namely 0.17-1.73 mg/L (nitrate) and 28-36 mg/L (mg/L).

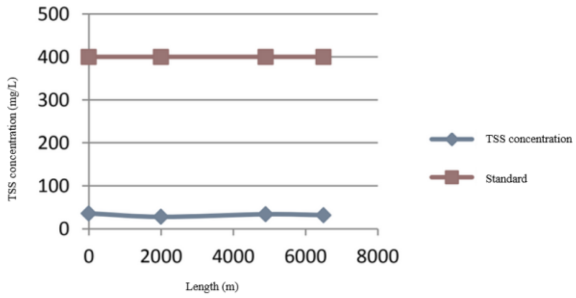

Figure 4. TSS Concentration at Study Locations from Each Segment (A-D)

Nitrate in waters is a macronutrient that controls primary productivity in euphotic areas (Krause et al., 2011). Nitrate levels in waters are strongly influenced by nitrate intake from river bodies (DeLaune et al., 2005). The primary sources of nitrate are household and agricultural wastes, including animal and human waste. It can be seen that the nitrate concentration in Figure 5 meets the quality standard, so it can be concluded that the macronutrients do not pollute the Bokor River.

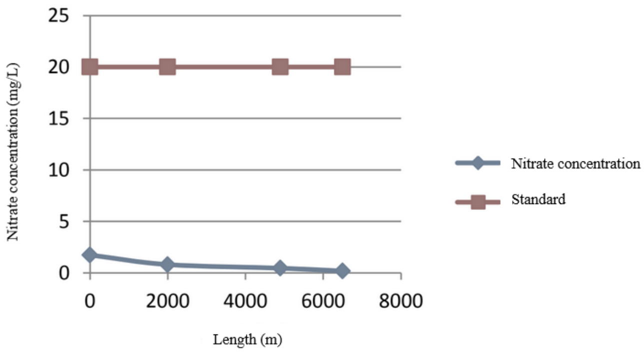

Figure 5. Nitrate Concentration at Study Locations from Each Segment (A-D)

The highest phosphate concentration is downstream of the Bokor River, Surabaya (Figure 6). The high value of phosphate in the waters is thought to be due to plantations around the study site that use fertilizers to increase soil fertility (F. I. P. Sari et al., 2019). The primary source of phosphate mainly comes from land, namely through weathering rocks (allotons) that enter the sea, primarily through river transportation. Basically, phosphate is already contained in abundant amounts in the soil (Yao et al., 2018). In the phosphate parameter, there was a significant increase from point 2 to point 3, and quite a lot of domestic waste caused this from washing using detergents and washing laundry washing business. Based on direct observation, several water hyacinths were found between point 2 to point 4. The presence of water hyacinth was caused by high levels of phosphate (Auchterlonie et al., 2021).

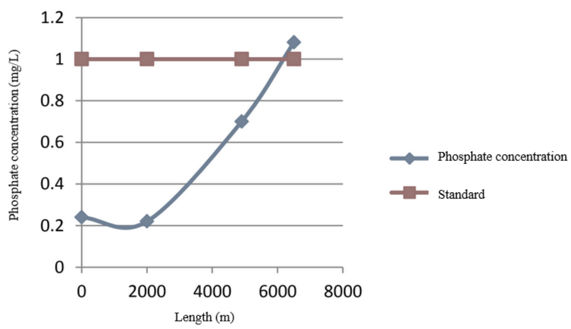

Figure 6. Phosphate Concentration at Study Locations from Each Segment (A-D)

Figure 7 shows that the ammonium has passed the quality standard and downstream for the phosphate parameter. In the ammonium parameter, the increase in latrines around the river causes points 3 to 4 to increase.

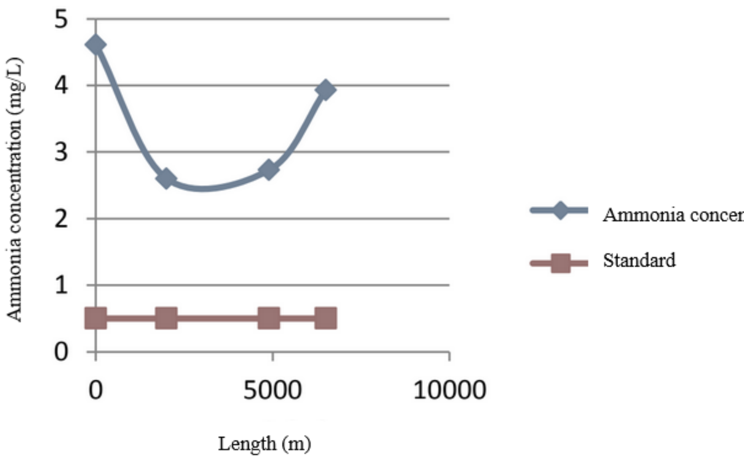

Figure 7. Ammonia Concentration at Study Locations from Each Segment (A-D)

Pollutants that enter Bokor River Surabaya are point sources and non-point sources (Figure 8). Point sources can be precisely located, while non-point sources/diffuse sources cannot be located precisely and generally consist of many individual sources that are relatively small (Andarani et al., 2021; Pegram & Bath, 1995).

Figure 8. Identification of Point and Non-Point Source Pollution from Each Segment (A-D) (Google Map, 2021)

Conclusion

Nutrient parameters, especially ammonia not in Bokor River, still do not meet the quality standards, as it is known that ammonia can provide toxic properties to fish. In addition, there is an opportunity for eutrophication of this quality. Pollutants entering the Bokor River are point sources and non-point sources, which cannot be located precisely and generally consist of many relatively small individual sources.

References

Afifah, A. S., Suryawan, I. W. K., & Sarwono, A. (2020). Microalgae production using photo-bioreactor with intermittent aeration for municipal wastewater substrate and nutrient removal. *Communications in Science and Technology*, *5*(2), 107–111. https://doi.org/10.21924/cst.5.2.2020.200

Ali Abed, S., Hussein Ewaid, S., & Al-Ansari, N. (2019). Evaluation of Water quality in the Tigris River within Baghdad, Iraq using Multivariate Statistical Techniques. *Journal of Physics: Conference Series*, *1294*(7), 72025. https://doi.org/10.1088/1742-6596/1294/7/072025

Andarani, P., Alimuddin, H., Yokota, K., Inoue, T., Obaid, S., & Nguyen, M. N. (2021). Baseflow and Stormflow Zinc Loads in a Small Agricultural River Catchment Influenced by an Industrial Area. In *Water* (Vol. 13, Issue 15). https://doi.org/10.3390/w13152113

Ariella, K., & Moesriati, A. (2017). The implementation of biological monitoring working party average score per taxon (BMWP-ASPT) in a water quality analysis at Kalibokor drainage in Surabaya region. *AIP Conference Proceedings*, *1908*(1), 30007. https://doi.org/10.1063/1.5012707

Auchterlonie, J., Eden, C.-L., & Sheridan, C. (2021). The phytoremediation potential of water hyacinth: A case study from Hartbeespoort Dam, South Africa. *South African Journal of Chemical Engineering*, *37*, 31–36. https://doi.org/https://doi.org/10.1016/j.sajce.2021.03.002

DeLaune, R. D., Jugsujinda, A., West, J. L., Johnson, C. B., & Kongchum, M. (2005). A screening of the capacity of Louisiana freshwater wetlands to process nitrate in diverted Mississippi River water. *Ecological Engineering*, *25*(4), 315–321. https://doi.org/https://doi.org/10.1016/j.ecoleng.2005.06.001

Google Map. (2021). *Google Map*. https://www.google.com/maps/place/

Helmy, Q., Suryawan, I. W. K., & Notodarmojo, S. (2022). *Ozone-Based Processes in Dye Removal BT - Advanced Oxidation Processes in Dye-Containing Wastewater: Volume 1* (S. S. Muthu & A. Khadir (eds.); pp. 91–128). Springer Nature Singapore. https://doi.org/10.1007/978-981-19-0987-0_6

Hou, F., Tian, Z., Peter, K. T., Wu, C., Gipe, A. D., Zhao, H., Alegria, E. A., Liu, F., & Kolodziej, E. P. (2019). Quantification of organic contaminants in urban stormwater by isotope dilution and liquid chromatography-tandem mass spectrometry. *Analytical and Bioanalytical Chemistry*, *411*(29), 7791–7806. https://doi.org/10.1007/s00216-019-02177-3

Jiao, N., Herndl, G. J., Hansell, D. A., Benner, R., Kattner, G., Wilhelm, S. W., Kirchman, D. L., Weinbauer, M. G., Luo, T., Chen, F., & Azam, F. (2010). Microbial production of recalcitrant dissolved organic matter: long-term carbon storage in the global ocean. *Nature Reviews Microbiology*, *8*(8), 593–599. https://doi.org/10.1038/nrmicro2386

Kozak, C., Fernandes, C. V. S., Braga, S. M., do Prado, L. L., Froehner, S., & Hilgert, S. (2019). Water quality dynamic during rainfall episodes: integrated approach to assess diffuse pollution using automatic sampling. *Environmental Monitoring and Assessment*, *191*(6), 402. https://doi.org/10.1007/s10661-019-7537-6

Krause, J. W., Nelson, D. M., & Brzezinski, M. A. (2011). Biogenic silica production and the diatom contribution to primary production and nitrate uptake in the eastern equatorial Pacific Ocean. *Deep Sea Research Part II: Topical Studies in Oceanography*, *58*(3), 434–448. https://doi.org/https://doi.org/10.1016/j.dsr2.2010.08.010

Lebepe, J., Khumalo, N., Mnguni, A., Pillay, S., & Mdluli, S. (2022). Macroinvertebrate Assemblages along the Longitudinal Gradient of an Urban Palmiet River in Durban, South Africa. In *Biology* (Vol. 11, Issue 5). https://doi.org/10.3390/biology11050705

Pegram, G. C., & Bath, A. J. (1995). Role of non-point sources in the development of a water quality management plan for the Mgeni River catchment. *Water Science and Technology*, *32*(5), 175–182. https://doi.org/https://doi.org/10.1016/0273-1223(95)00661-3

Prajati, G., Afifah, A. S., & Apritama, M. R. (2021). Nh3-n and cod reduction in endek (Balinese textile) wastewater by activated sludge under different do condition with ozone pretreatment. *Walailak Journal of Science and Technology*, *18*(6), 1–11. https://doi.org/10.48048/wjst.2021.9127

Sari, F. I. P., Mahardika, R. G., & Roanisca, O. (2019). Water Quality Testing Due to Oil Palm Plantation Activities in Bangka Regency. *IOP Conference Series: Earth and Environmental Science*, *353*(1), 12019. https://doi.org/10.1088/1755-1315/353/1/012019

Sari, M. M., Inoue, T., Harryes, R. K., Suryawan, I. W. K., & Yokota, K. (2022). Potential of Recycle Marine Debris in Pluit Emplacement , Jakarta to Achieve Sustainable Reduction of Marine Waste Generation. *International Journal of Sustainable Development and Planning*, *17*(1), 119–125.

Suryawan, I., Septiariva, I. Y., Helmy, Q., Notodarmojo, S., Wulandari, M., Sari, N. K., Sarwono, A., & Jun-Wei, L. (2021). Comparison of Ozone Pre-Treatment and Post-Treatment Hybrid with Moving Bed Biofilm Reactor in Removal of Remazol Black 5. *International Journal of Technology*, *12*(2).

Susilowati, S., Sutrisno, J., Masykuri, M., & Maridi, M. (2018). Dynamics and factors that affects DO-BOD concentrations of Madiun River. *AIP Conference Proceedings*, *2049*(1), 20052. https://doi.org/10.1063/1.5082457

Tao, J., Sun, X.-H., Cao, Y., & Ling, M.-H. (2022). Evaluation of water quality and its driving forces in the Shaying River Basin with the grey relational analysis based on combination weighting. *Environmental Science and Pollution Research*, *29*(12), 18103–18115. https://doi.org/10.1007/s11356-021-16939-z

Tiyasha, Tung, T. M., & Yaseen, Z. M. (2020). A survey on river water quality modelling using artificial intelligence models: 2000–2020. *Journal of Hydrology*, *585*, 124670. https://doi.org/https://doi.org/10.1016/j.jhydrol.2020.124670

Yao, Q., Li, Z., Song, Y., Wright, S. J., Guo, X., Tringe, S. G., Tfaily, M. M., Paša-Tolić, L., Hazen, T. C., Turner, B. L., Mayes, M. A., & Pan, C. (2018). Community proteogenomics reveals the systemic impact of phosphorus availability on microbial functions in tropical soil. *Nature Ecology & Evolution*, *2*(3), 499–509. https://doi.org/10.1038/s41559-017-0463-5