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Assessment of Water Quality Index and Pollution Load Capacity in the Sukowidi River and Bendo River, Banyuwangi Region

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Abstract

The river is a part of the surface water resource, which is very potential for living. River water quality is greatly influenced by land use and human activities in the catchment area. Increasing the population in Banyuwangi Region and its activity can reduce the river's water quality, especially in the Sukowidi and Bendo catchment areas; therefore, it is necessary to assess the water quality. This research was conducted to identify the source of pollutants, determine the pollution index status of water pollution, and determine pollution load capacity. The data analysis was done quantitatively, graphically, and spatially with the QUAL2Kw and the Inverse Distance Weighted (IDW) using ArcGIS 10.4.1. Land use on the two rivers is slightly different, that is, rural, suburban, and urban. The pollution sources in the study area were point source and non-point source. The results showed that the pollution status of the Sukowidi River was "Light Polluted" and the high pollutant load carrying capacity had total suspended solids and nitrates. Meanwhile, in the Bendo River, the pollution status is not polluted yet and the pollutant load carrying capacity is on the quality standards. These findings provide valuable information and guidance for the Banyuwangi Regency government to decide on land use policy.

Keywords: water quality index, load carrying capacity, QUAL2Kw model

INTRODUCTION

The problem of decreasing water quality has been occurring for a long time, but this problem cannot be resolved due to limited access to environmental data. This results in a lack of information to the wider community regarding the condition of the surrounding environment and the less optimal use of this data to formulate strategies in river water management. Water is an important commodity, both to sustain life and for the global economy. However, the quality of water in the world has rapidly declined for decades due to the impact of both natural and anthropogenic factors [1].

After Indonesian Government Regulation (PP) number 82 year 2001 about Water Quality Management and Water Pollution Control on Article 20, the central and local government has authority in the context of to control water pollution and to determine the pollution load carrying capacity. The carrying capacity of pollution load is the ability of a water body (stream, lake, reservoir) to receive the pollutant without causing the decreasing of living quality for living thing. The inventory of water pollutant sources is important to maintain living quality on the river. The inventory covers tracing, collecting and enumerating all activities that produce wastewater entering to the river [2]. Increase human activity as agriculture, industrial and tourism will be impact to water quality of river [3].

In Banyuwangi Regency, East Java Province, economic growth has been quite high in the last decade. One of the impacts that appears is an increase in the potential for surface water pollution. This research is important to evaluate the water quality condition of river, especially the water pollution index and the capacity of pollution loads, so that it can provide recommendations and considerations for stakeholders in development policies, land use planning and enhancement of economic activities.

STUDY LOCATION AND METHOD

The study has been held on Sukowidi River and Bendo River, Banyuwangi Region, East Java Province. These two rivers have a variety of land uses; rural area, dominated with agricultural land use, sub-urban and urban areas (Figure 1).

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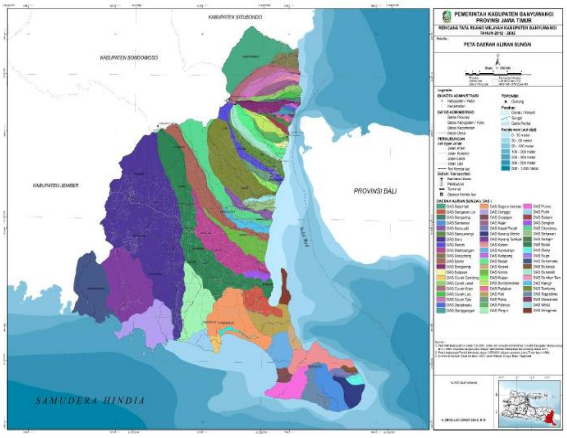


Figure 1. Banyuwangi Region Map, and its watershed.

Data for assessment of river water quality was obtained from different institution of local government, also water samples collecting and laboratory analysis. In each river, 3 samples were taken for laboratory tests from upstream, middle and downstream. Water sampling and laboratory testing methods follows Regulation of Indonesian Environment Minister number 01 Year 2010 about Water Pollution Control Procedure. Parameters of water quality testing including temperature, conductivity, pH, total suspended solid (TSS), Dissolved Oxygen, BOD_5, COD, Total Organon Content (TOC), Organic Nitrogen, NH4-Nitrogen, NO3-Nitrogen, Organic Phosphorus, Inorganic Phosphorus (SRP), Total Coliform, Alkalinity [5].

The analysis of the pollution load capacity two methods, namely the analytical method and the QUAL2Kw model. The QUAL2Kw model is a development of the QUAL2E model using the Visual Basic for Application (VBA) programming language that can be run with the Microsoft Excel program. In this study, the QUAL2Kw version 5.1 model was used [4].

The River Pollution Load (RPL) can be calculated using the formula [5]:

$$RPL = (Cs)j \times Qs \times f \quad (1)$$

Where *RPL* is river pollution load (kg/day), *(Cs) j* is actual measured levels of contaminants-j (mg/L), *Qs* is River water discharge (m^3/day), and *f* is conversion factor 86.4.

The Pollution Index is calculated by the following equation [5]:

$$PI_j = \sqrt{\frac{\left(C_i/L_{ij}\right)^2_M + \left(C_i/L_{ij}\right)^2_R}{2}} \quad (2)$$

where *PI* is pollution index, and C_i/L_i is value of measurement and calculation.

RESULT AND DISCUSSION

(1) Pollution Index

Based on the calculation of the pollution index in the Sukowidi River, the upstream or river is not polluted yet, but the downstream shows the results of the pollution index above 1, which means that the condition is "lightly polluted" status. Meanwhile, the pollution index in the Bendo River in the upstream, middle, and downstream parts is good condition, but the index of pollution is close to 1, so it needs more attention to prevent pollution in the future. The results of the calculation of the pollution index can be seen in **Table 1** and **Table 2.**

(2) Pollution Index by using QUAL2Kw

The calculation using QUAL2Kw model show that in the Sukowidi River, several parameters have reached their maximum of pollution index, especially the parameters of Nitrate and Phosphate. Judging from the distance from upstream to downstream, some parameters are in the maximum position when they are near the downstream area. Meanwhile, the simulation results on the Bendo River show that all water quality parameters are still below the maximum value of pollution index. The result of calculation using QUAL2Kw model in the two rivers can be seen in **Figure 2 and Figure 3.**

(3) Pollution Load Capacity

The results of the calculation of the pollution loads capacity of the Sukowidi River show, that will be close to maximum capacity limit, especially parameters of total suspended solid (TSS), nitrate, BOD_5, and Phosphate. This may be due to high sedimentation and high fertilizer use in agricultural cultivation.

Table 1. The pollution index in Sukowidi River

Parameter	(C_i/L_i) *		
	Upstream	Middle	Downstream
TSS	0.0042	0.00575	0.0042
pH	0.0533	0.1533	0.1867
BOD_5	0.0998	0.1983	0.14
COD	0.0602	0.0902	1.9291
DO	0.1323	0.0308	0.08
Nitrate (NO_3)	0.025	0.077	0.084
Phosphate (PO_4)	0.13	0.17	0.21
Ammonia (NH_3)	1	1	1.8804
Pollution Index	**0.7941**	**0.8379**	**1.1312**

Table 2. The pollution index in Bendo River

Parameter	(Ci/Li)*		
	Upstream	Middle	Downstream
TSS	0.0042	0.0085	0.0170
pH	0.1667	0.1267	0.1867
BOD_5	0.0998	0.17	0.5417
COD	0.0361	0.1504	0.1504
DO	0.1324	0.0308	0.3033
Nitrate (NO_3)	0.045	0.04	0.0385
Phosphate (PO	0.11	0.07	0.1
Ammonia (NH_3	1	1	1
Pollution Index	**0.7961**	**0.8053**	**0.9097**

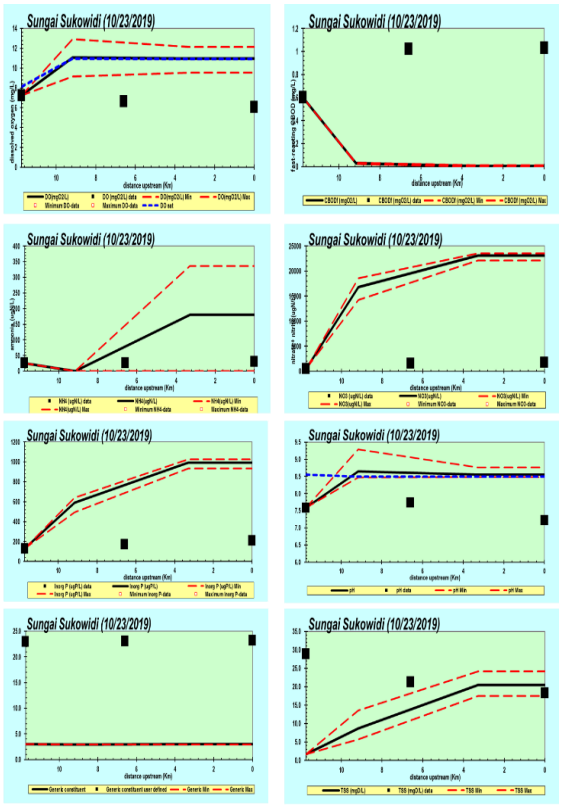


Figure 2. The calculation Pollution Index by using QUAL2Kw in Sukowidi river

Meanwhile, the calculation of the carrying capacity of pollution loads in the Bendo River, the parameter of total suspended solid is extremely high in the upstream and middle parts but decreasing in the upstream part, and other parameters are still in good condition. The results of the calculation of the carrying capacity of the pollution load can be seen in **Table 3** and **Table 4**.

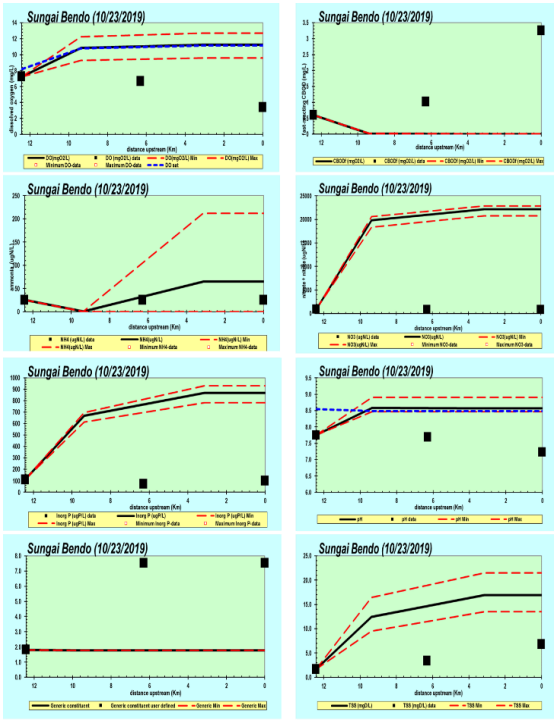


Figure 3. The calculation Pollution Index using QUAL2Kw in Bendo river

Table 3. Pollution Load Capacity in Sukowidi River

Parameter	Pollution Load Carrying Capacity		
	Upstream	Middle	Downstream
TSS	646.8956	1883.8421	573.5808
BOD_5	8.77154	22.78421	7.4304
COD	76.3145	215.4789	-38.448
DO	-6.8535	-17.1947	-4.3776
Nitrate (NO_3)	31.66917	87.44211	26.3808
Phosphate (PO_4)	1.412932	3.931579	1.1376
Ammonia (NH_3)	-0.00877	-0.02558	-0.0144

Table 4. Pollution Load Capacity in Bendo River

Parameter	Pollution Load Carrying Capacity		
	Upstream	Middle	Downstream
TSS	331.7093	726.7495	6.5432
BOD_5	4.4977	9.1255	0.0457
COD	40.1362	77.8425	0.7069
DO	-3.5142	-6.6518	-0.0060
Nitrate (NO_3)	15.9059	35.1830	0.3200
Phosphate (PO_4)	0.7411	1.7041	0.0149
Ammonia (NH_3)	-0.0045	-0.0099	-8.9861

The water quality of the Sukowidi River and Bendo River are influenced by many factors including the variation of land use in terms of biogenic and organic substances. Biogenic compounds within the river are the result of the decomposition process of the organic substances therefore the regime of the biogenic elements

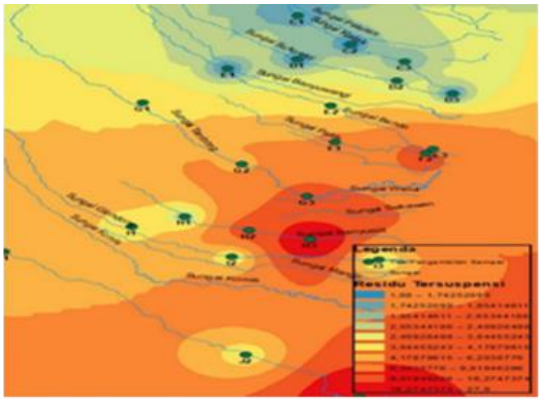
depends directly on the vital activity of the organisms from the rivers [9]. The values of the pollution load carrying capacity, which are influenced by the nutrients, by the high values of the agricultural practices, municipal and industrial wastewaters, manure from farms, and other sources. This result similar with research conducted by Dunca [10].

(4) Water Quality Patterns

The results of the analysis of the distribution of pollutants using the IDW (Inverse Distance Weighted) interpolation method show that each input point of pollutants entering the river has a local effect and it reduces related to the distance. **Figure 4** describes the distribution and the spreading pollutant in the river. The figure shows four parameter that is total suspended solid (TSS), biological oxygen demand on fifth days (BOD_5), chemical oxygen demand (COD), and Phosphate. Those parameter as the result of the calculation of pollution index and pollution load capacity.

CONCLUSIONS and SUGGESTION

The pollution index in the Sukowidi River is in the lightly polluted status while the Bendo River is still in good condition and has not been polluted. The pollution load capacity of the Sukowidi River has exceeded especially in the parameters of total suspended solids, phosphate, and nitrates, while the capacity of the Bendo River is on the quality standards. Based on the result, Banyuwangi Regency should manage land use management in the Sukowidi River to maintain the quality of the river. Furthermore, to prevent the pollution of Bendo River government should make regulations regarding land use management in the watershed of Bendo River.



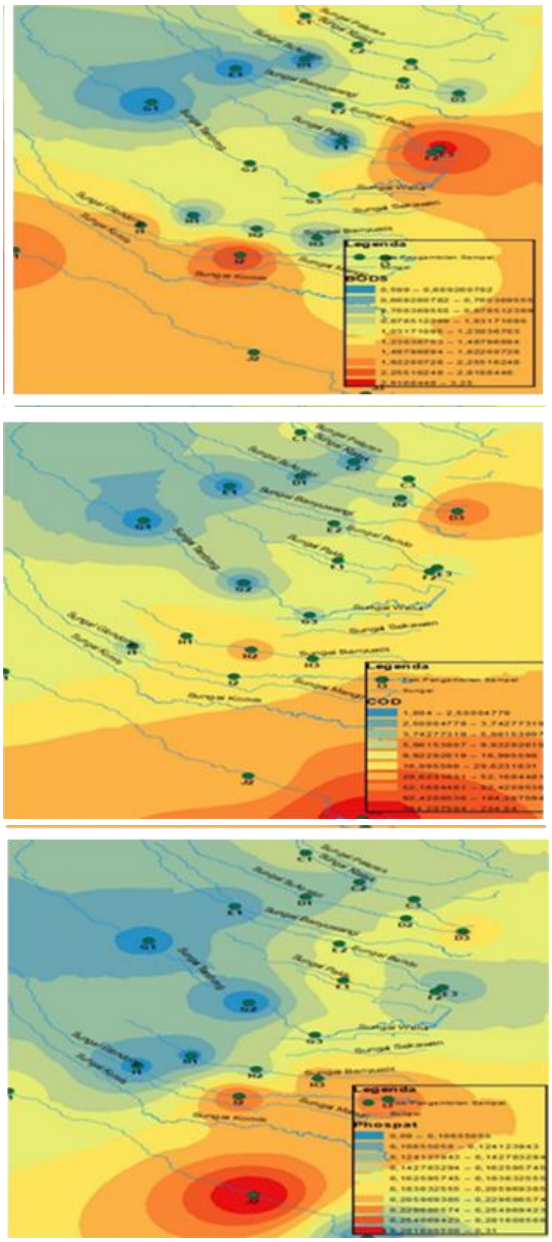


Figure 4. Water quality pattern using IDM method**.**

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REFERENCES

[1]. Vadde, K. K., Jianjun, W., Long, C., Tianma, Y., Alan, J. & Raju, S.2018 Assessment of water quality and identification of pollution

rick locations in Tiaoxi river (Taihu watershed), China. Water 10, 183.

[2]. Peraturan Pemerintah Republik Indonesia Nomor 82 Tahun 2001 tentang Pengelolaan Kualitas Air dan Pengendalian Pencemaran Perairan. Sekretaris Negara Republik Indonesia, Jakarta.

[3]. Samudro, S., Agustiningsih, D., & Sasongko, S. B. (2012). Analisis kualitas air dan strategi pengendalian pencemaran air Sungai Blukar Kabupaten Kendal. Jurnal Presipitasi: Media Komunikasi dan Pengembangan Teknik Lingkungan, 9(2), 64–71. doi:10.14710/presipitasi.v9i2.64-71.

[4]. Rusnugroho, A. Masduki, A., (2012) Aplikasi QUAL2Kw sebagai Alat Bantu Perhitungan Daya Tampung Beban Pencemaran Kali Madiun (Segmen Kota Madiun). Scientific Conference of Environmental Technology IX – 2012. Sepuluh Nopember Institute of Technology.

[5]. Peraturan Menteri Lingkungan Hidup nomor 01 tahun 2010 tentang Tata Laksana Pengendalian Pencemaran Air, Biro Hukum Kementerian Lingkungan Hidup, Jakarta.

[6]. Medeiros, A. C., Faial, K. R. F., do Carmo Freitas Faial, K., da Silva Lopes, I. D., de Oliveira Lima, M., Guimarães, R. M. & Mendonça, N. M. 2017 Quality index of the surface water of Amazonian rivers in industrial areas in Pará, Brazil. Mar. Pollut. Bull. 123 (1–2), 156–164.

[7]. Tripsthi, M. & Singhal, S. K. 2019 Use of principal component analysis for parameter selection for development of a novel water quality index: a case study of river Ganga India. Ecol. Indic. 96, 430–443.

[8]. Kükrer, S. & Mutlu, E. 2019 Assessment of surface water quality using water quality index and multivariate statistical analyses in Saraydüzü Dam Lake, Turkey. Environ. Monit. Assess. 191 (2), 71.

[9]. Oprean L., Lengyel E., and Lancu R., 2013 Monitoring and evaluation of Timis River (Banat, Romania) water quality based on physicochemical and microbiological analysis, Transylvanian Review of Systematical and Ecological Research, vol. 15, no. 3, pp.33–42.

[10]. Dunca, A.M, 2018 Water Pollution and Water Quality Assessment of Major Transboundary Rivers from Banat (Romania), Journal of Chemistry, Hindawi Volume 2018, Article ID 9073763, 8 pages https://doi.org/10.1155/2018/9073763.