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Land Use Impact to Water Quality in Bedadung River, Indonesia

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Land Use Impact to Water Quality in Bedadung River, Indonesia

Hendra Andiananta Pradana[1*], Elida Novita[2], Idah Andriyani[2], Bambang Herry Purnomo[2]

[1]Agricultural of Water Resource Management, Postgraduate, University of Jember, Jember Indonesia,
[2]Faculty of Agricultural Technology, University of Jember, Jember, Indonesia
*e-mail: hendraandianantapradana@gmail.com

Abstract. Bedadung River is one of the water sources in Jember Regency. However, the condition was in the category of polluted in heavy level at an urban area (i.e Sumbersari and Kaliwates Districts). Water quality monitoring was one method to pollution controlling efforts by the government and stakeholders. Water quality monitoring could be done with a. Water Pollution Index (WPI) described contaminating based on physical, chemical and biological parameters in the water. The focus of this research investigated land use impact for water quality of Bedadung River with Water Pollution Index (WPI) method. Water Pollution Index (WPI) used to input data consisting of physical, chemical and biological parameters. The parameters were physical, chemical, and biological. Sampling was carried out on 5 locations of the Bedadung River urban area segment (i.e Patrang, Sumbersari, and Kaliwates Districts) in 2016. Land use data was in 2010. The condition of the Bedadung River water quality in the urban segment in the lightly-moderately polluted category is based on the WPI with a value of 5.35-8.01 in the Bedadung River urban area segment (Patrang, Sumbersari, and Kaliwates District). Then it was supported mitigation and adaptation making for sustainability of water quality management by stakeholder and government in the urban area.
Keyword**:** jember regency, urban area, water pollution index, impact

1. Introduction

Pollution of water resources reduced water quality and access to clean water [1]. The consequence, this phenomenon was contamination of pollutants in the source of surface water. It impacted the poorness of water quality and aquatic ecosystem condition. Pollution occurs in several rivers in Indonesia. Some of the major rivers in Indonesia was polluted, such as the Citarum River, Brantas River and Ciliwung River [2][3][4]. It becomes one of national focus issue at Indonesia Country. The monitoring of river water quality based on assessing the condition of surface water sources. This step was used in consideration for water quality management in the sustainability of water resources and aquatic ecosystems [5][6]. The management of the quality and quantity of water resources on a watershed scale [7][8][31].

Bedadung Watershed covers urban areas in Jember Regency. Bedadung River is part of the watershed that crosses the urban segment of Jember Regency. The river has a vital function and role for the community and the government of Jember Regency [9] [10]. This river was used by the community for domestic activities such as bathing, washing, and latrines. Meanwhile, the Government of Jember Regency uses the Bedadung River water resources for irrigation and raw water sources [11][10][31]. One of the PDAM's raw water is taken from the Bedadung River. In 2015, PDAM water

customers amounted to 1650 and each year it was predicted to rise [12]. So, The Bedadung River had an important role as a water source in Jember Regency.

The land use affected the quality of surface water [13][14][15]. The settlements contributed to the value of TSS, COD, BOD, and Total E from urban activities. The E-Coli distribution from settlements greater than the agricultural area [16][17]. Empirical facts reveal that management poorness of domestic waste reduced water quality. The biggest risk of water pollution in rivers occurred in urban areas [18][13]. Uniform, Bedadung River that passes through urban areas based on the 2015 Jember Regency Master Plan (i.e District of Sumbersari and Kaliwates) in the category of heavily polluted and heavy metal contaminated. On the other hand, the river's Water Quality Index was classified as very low in 2016 with a value of 50.76[19][11]. The potential for pollution increased in Bedadung River. It caused sources of pollution from domestic and agricultural activities which were predicted to increase every year [11][20][31]. In addition, the Sumbersari and Kaliwates District had a greater than population than other District in the Jember Regency. The phenomenon of river water pollution decreased to access for clean water sustainably in Jember Regency. Water quality assessment was applied as a basis for controlling Bedadung River pollution.

Assessment of river water quality was done by approaching water pollution conditions. This approach was with a quality index and water pollution based on Regulation refer to in Indonesian Government No. 82 in 2001 dan Indonesian Ministry of Environmental and Forestry No. 115 in 2003. The relationship between the water quality index was inversely proportional to the pollution index [21][22]. The application of a pollution index was applied to assess the presence of pollutants which were not permitted on water bodies. This simple method describes the condition of water quality and contamination of pollutants that had been applied to several rivers in Indonesia by linking land use and natural process [23][3]. Therefore, the focus of this research evaluated the water quality of Bedadung River based on water pollution index in the i.e Patrang, Sumbersari, and Kaliwates segment.

2. Study Method

This research type was quantitative descriptive. It was done to assess water quality of Bedadung River in Urban Area used Water Pollution Index (WPI) refer to Indonesian Government No. 82 in 2001 dan Indonesian Ministry of Environmental and Forestry No. 115 in 2003. The secondary data of water quality was obtained Environmental Service of Jember Regency. The physical, chemical, and biological data were in 2016 (dry and rainy session). The physical parameters were temperature, total dissolved solids (TDS), and total solid suspended (TSS). The chemical parameters were pH, chemical oxygen demand (COD), biological oxygen demand (BOD), dissolved oxygen (DO), cadmium, iron, copper, oil and fat, nitrate, phosphate, and chromium. The land use data at Bedadung Watershed was in 2014. Location sampling is represented in figure 1. Additionally, the description of the sampling location is mentioned in table 1. The methodology of this research was the data collecting, land use analysis, and Water Pollution Index (WPI) analysis. WPI approach used equation 1.

$$IPj = \frac{\sqrt{\left(\frac{Ci}{Lij}\right)_M^2 + \left(\frac{Cij}{Lij}\right)_R^2}}{2} \quad (1)$$

Where:

WPI = Water Pollution Index (WPI)
- Good : $0 \leq$ WPI ≤ 1.0
- Lightly polluted : $1.0 <$ WPI $\leq 5{,}0$
- Moderately polluted : $5.0 <$ WPI ≤ 10.0
- Heavily polluted : WPI > 10.0

Ci = The concentration of water quality measurement (ppm)
Cij = The concentration of water quality in quality standard base on regulation (j)
(Ci/Lij)M = The maximum value of Ci/Lij
(Ci/Lij)R = Average value of Ci/Lij

Table 1. Sampling location

Point	Locations	District	Coordinate	
			Longitude	Latitude
1	Jl.Slamet Riyadi	Patrang	113.7256520	-8.1497490
2	Jl. Mastrip	Sumbersari	113.7121370	-8.1570250
3	Jl. Bengawan Solo	Sumbersari	113.7068930	-8.1547150
4	Jl. Sumatera 12	Sumbersari	113.7056960	-8.1763930
5	Jl. Mangkubumi	Kaliwates	113.6833410	-8.1863103

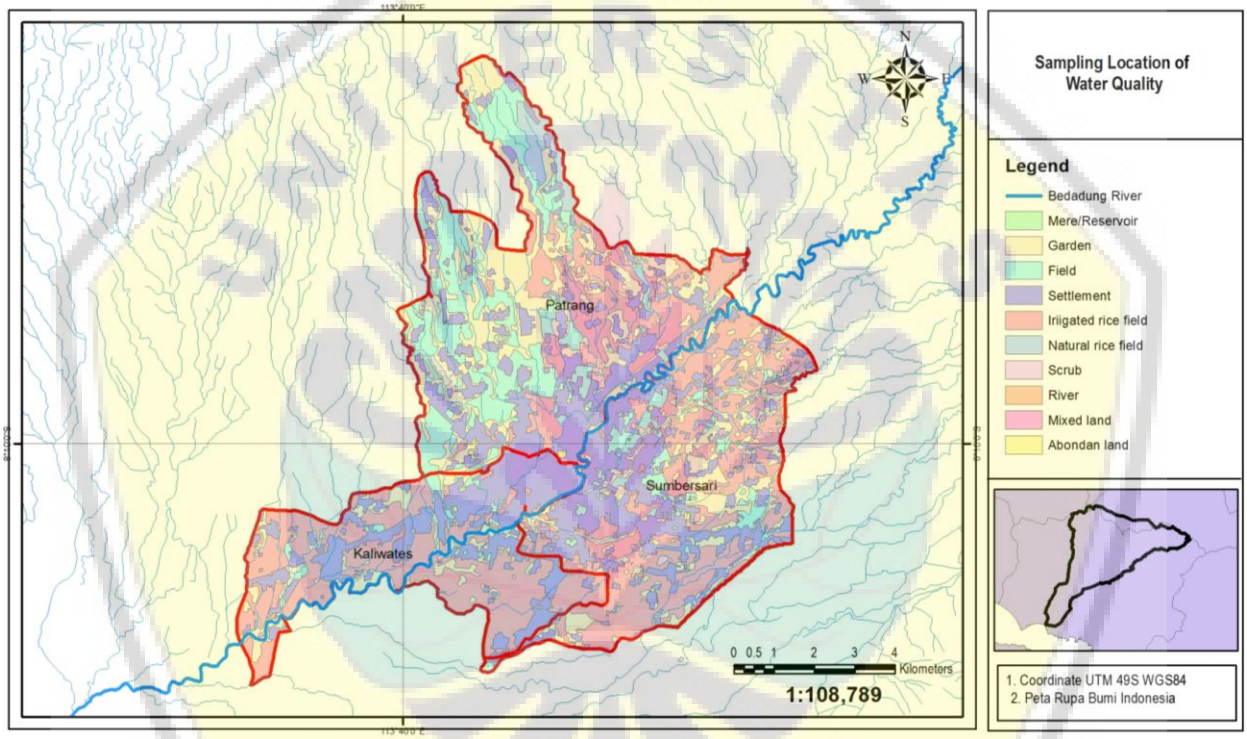

Figure 1. Sampling location profile

3. Results and Discussion

3.1 Land Use Identification

Land use in Patrang, Sumbersari, and Kaliwates District was variation. Based on Figure 2, the land use in the 3 districts was dominated by irrigated land and residential rice fields. The area of agricultural land in Patrang, Sumbersari, and Kaliwates respectively are 20%, 42.29, and 49.94%. While the area of settlement in Patrang, Sumbersari, and Kaliwates respectively are 23.54%, 30.79, and 34.56%. Patrang district becomes part of an urban area in Jember Regency.

Land use affected the quality of available natural resources, for example, the availability of water resources both in terms of quality and quantity [1]. The water quality poorness occurred due to the concentration over of pollutants into the body of water [24]. This condition became the Bedadung River. Urban area activities with settlements impacted river pollution potential if it did not manage properly [10] [11].

Based on Jember Regency Master Plan in 2015, Patrang, Sumbersari and Kaliwates District will be designed as urban systems. The potential for built-up land will be greater than in other districts. Based on this condition, the prediction of the phenomenon of conversion of an agricultural area to settlements would occur in Jember Regency [25]. The consequence was the threat of pollution in the Bedadung River in urban areas. Furthermore, it was one of the water resources for the urban area. The decision making for water pollution controlling must be considered from pollution characteristics. This investigation would be known from the analysis of water quality on the Bedadung River using the Water Pollution Index (WPI). This method had been applied in several tropical regions with fairly good accuracy [26][27][28].

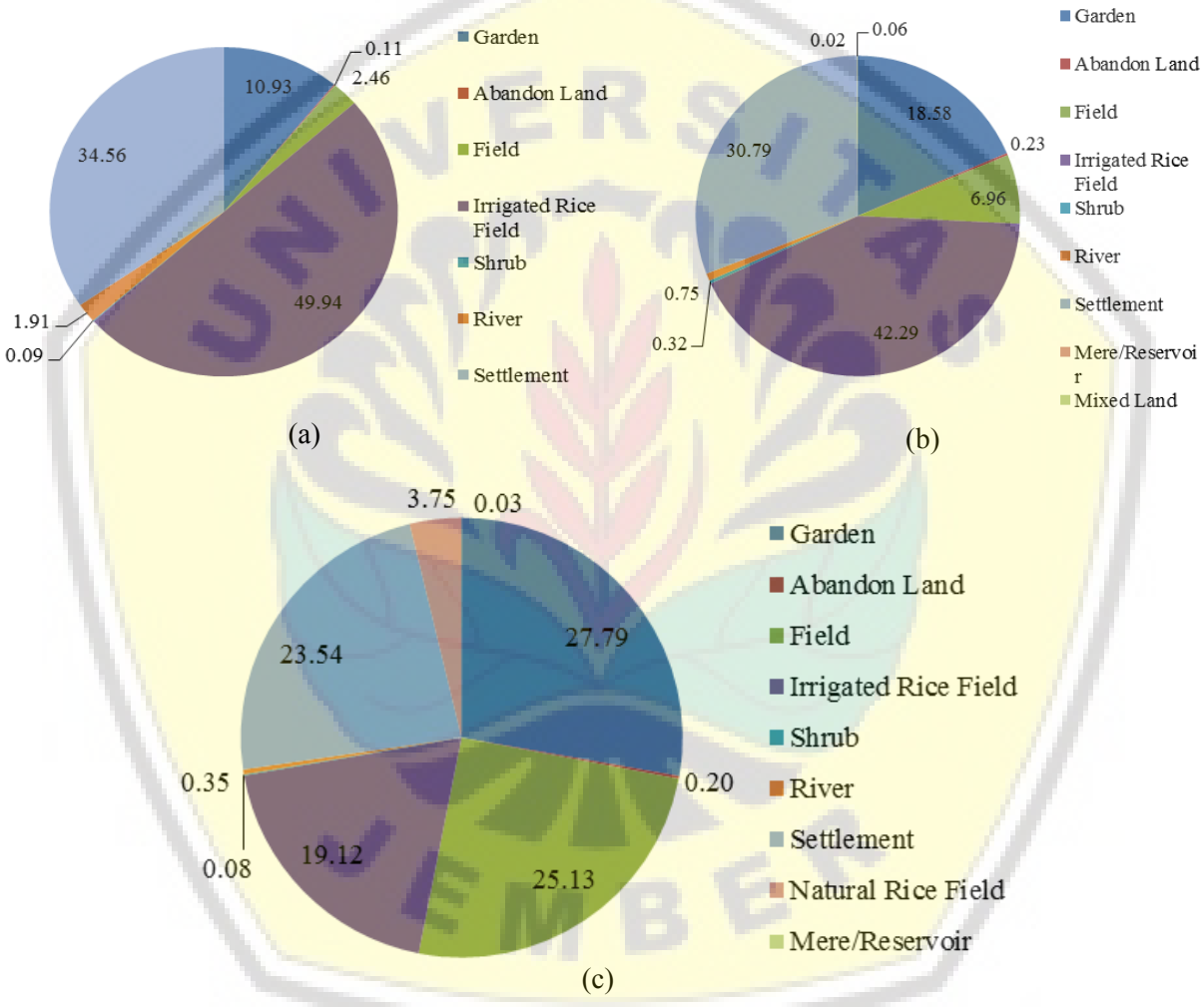

Figure 2. Land use: (a) Kaliwates Sub-District; (b) Sumbersari Sub-District; (c) Kaliwates Sub-District

3.2 Water Quality Analysis

Pollution index was an approach used to determine the amount of pollution that occurs in water bodies based on pollutants and their designation.

Table 2. Water quality analysis in Bedadung River

Point	Location	Districts	Season			
			Dry		Rainy	
			WPI value	WPI Category	WPI value	WPI Category
1	Jl.Slamet Riyadi	Patrang	3.02	Lightly polluted	4.03	Lightly polluted
2	Jl. Mastrip	Sumbersari	5.35	Moderately polluted	6.05	Moderately polluted
3	Jl. Bengawan Solo	Sumbersari	7.10	Moderately polluted	8.01	Moderately polluted
4	Jl. Sumatera 12	Sumbersari	5.95	Moderately polluted	6.55	Moderately polluted
5	Jl. Mangkubumi	Kaliwates	6.05	Moderately polluted	6.54	Moderately polluted

The urban segment in Sumbersari and Kaliwates District was classified as quality class III [29]. River water in this class was intended for livestock and fisheries. Based on Government Regulation No. 82 of 2001 the quality of water classes is divided into 4, such as class I for sources of clean water, class II for recreation, Class III for fisheries and livestock, and class IV for agriculture (irrigation). The condition of the Bedadung River water quality in the urban segment in the lightly-moderately polluted category is based on the WPI with a value of 5.35-8.01. This different condition in Patrang District was classified as lightly polluted. Then other research, water quality condition and river performance for organic matter degradation was a good condition in the Bedadung River in Patrang Segment [31]. The potential for pollution that occurs due to domestic activities occurs in the Sumbersari and Kaliwates District greater than the Patrang District. Therefore, pollution control efforts are needed which occurred in the form of the communal waste water treatment plant (WWTP) in this region [30].

The difference of WPI category from dry and rainy season had variation value in the overall urban area segment in the Bedadung Watershed. Based on table 2, maximum WPI value in dry and rainy is respectively 7.10 and 8.10 at Sumbersari Segment. Pollutant accumulation from inorganic or organic material increased water pollution. Besides that, the concentration of pollutant was influenced by streamflow [9][31]. WPI value in a rainy season more than dry season, but had the same category. It was represented by data empirical in the Patrang, Sumbersari, and Kaliwates segment. WPI value becomes preliminary analysis to prevention and controlling of pollution in the river [3] [14][21]. Then it was supported mitigation and adaptation making for sustainability of water quality management by government and stakeholder.

4. Conclusion

Assessment of river water quality was done by approaching water pollution conditions. This approach was with a quality index and water pollution based on Regulation refer to in Indonesian Government No. 82 in 2001 dan Indonesian Ministry of Environmental and Forestry No. 115 in 2003. The condition of the Bedadung River water quality in the urban segment in the lightly-moderately polluted category is based on the WPI with a value of 5.35-8.01. Then it was supported mitigation and adaptation making for sustainability of water quality management by government and stakeholder.

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References

[1] M. Benedini and G. Tsakiris, “Water quality modelling for rivers and streams,” in *European Water*, vol. 70, 2013, pp. 41–42.

[2] H. Effendi and Y. Wardiatno, "Water quality status of Ciambulawung River , Banten Province, based on pollution index and NSF-WQI," *Procedia Environ. Sci.*, vol. 24, pp. 228–237, 2015.
[3] H. Effendi, "River water quality preliminary rapid assessment using pollution index," *Procedia Environ. Sci.*, vol. 33, pp. 562–567, 2016.
[4] Y. Meilawati and L. Lidya, "Towards an Information System of Modeling and Monitoring of Cikapundung River, Bandung, Indonesia," *Procedia Eng.*, vol. 154, pp. 353–360, 2016.
[5] H. Sahabuddin, D. Harisuseno, and E. Yuliani, "Analysis of the status of water quality and capacity of pollution load of the Wanggu River in the Kendari City," *J. Tek. Pengair.*, vol. 5, no. 1, pp. 19–28, 2013.
[6] D. Chapman, *Water Quality Assessments - A Guide to Use of Biota, Sediments, and Water in Environmental Monitoring - Second Edition Edited by*. London: WHO by F & FN Spon, 1996.
[7] S. Schmutz, *Riverine Ecosystem Management*. Switzerland: Springer: Aquatic Ecology Series, 2018.
[8] R. B. Ibisch, J. J. Bogardi, and D. Borchardt, *Integrated Water Resources Management: Concept, Research, and Implementation*. Switzerland: Springer, 2016.
[9] S. N. Aziza, S. Wahyuningsih, and E. Novita, "Pollution load in the Jompo River di patrang - kaliwates district jember regency," *J. Agroteknologi*, vol. 12, no. 1, pp. 100–106, 2018.
[10] B. Santoso, K. Hendrijonto, A. Rahmawati, and R. Jannah, "Comunity based action research in Community at Bedadung Watershed," Jember, 2010.
[11] N. N. Suma, "Evaluation of the environmental quality of the estuary of the Bedadung Watershed in the Jember Regency," Universitas Gadjah Mada, 2010.
[12] R. Priadmaka, D. Sisinggih, and R. Asmaranto, "Epanet 2.0 application for the development of clean water distribution in Pakuasari District, Jember Regency," Malang, 2015.
[13] D. Shrestha and J. He, "Characterization and modeling of urban water quality in the city of Calgary, Canada," *Nat. Resour.*, vol. 8, no. 8, pp. 513–530, 2017.
[14] R. Y. Tallar and J. P. Suen, "Identification of waterbody status in Indonesia by using the predictive index assessment tool," *Int. Soil Water Conserv. Res.*, vol. 3, no. 3, pp. 224–238, 2015.
[15] M. Kändler *et al.*, "Impact of land use on water quality in the upper Nisa catchment in the Czech Republic and in Germany," *Sci. Total Environ.*, vol. 586, pp. 1316–1325, 2017.
[16] A. K. Dwivedi, "Researchers in water pollution: a review," *Int. Ser. Dir. Int. Res. J. Nat. Appl. Sci. ISSN*, vol. 118, no. February, pp. 2349–4077, 2017.
[17] P. Shi, Y. Zhang, Z. Li, P. Li, and G. Xu, "Influence of land use and land cover patterns on seasonal water quality at multi-spatial scales," *Catena*, vol. 151, pp. 182–190, 2017.
[18] D. A. S. Pohan, B. Budiyono, and S. Syafrudin, "Analysis of river water quality to determine designation in terms of environmental aspects," *J. Ilmu Lingkung.*, vol. 14, no. 2, p. 63, 2017.
[19] U. Nurjanah, "Study of the diversity of macrobenthos as a bioindicator of water quality in the Bedadung River Jember," in *Prosiding Seminar Nasional Biology*, 2015, pp. 202–209.
[20] M. Solichin, K. Munandar, and N. Eurika, "Diversity and abundance of fish in the bedadung river region of jember city," in *Seminar Nasional Biology*, 2015, pp. 36–48.
[21] S. Giri and Z. Qiu, "Understanding the relationship of land uses and water quality in Twenty-First Century: A review," *J. Environ. Manage.*, vol. 173, pp. 41–48, 2016.
[22] V. de Paul Obade and R. Moore, "Synthesizing water quality indicators from standardized geospatial information to remedy water security challenges: A review," *Environ. Int.*, vol. 119, no. May, pp. 220–231, 2018.
[23] D. Agustiningsih, S. B. Sasongko, and Sudarno, "Water quality analysis and strategies to control water pollution in the Blukar District of Kendal," *J. Presipitasi*, vol. 9, no. 2, pp. 64–71, 2012.
[24] Z. Zainudin, A. S. Azmi, D. Norainijimat, and P. Jamal, "Determination of waste assimilative capacity (WAC) of rivers located within the Desaru region, Johor," *Environ. Prot. Eng.*, vol. 41, no. 4, pp. 49–60, 2015.
[25] A. F. Sunartomo, "The development of conservation of agricultural land in the Jember Regency,"

Agrie, vol. 4, no. 1, pp. 16–30, 2015.
[26] F. Othman, M. E. Alaa Eldin, and I. Mohamed, "Trend analysis of a tropical urban river water quality in Malaysia," *J. Environ. Monit.*, vol. 14, no. 12, pp. 3164–3173, 2012.
[27] M. . T. Sikder *et al.*, "Vulnerability assessment of surface water quality with an innovative integrated multi-parameter water quality index (IMWQI)," *Pollution*, vol. 1, no. 3, pp. 333–346, 2015.
[28] O. Altansukh and G. Davaa, "Application of index inalysis to evaluate the water quality of the tuul river in mongolia," *J. Water Resour. Prot.*, vol. 03, no. 06, pp. 398–414, 2011.
[29] U. Nurjanah, "Study of the diversity of mcrobenthos as a bioindicator of water quality in the Bedadung River Jember," in *Prosiding Seminar Nasional Biologi*, 2016, pp. 202–209.
[30] B. K. Mishra, R. K. Regmi, Y. Masago, K. Fukushi, P. Kumar, and C. Saraswat, "Assessment of Bagmati River pollution in Kathmandu Valley: Scenario-based modeling and analysis for sustainable urban development," *Sustain. Water Qual. Ecol.*, vol. 9–10, pp. 67–77, 2017.
[31] H. A. Pradana, E. Novita, S. Wahyuningsih, and R. Pamungkas. Analysis of deoxygenation and reoxygenation rate in the Indonesia River (a case study: Bedadung River East Java), *IOP Conference Series: Earth and Environmental Science* 243, pp. 1-9, 2019.