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River water quality assessment in East Java, Indonesia

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Abstract

This study aims to assess the water quality and determine the pollution index of the Bedadung River in the urban-area segment of Jember Regency, East Java. The sampling in the urban segment of Jember was conducted in May 2019 at five different locations, namely Slamet Riyadi Street, Mastrip Street, Bengawan Solo Street, Sumatra Street, and Imam Bonjol Street. The pollution index assessment refers to the Decree of the State Minister for the Environment of Indonesia Republic number 115 of 2003. The analysis showed that the parameters of *TDS*, *TSS*, pH, *COD*, *BOD*, NH_3-N, Co, Cd, Cu, Zn, H_2S, Cl^-, SO_4, oil and fats, MBAS, NO_2-N, Fe, Pb, F, Cl_2, NO_3-N, phenol, and As did not exceed the quality standards. The parameters PO_4, CN, total coliform, and faecal coliform were found to breach the quality standards at the 5 water sampling points. Total coliform and faecal coliform were the dominant pollutants in this segment. Therefore, the parameters of PO_4, total coliform, and faecal coliform were considered as indicators of pollution arising from domestic and agricultural activities. The pollution index values for the five sampling locations ranged from 7.21 to 8.23. These scores indicate that the Bedadung River section that passes through the urban segment in Jember is classified as being in the moderately polluted category. This preliminary rapid assessment is therefore one of the considerations for the management of water quality in the Bedadung River section that passes through the urban area of Jember.

Key words: *Jember Regency, microbiology parameters, physicochemical parameters, pollution index, the Bedadung River, water quality monitoring*

INTRODUCTION

Deterioration in the quality of water resources is one of the most critical problems facing the world today and has an adverse impact on human health. The low quality of drinking water and raw water resources has been a factor in various deaths around the world [BABA, TAYFUR 2011; DWIVEDI 2017; HASEENA *et al*. 2017; KIDO *et al*. 2009; PAWARI, GAWADE 2015]. Besides, low public awareness of the environment and increasing economic activity have the potential to exacerbate the levels of pollution already found in water sources [CHEN *et al*. 2012; LEE *et al*. 1982]. In general, the sources of this pollution comprise anthropogenic activities in the form of domestic waste, industrialization, population growth, pesticides and fertilizers, organic and inorganic waste, urban development, and poor water resource management systems [HUANG *et al*. 2017; MATEO-SAGATA *et al*. 2017].

Water pollution is a primary issue in both Asia and Africa owing to the impact on water sources from the low level of sanitation facilities and wastewater treatment units [DWIVEDI 2017; EVANS *et al*. 2016; YUSTIANI *et al*. 2018]. This condition is also prevalent in Indonesian territory. There is empirical evidence to show that 44 major rivers in Indonesia, including the Musi, Citarum, Ciliwung, Brantas, and Barito Rivers, do not meet class ii quality standards. Despite this, the territory of Indonesia is estimated to potentially include 6% of the world's sources of fresh water. It had the potential to be the world's fifth-largest fresh water source in 2012 [ADB 2016]. However, an exponential increase in water consumption combined with a deterioration in the quality of water resources has created a range of problems with regard to the supply of clean water [KRANTZBERG *et al*. 2010; LEE *et al*. 1982]. The phenomenon of river or surface water resources pollution is impacted by policies in Indonesia that do not seek to maximize environmental control and monitoring [FULAZZAKY 2014; MARSELINA, BURHANUDIN 2017].

The quality of the water contained in water bodies has a tendency to fluctuate, as shown in the Indonesian Water Quality Index (*WQI*); however, the water quality fell during the period 2015–2017 [KLHK 2018]. The *WQI* presents a concern for the government in East Java. There, the *WQI* value is <40, which places it in the unfavourable category and means improvement must be included as a priority for Indonesia.

Water quality assessment in Bedadung River (Jember Regency) limited on oxygen and organic matter parameter i.e *DO*, *BOD*, and *COD*. The Bedadung River has good function to biodegradable pollutant reduction. It is indicated by reoxygenation rate > deoxygenation rate of the Bedadung River [PRADANA *et al*. 2019a]. Water quality status have to notice physical, chemical, and microbiological parameters.

Decree of the State Minister for the Environment No. 115 of 2003 [Keputusan Menteri Lingkungan Hidup No. 115 tahun 2003] concerning the determination of water quality status permits the use of the pollution index as a basic reference for pollution control. It is preliminary rapid approach which minimize data volume i.e. physical, chemical, and microbiological parameters to describe most of the water quality status. The pollution index results for surface water resources in Indonesia, i.e., rivers and coastal areas, can be used to illustrate the magnitude of the potential pollution [EFFENDI 2016; PUSPITA *et al*. 2016; TALLAR, SUEN 2015; TANJUNG *et al*. 2019].

This study aims to assess the water quality and determine the pollution index of the Bedadung River in an urban-area segment of Jember Regency, East Java. The assessment can become a consideration for controlling pollution and managing river water quality in urban areas to provide sustainable raw water sources.

MATERIALS AND METHODS

STUDY AREA AND INPUT DATA

Bedadung Watershed is one of the largest watersheds in East Java and includes Jember. The Bedadung River has a total length of 46,875 m. The river passes through an area in Jember that includes the Patrang, Sumbersari, and Kaliwates districts. The land use in Bedadung Watershed comprises forests, settlements, paddy fields, and grasslands [PRADANA *et al*. 2019a].

The Bedadung River is one of the most strategic rivers in East Java and is located in the Bedadung Watershed in Jember. It is used by the community and stakeholders as a source of both raw water and irrigation water. Therefore, it is used for washing, bathing, and toilet activities [MUNANDAR, EURIKA 2016]. However, the physical and chemical water quality of the Bedadung River has already been affected by pollution in some districts, including the Patrang, Sumbersari, Kaliwates, and Mangli Districts [NURJANAH *et al*. 2015]. In 2016, the Bedadung River had a very poor category on the parameters of *BOD*, *COD*, *TSS*, and Total Coliform [East Java Environment Agency 2017]. In other cases, PRADANA *et al*. [2019b] reported that the *COD* value of the water intake at Jember Regency Municipal Waterworks exceeded the class I quality standards in 2017.

The pollutants in the Bedadung River usually derive from anthropogenic activities such as domestic and residential liquid waste, rubbish, livestock, agriculture, and the activities of small and medium Enterprises. In line with this, AZIZA *et al*. [2018] stated that urban activity is the dominant factor affecting the high pollution load in the Kalijompo River, which is a tributary of the Bedadung River.

Fig. 1. Sampling location; source: own elaboration

The research sampling for this study was carried out in the Bedadung River, specifically in the urban segment of Jember, in May 2019. The river water was sampled at a total of five locations, i.e., (1) Slamet Riyadi Street – Patrang District; (2) Mastrip Street – Sumbersari District; (3) Bengawan Solo Street – Sumbersari District; (4) Sumatra Street – Sumbersari District; and (5) Imam Bonjol Street – Kaliwates District. It was divided into three categories, i.e., the upstream of the river in Patrang District, the middle of the river in Sumbersari District, and the downstream of the river in Kaliwates District. The river water sampling locations are shown in Figure 1. These locations were selected following a consideration of the types of community activities and land use in the Bedadung Watershed [PRADANA *et al*. 2019a, b].

MEASUREMENT AND ANALYSIS OF WATER QUALITY

The water sampling was carried out temporarily (grab sampling) at the point of observation [PRADANA *et al*. 2019a]. The sampling process for the Bedadung River water required a 5 dm^3 volume sample, with reference to the SNI 6989.57-2008 procedure regarding surface water sampling procedures. Samples were taken from the previously identified five water sampling points. Observations of the temperature, *DO*, and pH parameters were carried out directly at the locations, while the other parameters were analysed in the laboratory. The various other analytical methods related to water quality parameters as listed in Government Regulation of Indonesia No. 82 of 2001 concerning river pollution control were used as inputs for calculating the pollution index (*PI*) [Peraturan… 2001], and these are given in Table 1.

The water quality parameters were analysed at the Sucofindo Surabaya Laboratory (Ind. Laboratorium Sucofindo Surabaya), which has been accredited by the Committee National Accreditation (Ind. Komite Akreditasi Nasional – (KAN). The results of the parameter analysis were compared to the class I quality standards designated for raw water sources.

WATER POLLUTION INDEX (*WPI*)

The *WPI* is one of the determinants of water quality status referred to in Regulation of the State Minister for the Environment No. 115 of 2003. The function of the index is to identify the impact of the pollutant content on surface water quality conditions. This water quality status is employed as a consideration with regard to the utilization of surface water sources and their management efforts. The following data relate to the pollution index equation given as Equation (1) [EFFENDI 2016]. The concentration of water quality in quality standard base on regulation (*j*) uses class *i* quality standards based on Government Regulation of Indonesia Number 82 of 2001 [Peraturan… 2001]. The application of this standard was based on the utilization of Bedadung River water as a raw water resource by several parties.

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

Table 1. Standard's values and analytical methods for water quality parameters

Parameter	Unit	Standard	Analytical method
Temperature	°C	±3	APHA 2550 B 2017
TDS	mg·dm^{-3}	1000	APHA 2540 C 2017
TSS	mg·dm^{-3}	50	APHA 2540 D 2017
pH	–	6–9	APHA 4500-H+-B 2017
COD	mg·dm^{-3}	10.0	APHA 5220 B 2017
BOD	mg·dm^{-3}	2.0	APHA 5210 B 2017
DO	mg·dm^{-3}	6.0	APHA 4500-O B 2017
Ammonia total (NH_3-N)	mg·dm^{-3}	0.5	APHA 4500-NH_3-F 2017
Cobalt (Co)	mg·dm^{-3}	0.2	APHA 3120 B 2017
Cadmium (Cd)	mg·dm^{-3}	0.01	APHA 3120 B 2017
Copper (Cu)	mg·dm^{-3}	0.02	APHA 3120 B 2017
Zinc (Zn)	mg·dm^{-3}	0.05	APHA 3120 B 2017
Sulfide (H_2S)	mg·dm^{-3}	0.002	APHA 4500-S2–D 2017
Chlorine (Cl^-)	mg·dm^{-3}	0.03	APHA 4500-Cl B 2017
Sulfate (SO_4)	mg·dm^{-3}	400	APHA 4500-SO_4 2-E 2017
Oil and fats	µg·dm^{-3}	1000	APHA 5520 B 2017
MBAs detergent	µg·dm^{-3}	200	APHA 5540 C 2017
Phenol	mg·dm^{-3}	1.0	APHA 5530 C 2017
Nitrite (NO_2-N)	mg·dm^{-3}	0.06	APHA 500-NO2-B 2017
Iron (Fe)	mg·dm^{-3}	0.3	APHA 3120 B 2017
Lead (Pb)	mg·dm^{-3}	0.03	APHA 3120 B 2017
Flourine (F)	mg·dm^{-3}	0.5	APHA 4500-F–D 2017
Chloride (Cl_2)	mg·dm^{-3}	1.0	APHA 4500-Cl_2-B 2017
Nitrate (NO_3-N)	mg·dm^{-3}	10	APHA 4500-NO_3-E 2017
Phosphate (PO_4)	mg·dm^{-3}	0.2	APHA 4500-P C 2017
Manganese (Mn)	mg·dm^{-3}	1.0	APHA 3120 B 2017
Hexavalent chromium	mg·dm^{-3}	0.05	APHA 3500-Cr-B 2017
Cyanide (CN)	mg·dm^{-3}	0.02	APHA 9221 B # 2012
Arsenic (As)	mg·dm^{-3}	1.0	APHA 3114 B 2017
Barium (Ba)	mg·dm^{-3}	1.0	APHA 3120 B 2017
Boron (B)	mg·dm^{-3}	1.0	APHA4500-B-C 2017
Selenium (Se)	mg·dm^{-3}	0.01	APHA 3114 B 2017
Mercury (Hg)	mg·dm^{-3}	0.001	APHA 3112 B 2017
Total coliform	MPN·(100 cm)$^{-1}$	1000	APHA 4500-CN-E 2017
Faecal coliform	MPN·(100 cm)$^{-1}$	100	APHA 9221 E # 2012

Explanations: *TDS* = total dissolved solids, *TSS* = total suspended solids, *COD* = chemical oxygen demand, *BOD* = biological oxygen demand, *DO* = dissolved oxygen, MBAs = methylene blue active substances.
Source: APHA [2012] and APHA [2017].

Where: *WPI* = water pollution index; *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* = the average value of *Ci*:*Lij*.

WPI limits for water quality classes are as follows:
– good/meets standard ($0 \le WPI \le 1.0$),
– lightly polluted ($1.0 < WPI \le 5.0$),
– moderately polluted ($5.0 < WPI \le 10.0$),
– heavily polluted ($WPI > 10.0$).

RESULTS AND DISCUSSION

WATER QUALITY ANALYSIS

Water quality is closely related to water allocation. In general, physical, chemical, and biological parameters can be used to represent water quality conditions. The various physical, chemical, and microbiological parameter values used are shown in Table 2.

Table 2. The water quality parameters for the Bedadung River in Jember Regency, East Java, Indonesia

Parameter	Unit	Value for station				
		A	B	C	D	E
Temperature	°C	29.5	29	28.5	28.5	29
TDS	$mg \cdot dm^{-3}$	154	143	149	153	141
TSS	$mg \cdot dm^{-3}$	1.6	1.2	1.2	1.6	1.2
pH		8.2	8.17	8.15	8.17	8.16
COD	$mg \cdot dm^{-3}$	5.1	3.4	3.4	5.1	3.4
BOD	$mg \cdot dm^{-3}$	1.2	0.82	0.83	1.2	0.85
DO	$mg \cdot dm^{-3}$	5.6	5.4	5.6	5.4	5.4
Ammonia total (NH_3-N)	$mg \cdot dm^{-3}$	0.032	0.032	0.032	0.032	0.032
Cobalt (Co))	$mg \cdot dm^{-3}$	0.003	0.003	0.003	0.003	0.003
Cadmium (Cd)	$mg \cdot dm^{-3}$	0.003	0.003	0.003	0.003	0.003
Copper (Cu)	$mg \cdot dm^{-3}$	0.003	0.003	0.003	0.003	0.003
Zinc (Zn)	$mg \cdot dm^{-3}$	0.016	0.023	0.011	0.015	0.022
Sulfide (H_2S)	$mg \cdot dm^{-3}$	0.02	0.057	0.02	0.02	0.057
Chlorine (Cl^-)	$mg \cdot dm^{-3}$	2	3.9	3.9	2	3.9
Sulphate (SO_4)	$mg \cdot dm^{-3}$	11.8	19.3	21.1	5.8	19.9
Oil and fats	$\mu g \cdot dm^{-3}$	200	200	200	200	200
MBAS detergent	$\mu g \cdot dm^{-3}$	50	50	50	50	50
Phenol	$mg \cdot dm^{-3}$	0.002	0.002	0.002	0.002	0.002
Nitrite (NO_2-N)	$mg \cdot dm^{-3}$	0.005	0.003	0.004	0.005	0.003
Iron (Fe)	$mg \cdot dm^{-3}$	0.12	0.072	0.088	0.15	0.062
Lead (Pb)	$mg \cdot dm^{-3}$	0.003	0.003	0.003	0.003	0.003
Flourine (F)	$mg \cdot dm^{-3}$	0.48	0.17	0.25	0.25	0.52
Chloride (Cl_2)	$mg \cdot dm^{-3}$	0.02	0.02	0.02	0.02	0.02
Nitrate (NO_3-N)	$mg \cdot dm^{-3}$	2.6	1.9	1.8	2.6	2.1
Phosphate (PO_4)	$mg \cdot dm^{-3}$	0.3	0.3	0.3	0.3	0.3
Manganese (Mn)	$mg \cdot dm^{-3}$	0.003	0.003	0.003	0.003	0.003
Hexavalent chromium	$mg \cdot dm^{-3}$	0.003	0.003	0.003	0.003	0.003
Cyanide (CN)	$mg \cdot dm^{-3}$	0.03	0.03	0.03	0.03	0.003
Arsenic (As)	$mg \cdot dm^{-3}$	0.001	0.001	0.001	0.001	0.001
Barium (Ba)	$mg \cdot dm^{-3}$	0.033	0.028	0.23	0.0457	0.072
Boron (B)	$mg \cdot dm^{-3}$	0.043	0.031	0.031	0.035	0.04
Selenium	$mg \cdot dm^{-3}$	0.001	0.001	0.001	0.001	0.001
Mercury (Hg)	$mg \cdot dm^{-3}$	0.001	0.001	0.001	0.001	0.001
Total coliform	$MPN \cdot (100\ cm^3)^{-1}$	>1600	>1600	>1600	>1600	>1600
Faecal coliform	$MPN \cdot (100\ cm^3)^{-1}$	47	920	>1600	>1600	>1600

Explanations: A = Slamet Riyadi Street; B = Mastrip Street; C = Bengawan Solo Street; D = Sumatra Street; E = Imam Bonjol Street, the other as in Tab. 1.
Source: own study.

The values for the physical parameters i.e. temperature, total dissolved solids (*TDS*), and (*TSS*) do not exceed the class I quality standards, with average values of 28.9°C, 148 $mg \cdot dm^{-3}$, and 1.36 $mg \cdot dm^{-3}$ respectively. The water temperature determines the amount of oxygen dissolved in water, the rate of photosynthesis of aquatic plants, and the metabolism of aquatic organisms. Temperature changes are caused, among others, by the weather, the removal of shaded riverbank vegetation, containment, cooling water discharges, urban stormwater, and the flow of groundwater to rivers [OBADE, MOORE 2018]. The values for *TSS* and *TDS* were below the grade I quality standards owing to the influence of water discharge and runoff from the Bedadung River. May 2019 was predicted to be the dry season. *TSS* was a mineral or suspended sediment that moved in the water, depending on the water flow and rainfall levels. Meanwhile, sediments block light and contain pathogens and retained particles/algal pigments that affect the application and reflection of light in water bodies [LEE *et al*. 1982; OBADE, MOORE 2018]. The potential runoff from domestic activity is low during the dry season [OGDEN *et al*. 2013]. However, the minimum discharge of soil particles from the upstream area of the Bedadung Watershed did not carry over to the water body. These particles predominantly influence the increasing value of *TSS* and *TDS* in the river.

The chemical parameters tend to fluctuate with class I quality standards. The values for pH and dissolved oxygen (*DO*) values were still within the normal range. Reaction expressed in pH indicates the alkalinity or acidity of a substance, ranked on a scale of 1 to 14: pH < 7 is acidic while pH > 7 is basic, and pH 7.0 is neutral [OBADE, MOORE 2018]. The water at the five observation points in the Bedadung River that passes through the urban segment as water intake of Jember Regency Municipal Waterworkers (Ind. Perusahaan Daerah Air Minum) has a pH value of 8.17, which puts it in the neutral category. This drastic change in pH is influenced by the industrial waste that is discharged directly into water bodies. In line with these parameters, the *DO* values are classified as normal and almost reached 6 at each water sampling location. The average *DO* value was 5.48 $mg \cdot dm^{-3}$.

The high *DO* content is influenced by the river profile factors such as topography, river cross-sectional area, water flow velocity, and river rock shape [PRADANA *et al.* 2019a]. The shape of the Bedadung River rocks varies, which creates an increase in the flow turbulence. Flow turbulence works as a factor to increase the potential for oxygen uptake from above the water surface. The source of oxygen in surface water sources is indicated by the value of (*DO*), which is a component that supports photosynthesis and the degradation of organic matter in water bodies [NASHOLM *et al*. 2008; OBADE, MOORE 2018].

Several chemical parameters are used to indicate the presence of organic matter in river water. In this case, chemical oxygen demand (*COD*) and biological oxygen demand (*BOD*) indicate biodegradable organics matter. It is identified by *BOD*/*COD* in Bedadung River more than 0.1 [PRADANA *et al*. 2019b]. The mean values of *BOD* and *COD* were 4.08 $mg \cdot dm^{-3}$ and 0.98 $mg \cdot dm^{-3}$, respectively. Neither parameter exceeded the grade I quality standards. Points A and D had the same *COD* values of 5.1 $mg \cdot dm^{-3}$, which were higher than those recorded at the other points. This is due to waste from industrial activities but has little impact on the exposure of *COD* values to the Bedadung River. The degradation of organic matter and dilution of *COD* concentrations were also influenced by additional water discharges from various sources such as springs and creeks, as well as variations in the flow velocity due to topographic variations [GUMELAR *et al*. 2017; PRADANA *et al*. 2019a; RAHAYU *et al*. 2018]. In other cases, the *BOD* values for all points were below the class I quality standards. Therefore, the potential exposure of the water in the Bedadung River to biodegradable organic matter was quite low.

In general, the results of the examination of heavy metal content in the form of Hg, As, Cd, Ni, Fe, and Pb did not exceed the grade I quality standards. The concentrations of heavy metals dissolved in the Bedadung River were therefore relatively low. Heavy metal pollution in water can generally be attributed to electroplating and the mining industry.

Some of the parameters were found to exceed the class I quality standards, namely phosphate (PO_4), cyanide (CN), total coliform, and faecal coli. In this study, CN was found to be distributed equally across all of the observation points, with an average value of 0.03 mg·dm^{-3}. This exceeds the grade I quality standards, which stipulate a value of 0.02 mg·dm^{-3}. CN contamination derives from industrial waste and is toxic. Another study showed that certain mining activities can also be the cause of rivers' exposure to CN [HIDAYATI *et al*. 2009; WEI *et al*. 2018]. The average phosphate value at each observation point was 0.3 mg·dm^{-3}. The class I quality standard for this parameter is 0.2 mg·dm^{-3}. Therefore, based on the results of the examination, the phosphate content in the river that passes through this segment is classified as heavy.

The quality standard is the limit of orthophosphate in the form of phosphate as one of the macronutrient components. This nutrient has a function as a nutrient for phytoplankton [LOH *et al*. 2016; PIRANTI *et al*. 2019]. This type of result is one of the factors that triggers an explosion of algae in water bodies. It is thought that human faeces and the use of fertilizers in farming act as the source of one of the macronutrient components involved in the growth of contamination [MARSELINA, BURHANUDIN 2017; 2018; MASLUKAH *et al*. 2017].

The indications of exposure to pathogenic bacteria can be seen in the microbiological parameters of total coliform and faecal coliform. The average value of total coliform at each observation site was >1600 MPN·(100 cm^3)$^{-1}$. The data show that the total coliform is equally distributed and that the content is high in the section of Bedadung River that passes through the urban segment of Jember. On the other hand, however, different results were found with respect to the faecal coli values. The dynamics of faecal coli exposure varied between the upstream and downstream observation sites. In general, the faecal coli values exceeded the grade I quality standards, although there were differences in the inspection results between the upstream and downstream sections. The faecal coliform values at points A and E were 47 MPN·(100 cm^3)$^{-1}$ and >1600 MPN·(100 cm^3)$^{-1}$. The faecal coliform accumulated at the downstream point. This is supported by GENISA and AULIANDRI [2018], who found that the distribution of faecal coli was influenced by the accumulation of domestic activities, land use, and the presence of sediment in the downstream of the Musi River.

The examination of the water quality of the Bedadung River that passed through Jember found that the physical, chemical, and microbiological parameters generally exceeded the class I quality standards. In this segment, the Bedadung River is categorized as class III and is not viable for use as a source of clean water and drinking water. However, almost 90% of the 35 parameters were found to be good and can thus be categorized as meeting the class I quality standards. A total of 89% of the physical and chemical parameters met the class I quality standards, including *TDS*, *TSS*, pH, *COD*, *BOD*, NH_3-N, Co, Cd, Cu, Zn, H_2S, Cl^-, SO_4, oil and fats, MBAs, NO_2-N, Fe, Pb, F, Cl_2, NO_3-N, phenol, and As. The percentage of chemical and microbiological parameters that passed the class I quality standard was 11%, in the form of PO_4, CN, total coliform, and faecal coliform. These empirical findings indicate that the purification ability of the Bedadung River based on its physical and chemical components remains relatively good, despite the pollution caused by exposure to total coliform and faecal coliform. In line with this phenomenon, the potential for organic matter to decompose from the upstream part of Bedadung River is still good, based on its reoxygenation rate of 0.053 mg·day^{-1} [PRADANA *et al*. 2019a].

WATER POLLUTION INDEX

The assessment of water quality status is used as a benchmark in the allocation of water quality management. One method that can be used to assess water quality is based on exposure to pollutants. This involves a comparison of the physical, chemical, and microbiological parameters against the quality standards [EFFENDI 2016; TANJUNG *et al*. 2019]. It is a fairly comprehensive approach to consider a form of pollution control based on the source of pollution.

The *WPI* values at the five sampling locations were in the range 7.20 to 8.23, as shown in Figure 2. This indicates that the Bedadung River water that passes through the urban segment of Jember is in the moderately polluted category. This is evident from the fact that point A, which is in the upstream part, has a *WPI* value of 7.20. Points B and C are located in the middle section and have a *WPI* value of 8.23. Points D and E are located downstream and have *WPI* values of 7.21. The relatively high *WPI* values at points B and C reflect the high pressure of domestic activity. These points are located in the Sumbersari sub-district, thus indicating that the Bedadung River is polluted by domestic waste from bathing, washing, and toilet activities in the river. The agricultural waste be in the form of run off are also sources of pollutants in the Bedadung River [PRADANA *et al*. 2019b].

The assessment is one piece of information used in the management of water quality in the Bedadung River based on the level of pollutants with physical, chemical, and microbiological parameters that exceed the quality standards. The most dominant pollutants come from domestic and agricultural activities. This assumption is reinforced by the exposure to phosphate (PO_4), cyanide (CN), total coliform, and faecal coliform. Based on the result of the calculations in the *WPI* method, the urban segment in Jember is moderately polluted and certainly does not meet the clean water standard for the community. Therefore, it is necessary to manage water quality and control water pollution by considering the type of land use in urban areas and human behaviour of garbage management. However, the fact that some of the pollutants exceed the quality standard indicates the potential for diseases in the future and excessive phytoplankton growth in the Bedadung River.

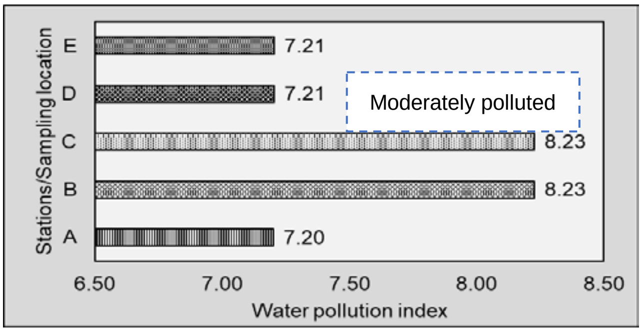

Fig. 2. Pollution index for the Bedadung River in the urban-area segment of Jember Regency, east Java, Indonesia; A = Slamet Riyadi Street; B = Mastrip Street; C = Bengawan Solo Street; D = Sumatra Street; E = Imam Bonjol Street; source: own study

CONCLUSIONS

The results from the examination of water quality in the section of the Bedadung River that passes through Jember based on its physical, chemical, and microbiological parameters generally exceed the grade I quality standards. Nearly 90% of the 35 parameters examined were found to be in a good condition and meet the quality standards of grade I. In addition, 89% of the physical and chemical parameters meet the class I quality standards, including *TDS*, *TSS*, pH, *COD*, *BOD*, NH_3-N, Co, Cd, Cu, Zn, H_2S, Cl^-, SO_4, oil and fats, MBAs, NO_2-N, Fe, Pb, F, Cl_2, NO_3-N, phenols, and As. A total of 11% of the chemical and microbiological parameters exceeded the quality standard of class I, comprising PO_4, CN, total coliform, and faecal coliform. However, it is potentially very dangerous for people to continue using the river as a source of clean water without the water passing through sterilization first.

As a result, the parameters requiring attention are PO_4, total coliform, and faecal coliform as indicators of pollution due to effluent domestic, agricultural, and industrial wastewater. The *WPI* values obtained at the five sampling locations ranged from 7.21 to 8.23. This means that the section of the Bedadung River that passes through the urban segment of Jember is categorized as moderately polluted. This assessment serves as information in the management of water quality in the Bedadung River based on its exposure to physical, chemical, and microbiological pollutants whose parameters fall outside the applicable quality standards.

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