

Water Quality of the Garang River, Semarang, Central Java, Indonesia based on the Government Regulation Standard

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Water quality of the Garang River, Semarang, Central Java, Indonesia based on the government regulation standard

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Abstract. The Garang watershed composed by three main river streams has been managed by the Regional water company of the Semarang city, Central Java for drinking water supply. A river is often polluted by domestic waste and industrial effluents. Therefore water quality of the river should be kept to meet the Government regulation standard. The study aims to analyze water quality of the Garang' river using pollution index based on the government regulation. Series data from 2010 to 2016 were derived from the Environmental and Forestry Office of the Central Java Province and sampling of water quality was taken in August 2017 from the middle of watershed area. Water quality parameters include temperature, pH, TDS, DO, COD, Phosphate, Nitrate, Chromium, Copper, Cadmium and H₂S. The research indicates that concentration of Copper has exceeds the standard of the Government Regulation No. 82 Year 2001. The water pollution index is 1.23, its means that the river is lightly polluted. Therefore the river should be managed comprehensively for sustainable uses in order to create one river one management concept.

Keywords : river, Garang watershed, standard, sustainable management, water quality

1. Introduction

Garang watershed from the upstream to downstream have three main streams from the river of Garang, Kripik and Kreo. The watershed support numerous uses from agriculture, household and industry [4] as well for fisheries and tourism. The river mainly recognized as a discharge place of domestic waste and industrial effluent. Water quality of the river is essential to be maintained for quality and quantity within the watershed. Therefore its need to be managed using a holistic approached for sustainable use of the ecosystem. Water of Garang river are be purified and processed as drinking water supply by the regional water company 'Tirta Moedal' of the Semarang city, Central Java, Indonesia. Another problem is a lot of housing on the near river upstream. Land use change came settlement area in upstream area. Changes in land use associated with economic activities have a negative impact on water quality [22].



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The Indonesian government has set a ¹⁸ Guidelines of Water Quality Status by the Environmental Ministerial Decree No. 115/2003 and a Government Regulation No. 82/2001 about Water Quality Management and Control of Pollution. In this government regulation, water quality is classified into 4 (four) classes: a) Class 1 ¹⁹ drinking, and/or other designations that require the same water quality as those uses; b) Class 2 for water recreation facilities, freshwater fish farming, livestock, ²⁰ crops irrigation, and/or other designations that require the same water quality as those uses; c) Class 3 for the cultivation of freshwater fish, ²¹ farms, water for cropping, and/or other designations that require water equal to those uses; d) Class 4 for irrigation, planting and/or other designations that require the same water quality as those uses. This paper analyze water quality of the Garang watershed particularly the Garang river using pollution index based on the government regulation.

Based on the Governor Regulation of Central Java Provincial No. 156/2010 about segmentation of Garang; the watershed is divided into 7 segments as a management unit. The purpose of this regulation is to preserve water function and water quality management furthermore the river can be utilized according to its allocation. Segment 1 is upstream area used for: agriculture area, coffee plantation, settlement, and industries (biscuit, soft drink, textile and tofu industry). Segment 2 is used for: settlement, agriculture, and industry (iron smelting industry). Segment 3 is used for settlement. Segment 4 is used for: agriculture, settlement, fishery, fishing and forest. Segment 5 is used for settlement, fisheries. Segment 6 is used for: settlement, fishery, industry and agriculture. Segment 7 is watershed downstream is used for: settlement, estuary, fishery, and port.

2. Methods

The research conducted based on available secondary data 2010 to 2016 derived from the Environmental and Forestry Office of the Central Java Province which provide data and information as well as to the authorized officials in the Garang Watershed. Sampling of water quality was taken in August 2017 from the middle of watershed area to measured water quality parameters.

2.1. Sampling Location

Within seven segments of the Garang watershed (see Figure 1), water samples were taken in the middle area of Watershed that is in segment 3, a confluence area between the Garang river and the Kreo river. The sample ²² located on coordinate 07°01'00.9" S and 110°24'08.8" E. The segment 3 is important area since interaction between flow dynamics, sediment transport and river morphology occurred [23]. It gets pollutants from domestic waste and industrial effluent. Thus it could influence water quality of the river.

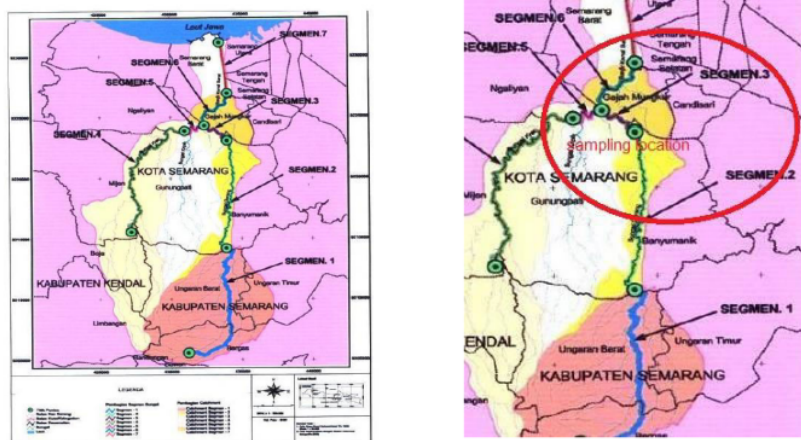


Figure 1. Sampling Location on the Garang Watershed Segments

2.2. Water Quality Parameter Selection

This research analyzed the most frequently measured water quality parameters i.e. temperature, DO, TDS, Nitrate, pH, Chromium, H₂S, COD, Cadmium, Copper and Phosphate.

The Indonesia Government Regulation No. 82/2001 about management of water quality and water pollution is used as a basis to evaluate water quality status. Environmental Ministry Decree No. 115/2003 [18] about Guidelines of Water Quality Status is used to analyze Water Pollution Index using formula:

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

Note:

P_{ij} : Pollution Index for the designation (j) that is a function of C_i / L_{ij}

C_i : concentration of water quality parameters (i) obtained from the analysis of water samples at a research study of a river,

L_{ij} : concentration of water quality parameters listed in the water quality standart (j)

P_{ij} pollution index for a specified water quality purpose (j) was compared to the criteria shown in Table 1, then calculated using excel. The result showed Pollution Index [5]:

Table 1. Pollution Index and Water Quality Status Criteria

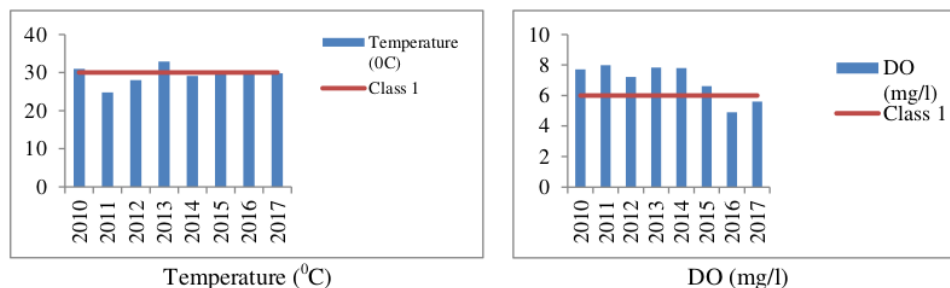
Pollution Index	Water Quality Status
0 ≤ P _{ij} ≤ 1.0	Meet quality standards (good)
1.0 < P _{ij} ≤ 5.0	Lightly polluted
5.0 < P _{ij} ≤ 10	Moderately polluted
P _{ij} ≥ 10	Heavily polluted

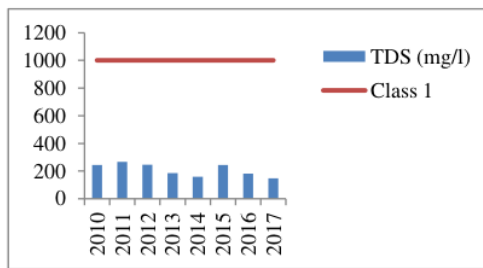
Minister of Environment Decree No. 115/2003 [5]

3. Result and Discussion

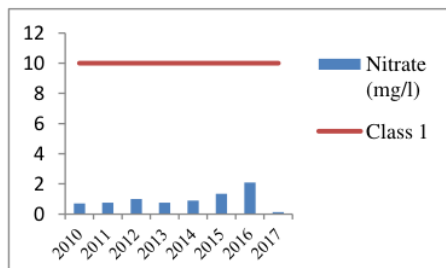
3.1. The Comparison of Pollution Index and Water Quality Standard

The following figure describes the measured water quality parameters

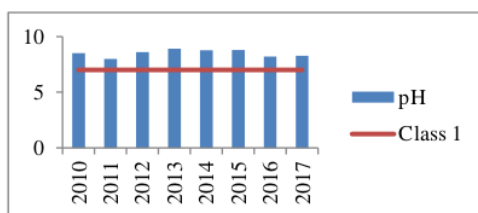




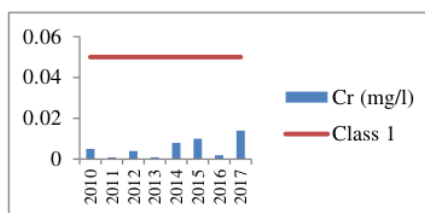
TDS (mg/l)



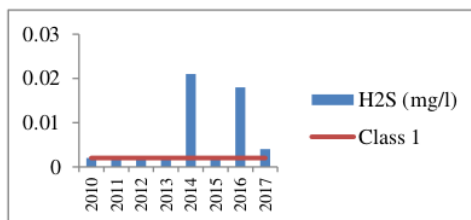
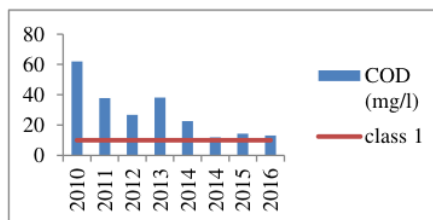
Nitrate (mg/l)



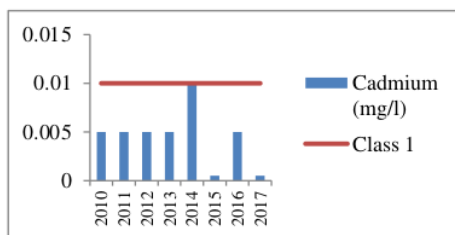
pH



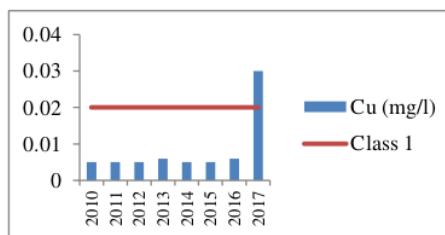
Cr (mg/l)

H₂S (mg/l)

COD (mg/l)



Cd (mg/l)



Cu (mg/l)

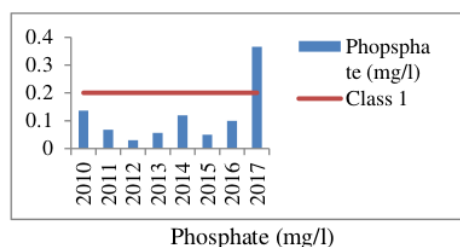


Figure 2. Average value of water quality measurement along the Garang Watershed

Figure 2 describes that the parameters which show their stability each year are TDS, temperature, DO, nitrate and Cr; while that experiencing fluctuation are pH and H_2S ; that decline are COD and Cd; that are increase are phosphate and Cu. Whereas, Cu higher than the water quality standard class 1.

Temperature has an important role in determining water quality in biology, chemistry, and physics [11]. Oxygen parameters are represented by COD and DO. DO is known as a major indicator of river water quality [26]. The measured temperature ranged from 24.8 - 32.9 °C. The sunny weather occurred at the time of sampling. Temperature affects the growth and reproduction rate of aquatic biota. The location of the study is the area of care of larvae and juvenile shrimp and other freshwater fish. DO for shrimp aquaculture ranged from 3-8 mg/l to 7 mg/l [13]. DO is an important parameter for aquatic biota for respiration. The presence of DO in water is caused by photosynthetic activity. DO affects biota nutrition, and stratification [9]. The measured DO ranged from 4.9 – 7.9 mg/l. The concentration of TDS is influenced by waterflow. TDS can occur natural [2] and due to the effect of human activities. Predicting the magnitude of TDS can help maintaining good water quality for the consumption of population, industry, fisheries, and agriculture [24]. The measured TDS ranged from 148-266 mg/l. Nitrate affects the process of nitrification and denitrification, and is an important element of the nitrogen cycle. The use of fertilizers containing nitrates can give the effect of increasing nitrate to the river cumulatively. Other factors that affect the magnitude of nitrate are waste discharge, nitrogen fixation, and water runoff [25]. The measured nitrate ranged from 0.13 – 2.1 mg/l. Heavy metals such as Cr can be harmful to humans even in trace amounts [20]. Cr can contaminate the waters, dissolved in water, settling in the bottom waters, corrosive, and toxic [6]. The results of his research in 2015 in Cimanuk watershed West Java Indonesia, Cr ranged from 0.01 - 0.016 mg / l, thus that Cr content remains potentially harmful to existing aquatic life [6]. The natural content of Cr heavy metals in water is 0.0017 mg / l, so that Cr content above the value is considered to be harmful to the life of aquatic biota [19]. The measured Cr ranged from 0.001- 0.014 mg/l at Garang river, in conclusion is a dangerous category.

Parameters experiencing fluctuating differences are pH and H_2S . pH of the water will change due to waste from industrial activities being dumped into the river. Waste interferes with the life of the organism in water. pH affects the toxicity of a chemical compound [16]. The measured pH ranged from 8-8.9. A good pH according to government regulation is 6-9. Hydrogen sulfide exists in unionized (H_2S) and ionized forms (HS^- and S_2^{2-}) in the water. H_2S is affected by pH, temperature, salinity, but most importantly influenced by pH [10]. The measured H_2S ranged from 0.002 – 0.021 mg/l.

The fluctuation parameters are COD and Cd. COD can be used to directly measure organic pollutants in the waters [17]. COD is a measure of oxygen consumed during the decomposition of organic matter and oxidation of inorganic chemicals [27]. The measured COD ranged from 11.9 – 61.93 mg/l. COD is influenced by the degradation of organic and inorganic materials. This comes from human activities that live around the river or industrial effluents that are not properly processed [26]. Cd came from welding, electroplating, pesticides, fertilizer [21]. The measured Cd ranged from 0.0005 – 0.01 mg/l.

The increasing parameters are phosphate and Cu. Household wastewater containing cleaning substance, agricultural runoff water from fertilizers, detergents and soaps are the main source of phosphate. The source of this phosphate is influenced by urbanization degree, agricultural practices and domestic waste [15]. The measured phosphate ranged 0.03 - 0.366 mg/l. Phosphate is considered to be the most significant among the nutrients responsible for eutrophication, as it is the primary indicating factor [25], furthermore that the community as a river water user should be wise in disposing their waste. The main cause of eutrophication in rivers when water quality is spoiled by nutrient pollution. Algal and plankton growth increases greatly (algal bloom) and this results in oxygen depletion for other aquatic life in the ecosystem [14], if condition closed by alga then the intensity of light entering the body of water will decrease. Consequently, the water will decrease its productivity.

Concentration of measured Cu in the location has exceeds the water quality standard class 1 of the Government Regulation No. 82/ 2001. It caused by effluent of electroplating industry and pesticides from agriculture from the upstream river. Cu is essential micronutrients metal, but it can be toxic at higher concentrations. At the same time, chronic exposure to low concentrations of some metals can also have various health effects [3]. Concentration of Cu, Nitrate and phosphate will pollute surface water as it may have negative impacts on water supply and ecosystems [8]. Good concentration of Cu and phosphate according to the government regulation are 0.02 and 0.2 mg/l.

The water quality standard of class 1 is for drinking water, and or other designations that require the same water quality as those uses [7]. Table 2 showed the comparison value between the pollution index of the Garang River (Ci) and the water quality standard class 1 (Lix). The water quality parameters that exceed the limit are Cu and phosphate. From the calculation of water pollution index (PI = 1.23) is means that water quality of the Garang river is lightly polluted

Table 2. The Comparison Pollution Indeks with Water Quality Standart Class 1

No	Parameters	Ci	Lix	(Ci/Lix)	(Ci/Lix) _{measurement}
1	pH	8.28	6.0 - 9.0	1.08	1.07
2	TDS	148	1000	0.15	0.15
3	Cr	0.014	0.05	0.28	0.28
4	Cu	0.03	0.02	1.50	1.35
5	Nitrate	0.06	10	0.01	0.01
6	DO	5.6	6	0.93	0.93
7	Phosphate	0.366	0.2	1.83	1.52
				(Ci/Lix) _M	1.52
				(Ci/Lix) _R	0.83
				PI	1.23
				status	lightly polluted

4. Conclusion and Recommendation

Water quality of the Garan river met water quality standard class 1 based on the Government Regulation No 82/2001 that is considered safe for drinking water supply. However, concentration of Copper and phosphate have exceeds the water quality standard with a value of water pollution index is 1.23 that is considered to lightly polluted.

Information on water quality status of the watershed could assist stakeholders in evaluating their uses and its impacts to be formulated for setting management strategies of the watershed. The local government should endorse the prevailing laws and regulations to users who dispose their waste

wisely. The existence of cooperation within and between institutions is necessary in managing the river. The water quality index method is very helpful in analyzing river pollution levels.

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