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INVESTIGATION ON THE BIODEGRADATION CAPACITY OF URBAN RIVERS IN JAKARTA, INDONESIA

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ABSTRACT: Jakarta is a city with dense population and various activities causing the heavy pressure to the environment. Domestic and non-domestic activities are generating pollution to its rivers. The water body actually has itself a self natural purification capability. The characteristic of the river water quality will affect this pollution degradation process. This research is conducted to examine the biodegradation capacity of Jakarta's rivers. Water quality data of 23 rivers were collected for the time period of 2011 to 2015. Biochemical Oxygen Demand (BOD) and Chemical Oxygen Demand (COD) concentrations are then being used to calculate the BOD/COD ratio. The calculation results show that during the period time of 2011-2013 the ratio ranges between 0.36 and 0.63, which indicates that the rivers have average biodegradation capability. However, the 2014 year's data show that almost all of the rivers have ratio less than 0.2, indicating the no-biodegradation capability. Existence of metals can also inhibit the biodegradation process. The water quality data shows significant increase of metals in the year of 2014, especially Copper and Zinc in several rivers. Surfactant was also observed in extremely high concentration. Thus, most of the Jakarta's rivers have relatively low capability in biodegradation capacity and self purification capability. Although the latest year data shows an improvement, yet the BOD/COD ratio is still in the range of slow of biodegradation capacity.

Keywords: biodegradation capacity, BOD/COD ratio, self purification

1. INTRODUCTION

Urban river systems are often heavily degraded, a situation that is not confined to a particular geographic region of the world, but common to all areas subject to urbanization [1]. Urban development imposes enormous changes on the form and function of river systems [2]. Nowhere is the impact of human population growth and land alteration more apparent than in the water quality of urban rivers [3]. River water and sediment quality are affected by storm water and waste water drainage and by point and diffuse inputs of pollutants [2]. Balancing the interactions between natural and constructed systems in urban areas is crucial for the future supply of water for large human settlements [4].

Jakarta, as a capital city of Indonesia, has several rivers crossing across its area. Visually, those rivers water quality apparently suffer with heavy pollution. There are 13 major rivers flowing through the city of Jakarta. These rivers receive pollutants from industrial and household sources in both solid and liquid forms [5].

Naturally, the organic-polluted rivers can purify themselves. Many physical, chemical, and biotic processes are important for the formation of water quality and water purification in aquatic ecosystems. Many of these physical and chemical processes are either controlled or affected to a certain degree by biological factors. For example, the rate of the sorption of pollutants by settling particles of suspensions depends on the concentration of phytoplankton cells; photochemical decomposition of substances is only possible in transparent water, and the transparency is ensured by the filtration activity of hydrobionts. Thus, biotic processes are pivotal for the entire system of water self purification [6]. The removal of pollutants from a water body without any artificial controls is called self-purification, or natural purification. The mechanism of self-purification of water bodies can be divided into three groups: physical processes, chemical processes and biological processes [7].

The characteristic of the river water quality will affect the pollution degradation process. This research is conducted to examine the biodegradation capacity of Jakarta's rivers. Monitoring of biochemical parameter is a routine water quality assessment for river quality where pollution is of concern due to rapid urbanization and industrialization that can post threat to sustainability of river conservation. Thus BOD and COD are two widely used parameters for organic pollution measurements [8]. The BOD/COD ratio is an indicator of biodegradation capacity [9]. The ratio is also affected by the concentration of non-biodegradable material.

BOD/COD ratio is found to be reliable and useful indicator to relate organic matter content in the river under tropical climate condition.

BOD/COD ratio can be used as crucial attribute for characterization of river and critical indicator for pollution measurement in the river water study [8].

A value of >0.5 BOD/COD ratio denotes rapid biodegradation, and a range of 0.2-0.4 indicates biodegradation only in favorable thermal condition [10]. Having the biodegradation capacity will suggest the further treatment and strategy to overcome the polluted urban rivers.

2. METHODOLOGY

Yearly samples were taken by the River Agency of Ciliwung-Cisadane River Region. The number of sampling stations in the Ciliwung-Cisadane Basin Region is 50; however some of the sampling stations are determined later, started from 2012. In the year of 2011, the sampling stations were lesser that those today. To have a better comparison, this research is only analyzing 34 stations which have complete data since 2011. Figure 1 shows the location of all sampling stations. In the year of 2013, the samples were taken twice a year denoting the rainy and dry seasons.

The biodegradation capacity of river water is determined by using BOD/COD ratio. In most effluents, BOD is less than COD, and elevated BOD5/COD ratio signals a high rate of biodegradation of wastewater [11]. This ratio is generally considered the cut-off point between biodegradable and non-biodegradable waste [12].

Measurement of BOD and COD were carried out using dilution method and dichromate method, respectively, according to the APHA's Standard Method [13].

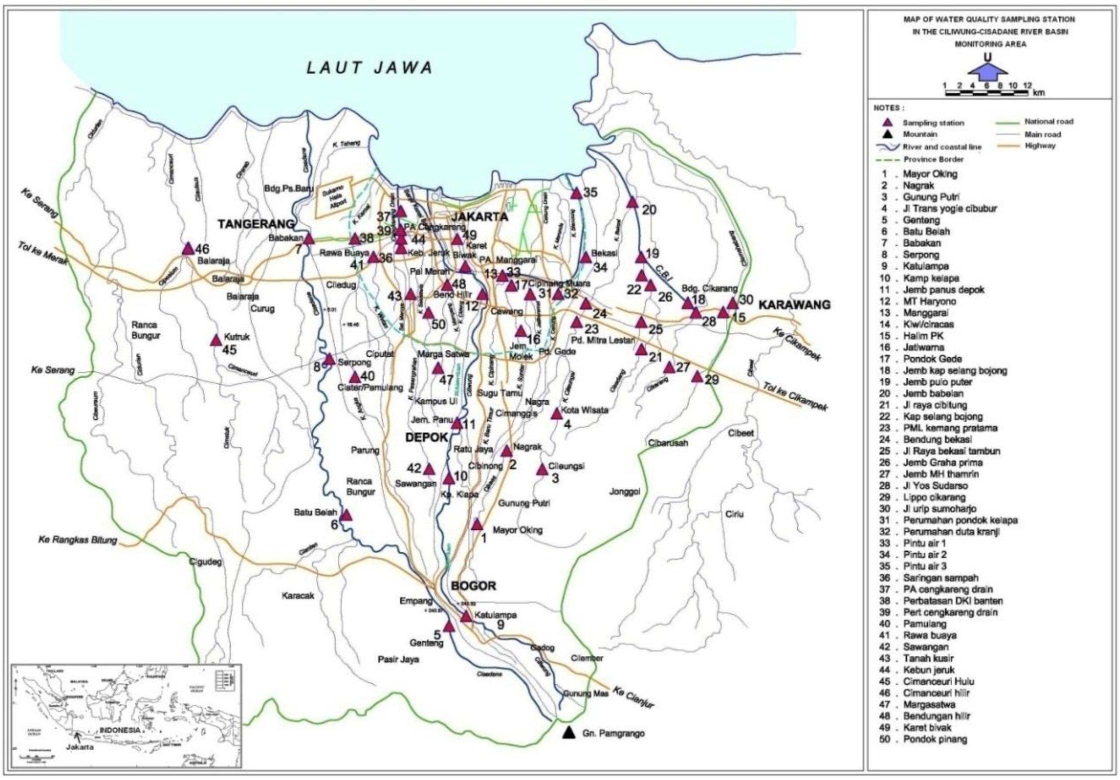

Fig. 1. Map of Ciliwung-Cisadane River Basin and water sampling stations [14].

Biodegradation capacity determination can be indicated by observing the inhibitor of self-purification process. Heavy metals and MBAS surfactant were also determined from the water samples to support the result of river water biodegradable capacity results. Measurements of heavy metals were conducted using the spectrometry method [13]. The inhibitory effects of heavy metals on the self-purification process started at much higher concentrations of metals than those typically found in surface water [15].

Use at most three levels of headings that correspond to chapters, sections and subsections. The first level headings for chapter titles should be in 10pt, bold, justified, and upper case font. Leave one-blank line before and after the first level headings, respectively.

3. RESULT AND DISCUSSION

The Figure 2, 3, 4, 5 and 6 depict the BOD/COD ratio of Jakarta's Rivers for the year of 2011, 2012, 2013, 2014 and 2015, respectively. There are two set of data of the year 2013 representing the rainy and dry season. The black shading on the Fig 4 shows the rainy season's data, whereas lighter grey shading on the Fig. 4 shows the dry season’s.

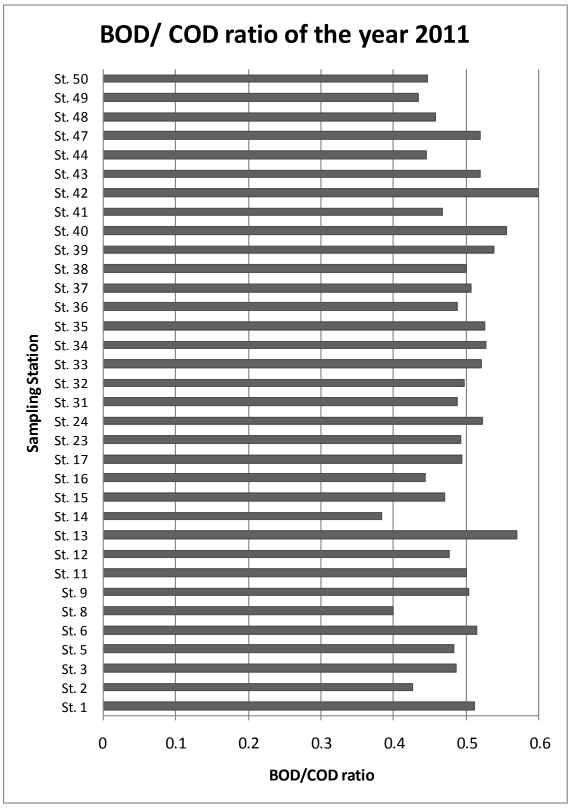

Fig. 2 BOD/COD ratio of the year 2011

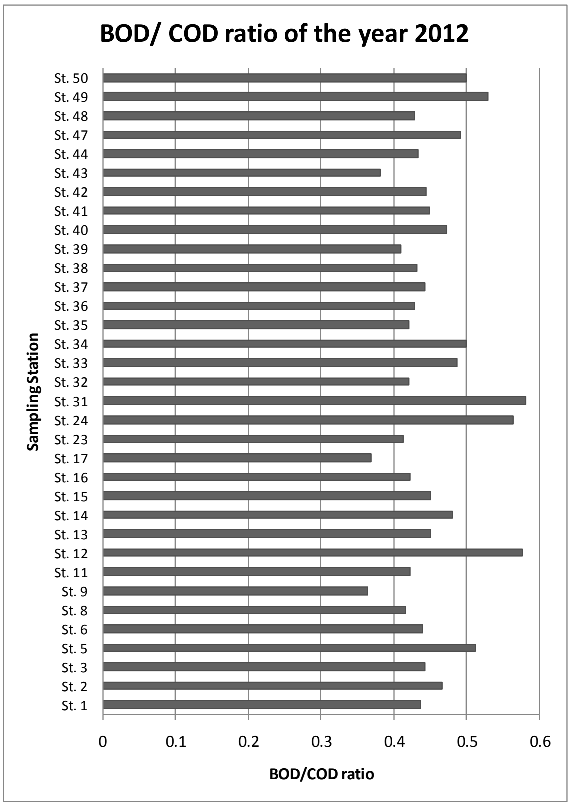

Fig. 3 BOD/COD ratio of the year 2012

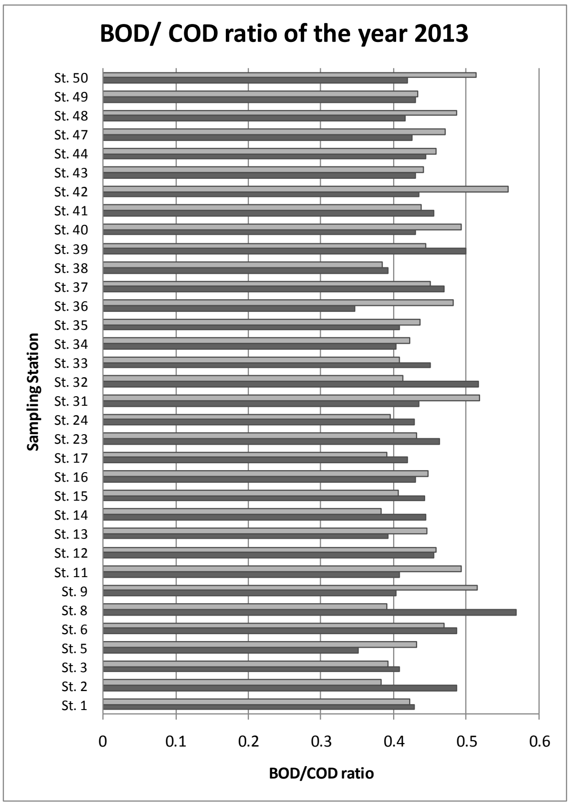

Fig. 4 BOD/COD ratio of the year 2013

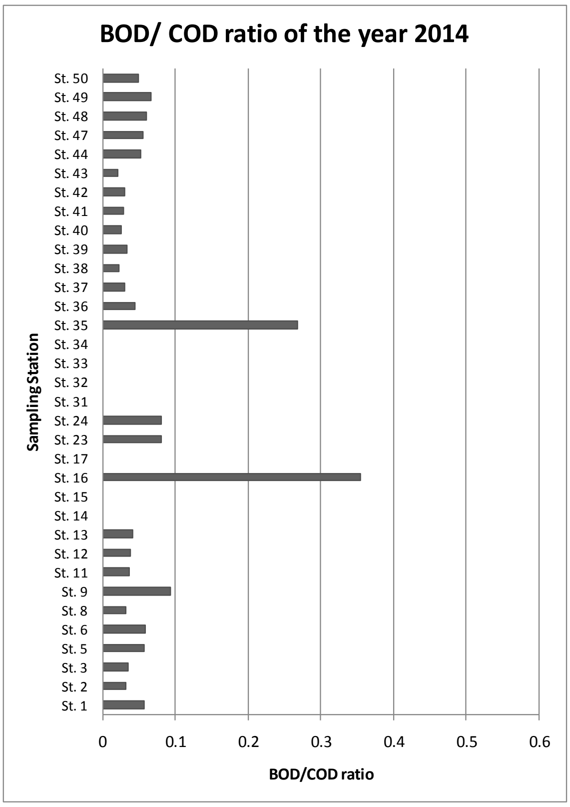

Fig. 5 BOD/COD ratio of the year 2014

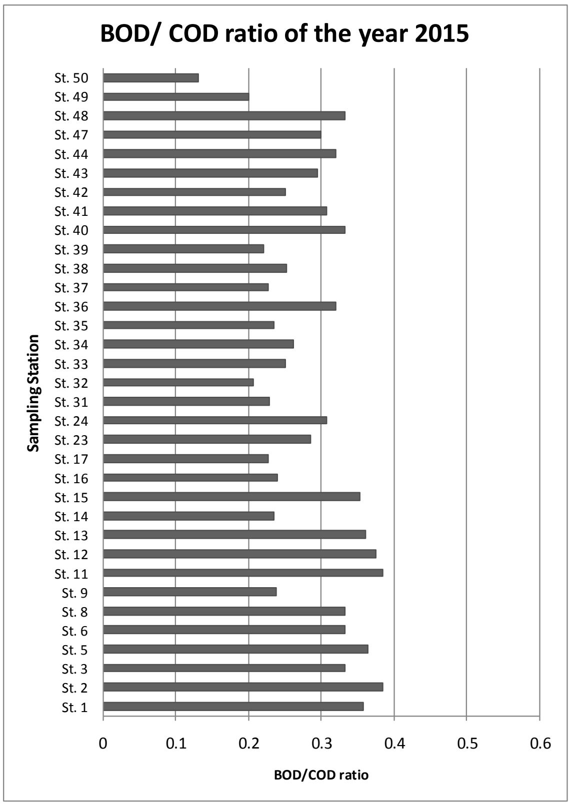

Fig. 6 BOD/COD ratio of the year 2015

The recapitulation of the range and mean value of BOD/COD ratio are displayed in Table 1.

Table 1 The BOD/COD value

Year	min	max	mean value
2011	0.38	0.63	0.49
2012	0.36	0.58	0.46
2013a	0.43	0.56	0.44
2013b	0.38	0.55	0.44
2014	0.02	0.35	0.07
2015	0.13	0.38	0.29

Note: 2013a represents the rainy season, whereas 2013 represents the dry season.

The table and figures show that, the BOD/COD ratio decline from year to year, especially in the year of 2014. It can be seen significantly that the water quality of rivers deteriorated in the year 2014 almost thoroughly. Only two stations showed the value above 0.1. In the year of 2015, the ratios are improved to 0.29 in average. Observing data sets of the year 2013 that are representing the season, it can be seen that there is no significant different between rainy and dry seasons. Low value of BOD/COD ratios can be affected by the increasing of COD concentration. High concentration of COD indicates pollution from non-domestic activities. The results can be used to focus on the industrial wastewater treatment. This measurement might have been conducted to improve the following year's river water quality condition.

The further observation was carried out to investigate the water quality condition of the rivers considering the biodegradable capacity. Based on research, there is a strong relationship between water quality and land use [16]. Table 2 depicts the concentration of Copper, Zinc and MBAS (methylene blue active substances) surfactants to represent the content of heavy metal and detergent. Heavy metals are toxic to the mixed culture of microorganisms responsible for the decomposition of organic compounds in surface waters [15].

Depending on the situation, synthetic surfactants and other pollutants may have different effects on hydrobionts (they can inhibit their growth, change their behavior, and the like), which can affect the water purification processes [17].

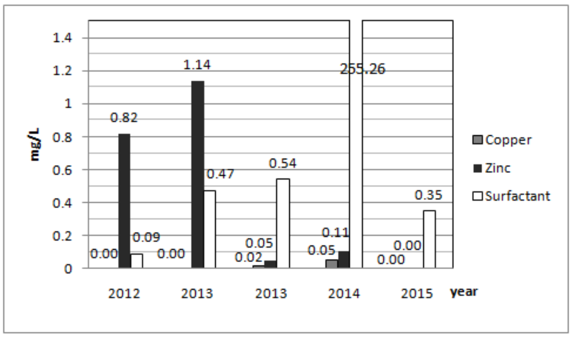

Fig. 7. Concentrations of Copper, Zinc and MBAS Surfactant

Almost all heavy metals concentrations were under the maximum level of the river water quality standard. These metals can be derived from the industrial wastewater. Copper was found slightly high in the year 2013 and 2014, and Zinc was also detected rather high in the year 2012 and 2013. Those metals concentration decrease from year to year. Nevertheless, the MBAS surfactant concentration increase, and reached an extremely high value in the year 2014. This condition worsens the river water considering its capability of self-purification process. Surfactant can be derived from the washing activities in the domestic area. Much of aquatic pollution involves sewage in which organic waste predominate. This waste can increase secondary productivity while altering the character of the aquatic community. Most fishes especially the species desired as food by man are among the sensitive species that disappear with the least intense pollution [18].

The BOD/COD ratios are highly affected by the wastewater discharged into the river. Variation of the ratios in each sampling station shows that every river segments is influenced by the activity's wastewater located near it. Besides that, many other factors might affect the BOD/COD ratio, such as river's physical condition, decomposer microorganism existence, etc.

The conditions of those rivers were improved in the year of 2015. Heavy metals were not detected and the concentration of MBAS surfactant was lowering. This improvement will lead to an enhancement of the biodegradation capacity of the rivers. Fluctuation of water quality can be caused by many factors. Therefore the unpredictability in the water quality management is physical characteristics and phenomena change of nature [19]. The activities to manage the domestic and non-domestic wastewater are needed to be continuously conducted.

4. CONCLUSION

Jakarta as a capital city of Indonesia has urban rivers affected by its activities. The ratio of BOD/COD decreases from the year of 2011 to 2014, and slightly increases in the latest year. Based on the BOD/COD ratio values, it can be concluded that the Jakarta's rivers generally have slow biodegradation capacity during 2011-2015, except in the year of 2014 that showing the non-degradable condition. Improvement was observed in the latest year which gives slight increment of biodegradation capacity and decrease of self-purification inhibition parameters' concentrations. Although the improvement has been perceived lately, the measurement to manage the domestic and non-domestic wastewater need to be continuously conducted.

5. ACKNOWLEDGEMENTS

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