

Domestic Wastewater Contribution to Water Quality of Brantas River at Dinoyo Urban Village, Malang City

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Abstract

Domestic wastewater from human activities in densely populated settlements could affect the quality of streamflow because its organic matter could affect the amount of oxygen in aquatic ecosystems as an impact from biological and chemical degradation processes. The main aim of this research was to analyze the contribution of domestic wastewater from Dinoyo Urban Village settlement to the water quality of Brantas River on BOD and COD concentrations. The sampling of water and respondents were taken by purposive sampling method. The water sampling using grab sample method was performed at upstream, middle, and downstream stations of the river segment. The Estimation Method by regulation was employed to calculate BOD and COD emissions. The results showed that BOD concentrations were between 12.7 to 13.627 mg/l⁻¹ and COD concentrations were between 26.677 to 28.197 mg/l⁻¹. The amount of BOD emission was 539 kg/day and COD emission was 1032 kg/day which were dominated by human activities in bathing, washing, and lavatory. It concluded that domestic wastewater from settlement contributed to the streamflow quality by the increase on BOD and COD concentrations at each sampling points and it could not be used to its utility because it exceeded the class II of water quality standards.

Keywords: BOD, COD, emission, human activities, water quality.

INTRODUCTION

Water pollution has been a major problem in several countries in recent years. In Northern Ireland, there were almost 1200 water pollutions every year. In China, almost 1700 water pollutions occurred every year and up to 40 percent of rivers were heavy polluted [1]. In Japan, water pollutions were almost 1487 incidents in the last 10 years, with four incidents occurred per day in a class I river system which caused harmful effects on the economy sector and society [2]. In Indonesia, especially in Malang, Brantas River is one of the main rivers. However, several studies have reported that it has been polluted for a long time with different level of pollution [3][4][5][6].

Some areas on the Brantas River are heavily polluted because of erosion and nonpoint sources pollutant [3]. At the upstream of Brantas Watershed in Malang, some areas had poor quality and had decreased because of waste disposal into the river [4][5][6][7]. The other research reported that Brantas River has been light and moderate polluted from upstream, this condition is related to development activities,

land uses, and domestic activities in the watershed [8][9][10][11].

Rapid population growth can cause several problems in developing countries, such as Indonesia. Sometimes, the existence of development for the prosperity of society does not attend the rules of environmental sustainability. It raises problems that relate to the social and environmental dimensions that must be resolved immediately. One of them is river water pollution caused by domestic wastewater. The existence of densely populated settlements which is not supported by proper domestic wastewater treatment facilities, and also the function changes of land use have the potential to cause pollution on water bodies [12]. The results of research at many locations prove that human activities can cause water pollution and affect the sustainability of water resources [13][14][15][16][17][18]. The increasing of population number affects the increasing of the utility for clean water, but water pollution causes limited availability for proper quality water. Therefore, the sustainability of

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water resources in quality, quantity, and continuity is very important.

Indonesia is one of the countries that contributes 85% of domestic pollution to water bodies [19]. Most of the rivers in Indonesia have been polluted after passing settlements, industries, and agriculture areas. Domestic activities are the largest contributor to BOD concentrations in rivers [20][21]. Domestic wastewater from households causes pollution because it is not managed properly so it has high pollution load to river water. Meanwhile, the contribution of domestic waste to water pollution is as much as 80% in Bandung City and 75% in Jakarta. It is caused by the low level of people knowledge and awareness of the environment.

The periodic monitoring of river water quality is needed as one of the pollution control efforts. It can keep the water quality in accordance with its classification. Water quality can be measured from physical, chemical, and biological parameters [22]. Water quality that is not in accordance with its quality standards can be said to be polluted [23]. Pollutant sources are classified as point sources and nonpoint sources. Point sources are can be determined geographically, while nonpoint sources are cannot be located precisely which is generally consists of a large number of relatively small individual sources, such as agriculture, settlement, and transportation [24].

Domestic wastewater that enters water bodies can originate from activities of residential settlements, restaurants, offices, commerce, apartments, and wastewater treatment plants [25][26][27]. Most of them contain organic matter that comes from the disposal in bathrooms, kitchens, and washing facilities [28]. The impact of pollution on water bodies is the reduction of the amount of oxygen in the water that threatens the existence of aquatic biota and provides bacteria to grow [29][30][31]. The presence of organic matter as much as 66% and the presence of anaerobic microorganisms cause discoloration and foul smell in water bodies.

This research was located in Dinoyo Urban Village, it is one of the areas in Malang City which is passed by the Brantas River and has high population density. In addition, in some areas are near and adjacent directly to the river, so the domestic wastewater that produced flows directly into water bodies. Most of the land use is used for residential settlements and its support facilities. Dinoyo Urban Village can be classified as a dirty area which includes three of seven hamlets.

So far, domestic wastewater from settlements as river water pollutants has received few attention and considered as an unimportant problem. Many people do not know that it is one of the biggest pollutants in Indonesia and gives impact to the water bodies. Based on the description and urgency above, there is not much publication to this matter, so this research needs to be done. The main aim of this research is to analyze the contribution of domestic wastewater from Dinoyo Urban Village settlement to the water quality of Brantas River on BOD and COD concentrations.

MATERIAL AND METHOD

This study used a quantitative descriptive method to explain and describe the conditions in field factually which was based on obtaining the quantitative data. The research was located in Dinoyo Urban Village, Malang City, particularly in three hamlets that were RW 01, 03, and 06 which located near the river.

Data Collection

Data collection was carried out by survey and direct observation in the field through the sampling of river water and resident respondents by purposive sampling. The data were primary and secondary data. Primary data were the results of the laboratory test on river water quality about BOD and COD concentrations, as well as the results of the questionnaire and interview with residents. Secondary data was the number of residents that was collected from Dinoyo Urban Village Office. Univariate analysis was used as a descriptive statistical analysis to determine the frequency distribution of data, such as mean and deviation standard for BOD and COD concentrations data, as well as the percentage for questionnaire data presentation.

The reason of using BOD and COD parameters was because it is the basic and important indicators that can be used to determine the water pollution, particularly due to domestic wastewater that contains high organic matter [28]. In addition, domestic activities are the largest contributor to BOD concentrations in rivers [20][21]. So, it can describe the impact of domestic wastewater pollution [34][35] on water bodies through the amount of oxygen that is needed on chemical and biological degradation of organic matter. Meanwhile, organic matter inside of wastewater produced by the use of water in human activities can contribute to BOD and COD emissions in water bodies. Nowadays, BOD and

COD become the urgency of water pollution control. The previous data record which was sourced from related institution [54] showed that pathogenic microorganisms such as coliform total bacteria in water bodies quality had not exceeded the quality standard in research location. It was different from BOD parameter which always exceeded the quality standard and COD parameter which had a relatively high concentration on quality standard. So, it became why coliform did not use as an indicator in this research.

The water sampling was conducted by grab sample method during the morning with three times repetition on each station and the quality testing was in the laboratory. The sampling points were determined into three stations at the upstream (T1), middle (T2), and downstream (T3) of Brantas River at Dinoyo Urban Village segment. Questionnaire data collection were conducted on 72 respondents who were selected based on their access to proximity and live near the river.

The data analysis were conducted as follows:

a. Water quality analysis

The data of water quality were evaluated by comparing the laboratory results and second class water quality standard in the Government Regulation Number 82 of 2001 about Management of Water Quality and Water Pollution Control [23]. Brantas River on the research location is classified as class II, the water is used for water recreational facilities, cultivation of freshwater fish, livestock, water for irrigating agricultural crop, and other utility that requires the same water quality as use that is. And also, it was analyzed by calculating the differences between BOD and COD concentration on before, during, and after passing the settlement.

b. Domestic wastewater pollution load analysis

The level of pollution or contribution of domestic wastewater could be estimated by The Estimation Method [24]. The Estimation Method is the multiplication of emission factor per resident, population density, and an inventory area. Emission factors could be seen in Table 1.

Table 1. Emission Factors of Nonpoint Pollutant Sources

	Emission factors (g/person/day)	
	BOD	COD
Wastewater without treatment	53	101.6
Using septic tank	12.6	24.2

Source: The Regulation of Minister of Environment Number 01 of 2010.

c. Questionnaire Analysis

The questionnaire used the Likert Scale with four choice answers. The questionnaire results were presented using a graphical form with a percentage number.

RESULTS AND DISCUSSION

The results of water quality monitoring in the Brantas River could be seen in Figure 1 and the statistic analysis could be seen in Table 2. The results showed that there were increases in the average BOD and COD concentrations at each station. The BOD concentrations were in the range of 12.7 to 13.6 mg/l⁻¹ with the deviation standards were 1.64 and 1.73. Based on Government Regulation Number 82 of 2001, that value exceeded its quality standard for class II water that is 3 mg/l⁻¹. The COD concentrations were between 26.68 to 28.20 mg/l⁻¹ with the deviation standards were 3.33 and 3.83. It also exceeded its quality standard that is 25 mg/l⁻¹. The results of statistic analysis reported that the value of deviation standards were less than the mean value. It could be inferred that the data had good distribution and it was not refract. It was caused by deviation standard value described that the data deviations were low.

Table 2. The Results of Statistic Analysis

Variable	Mean	Deviation Standard
BOD		
T1	12.7	1.64
T2	13.2	0.26
T3	13.6	1.73
COD		
T1	26.68	3.33
T2	28.06	0.87
T3	28.20	3.83

Source: The Result of Analysis

The highest concentration of research result was at the third station (T3) and it showed that the increase of BOD was proportional related to the increase of COD. [33] If BOD and COD concentrations were greater, so water pollution would be higher. It showed that activities in Dinoyo Urban Village contributed to the pollution of the Brantas River. The main activities came from settlement and residential support facilities, such as schools and campuses, stalls and shops, malls, offices, and even hospitals. However, it should be noted that before entering the research location (T1), the water had been polluted and its quality exceeded the applied standards.

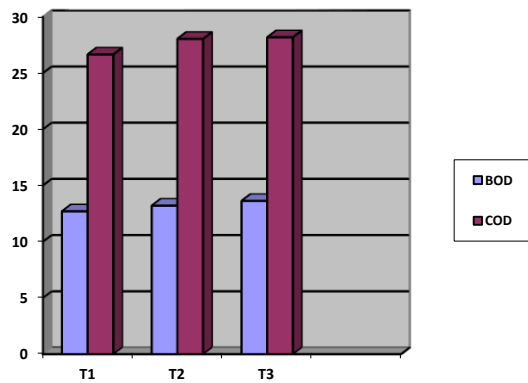


Figure 1. BOD and COD concentrations (mg/l^{-1}) of streamflow in the research location (T: point of water sampling)

The amount of dissolved oxygen that was needed by bacteria to degrade organic matter as biologically in water is called BOD. Organic matter in water could come from natural sources and human activities, especially household waste, as well as others from agriculture, livestock, and industry. The BOD estimation was used to evaluate the pollutant load caused by domestic waste and estimated its impact on the environment [34][35]. If the BOD value was getting bigger, the amount of organic matter in the water was also getting bigger. It was indicated by the increase of water quality in each sampling station that most received input from domestic waste in Dinoyo Urban Village settlement. It was related to [36] that stated an increase of BOD could be indicated from domestic waste and others. The existence of disposal waste from settlements into a river could affect BOD values became high [37].

COD was the amount of oxygen that was needed to decompose organic matter chemically and a high value of COD indicated water pollution increase [35]. Based on the results of the study, showed that the COD concentration had exceeded the quality standard, which was above 25 mg/l^{-1} , while non-polluted water had COD value of fewer than 20 mg/l^{-1} [38][39]. A study reported that domestic waste and other sources that entered the river could contribute to pollution loads for COD. It was indicated by an increase in COD value from each station that received input from settlement and its support facilities wastewater.

Pollutant load or contribution from domestic wastewater in Dinoyo Urban Village settlement to the quality of Brantas River water bodies were

based on emission factors which could be seen in Table 3.

Table 3. Emission Ammount of Non Point Pollutant Sources

Emission ammount (kg/day)	
BOD	COD
539	1032

Source: The Result of Analysis

The amount of domestic wastewater emissions were estimated through the pollutant load of BOD and COD that were produced by three hamlets which disposed of their emissions to water bodies, namely RW 01, RW 03, and RW 06. The contribution of each area could be seen in Table 4.

Table 4. BOD and COD Emissions in The Research Locations

Location	Population Density (person/ha)	Total Area (ha)	Emission Ammount (kg/day)	
			BOD	COD
RW 01	695.7	12.5	110	210
RW 03	520	18.6	122	234
RW 06	861.9	17.2	307	588

Note: RW 01, RW 03, RW 06 are the hamlets of residential settlements which are located nearest to the streamflow

Each area gave different contribution because of population density and area size factors. Besides that, the existence of waste treatment technology was also very influential. RW 01, RW 03, and RW 06 had Communal Wastewater Treatment Plant (WWTP) to treat domestic wastewater but it was not applied to the entire population, only who lived nearest to the river, while the others used a septic tank or not any processing technology. In RW 01 and RW 03, Communal WWTP was only used to process black water but the application was only in settlement nearest to the river and the others used septic tanks. Whereas RW 06 used Communal WWTP for black water and gray water but it also did not reach the entire population. In RW 06, the majority of 80% used private or shared septic tanks, and others were connected to Communal WWTP. Meanwhile, others did not use either WWTP or septic tanks. Therefore, these emissions of BOD and COD at RW 06 were the largest. The treatment type of domestic wastewater would affect different BOD and COD emissions. The septic tanks use could reduce pollution load up to 50% [40][41][42]. In fact, the proper mechanical and biological processing systems could reduce pollutants up to 90-95%. RW 06 also had the highest population density in this area, so it would

be the highest contributor to BOD and COD emissions. The building of settlements that did not well planned resulted in poor sewerage systems that could affect the water sources quality [43][44]. It explained that the existence of continuous building of settlements in high population density could cause water pollution because of bad wastewater treatment systems before being discharged into water bodies [45].

The production of domestic wastewater from the nearest settlement to water bodies of Brantas River at Dinoyo Urban Village was influenced by the daily activities of community which were dominated by bathing, washing, as well as serving as a lavatory that were presented in Figure 2. Figure 2 showed an incidence scale of one to four, where one was the most frequent occurrence and four was the least occurrence.

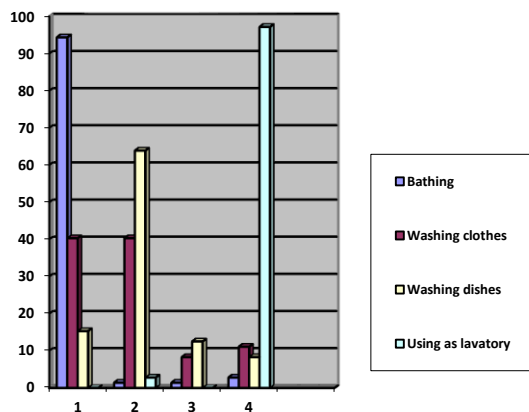


Figure 2. The water use activities in the household

The result of the questionnaires showed that 94.4% of the people always took a bath regularly in the morning and evening, 40.3% of people washed clothes every day and 40.3% others washed once in two days, 63.9% of people washed dishes three to four times a day, and 97.2% of the residents had never done those activities and defecation in the river because 98% of them had their own lavatory. These activities affected the amount of BOD and COD emissions that were discharged into water bodies and affected river water quality [12][46]. The community activities produced two types of domestic wastewater, that were wastewater that came from washing water (soap, detergent, and oil) and from lavatory (soap, shampoo, feces, and urine).

The results of some studies showed waste that contained high organic matter could cause the increase in BOD and COD concentrations and

decreased water quality [39][47][48][49][50]. The organic matters as the composition of domestic wastewater mostly contained nitrogen, phosphorus, detergent, phenol, and *E. Coli* bacteria [40][51]. The high organic matter as the content of domestic wastewater which was discharged into a river caused water bodies to require more oxygen to degrade them. It affected the low amount of dissolved oxygen in the water, so it made aquatic biota were lack of oxygen and caused death [12][52][53]. In fact, aquatic biota was very necessary for balancing the aquatic ecosystems.

CONCLUSION

Domestic wastewater at Dinoyo Urban Village settlement contributed to the water quality of Brantas River with the presence of the increasing on BOD and COD concentrations at each sampling points and it could not be used to its utility because it exceeded the quality standards. The contributions were estimated around 539 kg/day in BOD emission and 1032 kg/day in COD emission as the pollutant load of domestic wastewater to water bodies. The main contributors were sourced from human activities, such as bathing, washing, and lavatory.

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