

# Evaluation of Kalibomo watershed water quality using the storet method

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## Evaluation of Kalibomo watershed water quality using the storet method

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**Abstract.** The Kali Bomo watershed has a length of  $\pm 7,417$  km and passes through Rogojampi District, Banyuwangi Regency. Rogojampi sub-district consists of 10 villages, including Aliyan Village, Powder Village, Gitik Village, Gladak Village, Karangbendo Village, Kedaleman Village, Lemahbangdewo Village, and Mangir Village. The area of Rogojampi District is 102.25 km<sup>2</sup> with a population of 94,268 people. There are 4 watersheds (DAS) in Rogojampi District, namely Binau, Tambong, Bomo and Lumbun which irrigate 11,819 hectares of rice fields and 1,113 hectares of land for corn cultivation. The main problem in watersheds in general is the occurrence of changes in land use due to development both upstream, middle and downstream as well as the conversion of forests into cultivated agricultural land. This has an impact on reduced water absorption function, increased erosion, sedimentation and river water quality. Based on the above conditions, it is very important to conduct water quality analysis, especially in the Kali Bomo watershed so that its sustainability can be maintained. The results of the water quality analysis using the STORET method show that the water quality of the Kali Bomo watershed in the 2017 period from January to April for class I, II, III and IV quality is poor, bad, moderate and moderate, respectively.

### 1. Introduction

The working area of the Water Resources Management Technical Implementation Unit (UPT) in Bondowoso Regency has a Sampean Baru watershed (DAS) consisting of several watersheds, including: (1) the Sampean River Watershed; (2) Kalideluwang Watershed; (3) the Lobawang River Basin; (4) the Tlogo Ampel River Basin; (5) River Basin Curah Macan; (6) the Kali Baru watershed; (7) the Kali Stail Watershed; (8) the Kali Bomo watershed; (9) the Tambong River watershed; (10) The Bajulmati River Watershed.

Research on the determination of water quality in several watersheds has been carried out by [1], [2], [3], [4] and the impact of land use change on damage to watersheds (DAS) was carried out by [5]. This is proven by the fact that the construction of both settlements and cultivated land that does not pay attention to the carrying capacity and carrying capacity of the watershed has resulted in flash floods, which occurred in the Sempol River watershed on the slopes of Mount Ijin, Bondowoso Regency.

The source of pollution that occurs in the Kalibomo watershed comes from waste from the population, agriculture and industry. According to [6], the source of pollutants comes from residential areas producing detergent waste, solid substances, BOD, COD, DO, nitrogen, phosphorus, pH, calcium, chloride and sulfate. Sources of pollutants from agriculture produce waste pesticides, toxic materials and heavy metals. Sources of industrial pollutants include BOD, COD, DO, pH, TDS, oil and grease,



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urea, phosphorus, temperature, toxic materials and turbidity. By knowing the source of pollution, recommendations can be given to reduce the pollutant load along the watershed. This is to ensure water quality and maintain its sustainability, so that people who consume water can be healthier [7].

## 2. Literature Review

### 2.1. Water Pollution and Pollution Sources

Water pollution is pollution of water bodies (such as oceans, seas, lakes, rivers, groundwater and others) which is usually caused by human activities. Changes in the physical, chemical or biological properties of water will have adverse consequences for living organisms. According to the Encyclopaedia Britannica, water pollution is the release of substances into groundwater below the surface or into lakes, streams, rivers, estuaries and oceans to the point where the substances interfere with the beneficial use of water or the natural functions of the ecosystem [8]. Water pollution is when hazardous substances (chemicals or microorganisms) contaminate streams, rivers, lakes, oceans or other water bodies thereby reducing water quality and becoming toxic to humans and the environment. Water pollution causes a fresh water crisis, threatens drinking water sources and other essential needs for humans and other living things. materials that enter and pollute the environment in the form of toxic substances, increase in suspended solids, oxidation and increase in water will change the ecological conditions of the waters in general and the quality of biota in particular. Types of industrial activities with generated waste are presented in Table 1 [9].

**Table 1.** Activities and Types of Waste Produced

No	Activity	Waste generated
1	Raw Food industry	BOD, COD, TOC, TOD, pH, suspended solids, oils and fats, heavy metals, cyanide, chlorides, ammonia, nitrates, phosphorus and phenols
2	Beverage industry	BOD, pH, suspended solids, settleable solids, TDS, oils and fats, color, amount of coli, toxic materials, turbidity and foam temperatures
3	Food Industry	BOD, COD, TOC, pH, oils and fats, heavy metals, nitrates, phosphorus and phenols
4	Printing industry	BOD, COD, TOC, total solids, suspended solids, TDS, oils and fats, heavy metals, ammonia, sulfites, nitrates, phosphorus, color, amount of coli, coli faeces, toxic materials, temperature, turbidity, chlorinated benzoids
5	Timber and motorcycles	COD, heavy metals, and toxic materials
6	Apparel industry	BOD, COD, TOD, suspended solids, TDS, oils and fats, heavy metals, chromium, color, toxic materials, temperature, chlorinated, benzoids and sulfides
7	Plastic industry	BOD, COD, total solids, settleable solids, TDS, oils and fats, zinc, cyanide, sulfates, ammonia, phosphorus, inorganic urea, toxic materials, phenols and sulfides
8	Leather industry	Total solids, salts, sulfides, chromium, pH, limestone deposits, and BOD
9	Iron and metal industry	COD, suspended solids, oils and fats, heavy metals, toxic materials, cyanide, pH, suspended solids, chromium, iron, zinc, chloride, sulfate, ammonia, and turbidity
10	Various industries	BOD, pH, suspended solid, settleable solid, TDS, oils and fats, color, amount of coli, toxic materials, temperature, turbidity, ammonia and turbidity

### 2.2. Water Pollution Parameters

Water pollution parameters can be divided according to their source into two, namely physical and chemical parameters. Physical pollution parameters include: temperature, total dissolved solids, total

suspended solids. While the parameters of chemical pollution include: dissolved oxygen levels, biological oxygen demand, acidity, phosphate, chemical oxygen requirements [10].

**2.3. Water Quality Criteria, Status, and Standards**

According to [11], water quality classification is a limit to the concentration of water quality parameters suitable for a particular use. Water quality standards are regulations according to laws stipulated by the government which include restrictions on the concentration of various water quality parameters.

Water classification based on its designation is followed by the water quality criteria according to the category, namely [12]:

1. Class I, for drinking water raw water, and / or other designations;
2. Class II, for water recreation infrastructure / facilities, freshwater fish farming, livestock, water for irrigating crops;
3. Class III, for freshwater fish farming, livestock, water for irrigating crops;
4. Class IV, to irrigate crops.

**2.4. Analysis Method Storet**

The principle of the Storet method is to compare the water quality data with the water quality standards that are adjusted to their designation in order to determine the water quality status. The method for determining water quality status uses the US-EPA (Environmental Protection Agency) value system by classifying water quality into four classes. As for the classification of water quality based on EPA can be seen in Table 2 [13]. The determination of the value system to determine the status of water quality can be seen in Table 3.

**Table 2.** Determination of Value Systems for Determining Water Quality Status

Number of examples	Score	Parameter		
		Physical	Chemistry	Biology
<10	Max	-1	-2	-3
	Min	-1	-2	-3
	Average	-3	-6	-9
≥10	Max	-2	-4	-6
	Min	-2	-4	-6
	Average	-6	-12	-18

**Table 3.** Water Quality Classification Based on EPA (Environmental Protection Agency)

Class	The total score	Water quality
A	0	Very Good
B	-1 s/d -10	Good
C	-11 s/d -30	Moderate
D	≤ -31	Bad

**3. Material and Methods**

**3.1. Research Procedure**

Water sampling for physical, chemical and microbiological characteristics measurement at each station was carried out three times on the middle side and both riverbanks. Taking the sampling point considers the process of mixing the water mass and river flow [14].

3.2. *Research Location*

Research was conducted in the Kali Bomo watershed with observation points carried out at the observation station which is located in Parijatak Village, Srono District with a location of 8° 21 '52 "LS and 114° 17" 15 "East Longitude using the purposive sampling method.

3.3. *Tool and Material*

This research used Ms.excel 2017 for data analysis using the storet method. The materials used include 1). Physical parameters (pH), chemical parameters (BOD, PO4P, NO2N) and microbiological parameters (Fecal coli) Calculated Analytical Hierarchy Process (AHP) [15].

3.4. *Research Methodology*

3.4.1. *The Framework of the Research Approach*

The measured variables, methods and equipment for determining the quality of water in the Kalibaru watershed are listed in Table 4.

Sample analysis of the research is as follows: (1) Temperature analysis is carried out by measuring temperature; (2) TSS analysis using Gravimetric method; (3) pH analysis using the potentiometer method; (4) BOD analysis using the open reflux method; (5) COD analysis using the open reflux method; (6) NO3N analysis using the spectrometric method; (7) NH3N analysis using the spectrometric method; (8) Total coli analysis using the MPN method; (9) Analysis of total coliform using the MPN method [16].

Determination of the quality status of the Kalibomo watershed uses the Storet method. Determination of the water quality status of the Storet method is carried out by the following steps: (1) comparing the measurement results of the sample with the quality standard values that are in accordance with the water quality class; (2) if the measurement results meet the quality standard value (measurement result <quality standard) then it will be given a score of 0, (3) if the measurement result does not meet the water quality standard (measurement result > quality standard) then it will be given a score. This study used a sample sample at each observation station as many as 3 samples (<10 number of samples) so that the assessment is as shown in Table 5 [17].

**Table 4.** Water Quality Variables, Analysts and Tools Used

No	Parameters	Unit	Quality I	Quality II	Quality III	Quality IV	Analytical Model
1	pH		6 s/d 9	5 s/d 9	5 s/d 9	5 s/d 9	potentiometer
2	BOD	mg/L	2	3	6	12	open reflux
5	PO4-P	mg/L	0.2	0.2	1	5	spectrometry
6	NO3-N	mg/L	10	10	20	20	spectrometry
<b>Microbiology</b>							
1	Total Coli	total/100ml	5000	5000	5000	5000	MPN method
2	Fecal Coliform		5000	5000	5000	5000	MPN method

**Table 5.** Determination of Value Systems for Determining Water Quality Status

Total Sample	Score	Parameter		
		Physic	Chemical	Biology
<10	Max	-1	-2	-3
	Min	-1	-2	-3
	Average	-3	-6	-9

The determination of the water quality standard is analyzed according to the following provisions Class A : Excellent, Score = 0 fulfilled quality standard, Class B : Good, Score = -1 s/d -10 light polluted,

Class C : Moderate, Score = -11 s/d -30 moderately polluted and Class D : Bad, Score =  $\geq$  -31 badly polluted. This research was conducted by collecting data and then conducting a homogeneity test, then analyzing the water quality status using the STORET method and the Pollution Index. Determining the trend of the water quality status with the STORET method and the Pollution Index method at the monitoring station. The parameters used at each station are temperature, TSS, DO, BOD, NO<sub>2</sub>, NO<sub>3</sub>, pH, phenol, detergent and bacteria e. colli [18].

#### 4. Result and Discussion

##### 4.1. Physical Properties

Changes in river water temperature can affect physical, chemical, and biological properties because they play a role in controlling the condition of aquatic ecosystems. An increase in river water temperature causes an increase in viscosity, chemical reactions, evaporation, volatilization and a decrease in the solubility of gases in water, for example O<sub>2</sub>, N<sub>2</sub>, CO<sub>2</sub>, NH<sub>4</sub> and so on. require changes in water temperature not to exceed 2.8°C or not to exceed the normal temperature value  $\pm$  3°C according to the water quality I, II, III and IV. The results of observation of the temperature value of the Kali Bomo watershed are shown in Table 6. Based on the monitoring results, the temperature change value was still within the range of  $\pm$  3°C from the normal temperature. Water temperature is influenced by season, latitude and height of the sea level. The increase in the temperature value which tended to get bigger downstream was caused by the increasing of population, industry and ranch growth. The increase in river water temperature was caused by pollution or waste content that entered the river as a result of household, agricultural, ranch and industrial activities which caused an increase in the decomposition of organic matter by microbes. the increasing number of industrial and human activities can result in an increase in water temperature and the measurement time can also affect the value of water temperature because of the ability of water to absorb heat from its environment. TSS consists of silt and fine sand and microorganisms, mainly caused by soil erosion or soil erosion that is carried into water bodies (Effendi, 2003). The TSS value of Kali baru watershed met the requirements for water quality I, II, III and IV where <1000 mg/L, so that the TSS parameter had no significant effect. The results of the observation of the minimum, maximum and average TSS values of the Kali Bomo watershed are shown in Table 12. Based on the results of water quality monitoring from the monitoring point, the TSS parameter value fluctuated significantly but still met the requirements for the water quality I, II, III, and IV, which was <1,000 mg/L.

**Table 6.** Value of observations of physical properties (Temperature and TSS)

No	Information	Physical Properties (Temperature, TSS)						
		January	February	March	April	Minimum	Maximum	Average
1	Temperature(°C)	24,70	24,70	24,70	23,80	23,80	24,70	24,48
2	TSS (mg/L)	18,80	17,10	29,90	86,40	17,10	86,40	38,05

##### 4.2. Inorganic Chemical Properties

pH value as a measure of the acidity and basicity of water, where the pH value for normal river water meets the life requirements ranging from 6.5 - 7.5 BOD is a description of the level of organic matter in the watershed, which is the amount of oxygen required by aerobic microbes to oxidize organic matter into carbon dioxide and water. Waters in watersheds with high COD values are not good for fishing activities. The COD value in uncontaminated waters is usually less than 20 mg / L, in polluted waters the COD value can exceed 200 mg / L.DO is an important water quality parameter as well as a limiting factor in determining aquatic life. The factors that affect oxygen solubility are temperature, salinity, water turbulence and atmospheric pressure.

The nitrate content in the Kalibaru watershed in 2016 is shown in Table 13. Water quality criteria II from the Regional Regulation of East Java Province No. 2 of 2008 stipulates the upper limit of nitrate content is 10 mg / L. The nitrite content in the Kalibaru watershed in 2016 is shown in Table 15. Water quality criteria II from the Regional Regulation of East Java Province No. 2 of 2008 stipulates the upper limit of the nitrate content is 0.06 mg / L. The results of observations of chemical properties in the form of pH, BOD, COD, DO, total phosphate, nitrate, ammonia, and nitrite are listed in Table 7.

#### 4.3. Microbiological Parameters

The indicator of pollution of a water body from a watershed is the content of the coliform group *Escherichia coli* bacteria and live normally in human and animal feces. The presence of these bacteria is commonly used as an indicator to assess the level of water hygiene.

Several microbiological parameters that can be used to determine water quality are the total number of bacterial viruses, bacteriophages, fungi (fungi), actinomycetes, protozoa, nemathodes and algae. The results of observations of microbiological properties in the form of total coliform and fecal coliform are listed in Table 7.

**Table 7.** Observations of organic chemical properties

No	Variable	Inorganic Chemical Properties (mg / L)						
		January	February	Mach	April	Minimum	Maximum	Average
1	pH	7,40	7,70	6,20	7,10	6,20	7,70	7,10
2	BOD	2,40	5,60	8,75	5,75	2,40	8,75	5,63
3	COD	18,36	24,15	30,49	13,86	13,86	30,49	21,72
4	DO	7,00	6,60	6,00	6,50	6,00	7,00	6,53
5	Total Phospat	0,10	0,17	0,94	0,10	0,10	0,94	0,33
6	NO3-N	0,34	2,02	1,15	1,44	0,34	2,02	1,24
7	NH3-N	tt**)	0,11	0,00	0,06	0,00	0,11	0,06
8	NO2-N	0,01	0,02	0,02	0,10	0,01	0,10	0,04

**Table 8.** Results of observations of microbiological properties

No	Variable	Microbiological Properties (Total/100 mL)						
		January	February	Mach	April	Minimum	Maximum	Average
1	Total coliform	75	93,0	150,0	64	64,00	150,00	95,50
2	Fecal coli	39	39,0	43,0	39	39,00	43,00	40,00

#### 4.4. Organic chemical content

The measured organic chemical components include oil or fat content, MBAS and phenol content, as shown in Table 8.

**Table 9.** Organic chemical content

No	Variable	Organic chemical characters ( $\mu\text{g/L}$ )						
		January	February	Mach	April	Minimum	Maximum	Average
1	Fat	1,90	1,90	1,90	1,90	1,90	1,90	1,90
2	MBAS	0,05	0,013	0,03	0,06	0,03	0,06	0,05
3	Phenol	0,00	0,013	0,00	0,00	0,00	0,013	0,00

#### 4.5 Metal Content



The components of the metal content measured include the content of chromium and copper, as shown in Table 9.

**Table 10.** Metal content

No	Variable	Metal Content (mg/L)						
		January	February	Mach	April	Minimum	Maximum	Average
1	Chrome	0,000	0,000	0,000	0,000	0,000	0,000	0,000
2	Copper	0,000	0,020	0,000	0,000	0,000	0,020	0,005

#### 4.5. Physical Properties

Changes in river water temperature can affect physical, chemical, and biological properties because they play a role in controlling the condition of aquatic ecosystems. An increase in river water temperature causes an increase in viscosity, chemical reactions, evaporation, volatilization and a decrease in the solubility of gases in water, for example O<sub>2</sub>, N<sub>2</sub>, CO<sub>2</sub>, NH<sub>4</sub> and so on. Require changes in water temperature not to exceed 2.8°C or not to exceed the normal temperature value ± 3°C according to the water quality I, II, III and IV. The results of observation of the temperature value of the Kali Bomo watershed are shown in Table 11.

**Table 11.** Observation of temperature (min, max and average) in the Kali Bomo watershed

No	Variable	Temperature (°C)			Δ T (°C)	
		Minimum	Maximum	Average	Δ min	Δ max
1	Temperature	23,80	24,70	24,48	1,2	0,3

Based on the monitoring results, the temperature change value was still within the range of ± 3°C from the normal temperature. Water temperature is influenced by season, latitude and height of the sea level. The increase in the temperature value which tended to get bigger downstream was caused by the increasing of population, industry and ranch growth. The increase in river water temperature was caused by pollution or waste content that entered the river as a result of household, agricultural, ranch and industrial activities which caused an increase in the decomposition of organic matter by microbes. The increasing number of industrial and human activities can result in an increase in water temperature and the measurement time can also affect the value of water temperature because of the ability of water to absorb heat from its environment. TSS consists of silt and fine sand and microorganisms, mainly caused by soil erosion or soil erosion that is carried into water bodies. The TSS value of Kalibaru watershed met the requirements for water quality I, II, III and IV where <1000 mg/L, so that the TSS parameter had no significant effect. The results of the observation of the minimum, maximum and average TSS values of the Kali Bomo watershed are shown in Table 12. Based on the results of water quality monitoring from the monitoring point, the TSS parameter value fluctuated significantly but still met the requirements for the water quality I, II, III, and IV, which was <1,000 mg/L.

**Table 12.** Observation of TSS Value in Kalibaru Watershed in 2016

No	Variable	Physical properties of TSS			Requirements (< 1000 mg/L)
		Minimum	Maximum	Average	
1	TSS (mg/L)	17,10	86,40	38,05	Qualified

#### 4.6. Chemical Properties

The pH measurement of Kali Bomo watershed showed that the minimum, maximum and average pH values were 6.20; 7.70 and 7.10. The tendency of the pH value which constantly fluctuated was still within the normal water quality standard for life based on PP. 82 of 2001. This pH value met the requirements for the water quality I (pH 6-9), II, III and IV (pH 5-9). The minimum, average and maximum pH values are shown in Table 13.

**Table 13.** Minimum, average and maximum pH values

No	Variable	pH			Standard Quality I (pH 6-9)	Standard Quality, II, III, IV (pH 5-9)
		Minimum	Maximum	Average		
1	pH	6,20	7,70	7,10	Qualified	Qualified

BOD value of 1 mg/L, water with a BOD value of 3 mg/L is still considered quite pure, but the purity of water is doubtful if the BOD value reaches 5 mg/L or more. Classified water quality based on the BOD value, as shown in Table 14, while the minimum, maximum and average BOD values of the Kali Bomo watershed are listed in Table 14.

**Table 14.** Classification of water quality based on BOD value

BOD ( mg/L)	Water quality
<3	Not Polluted
3-5	Lightly Contaminated
5 - 15	Moderately polluted
>15	Heavily polluted

It shows the minimum, average and maximum BOD values respectively 2.40 mg/L; 8.75 mg/L and 5.63 mg / L. This means that the Kali Bomo watershed is not polluted to moderate when compared to the water quality standard figures based on the BOD value (mg/L), namely the condition of the waters that are not contaminated (BOD value <3 mg/L), lightly polluted (BOD value 3 -5 mg/L) and heavily polluted (BOD value > 15 mg / L). The increasing BOD value was caused by the input of the pollution load which was above the monitoring point such as real domestic waste, domestic/household, industry and ranch waste as well as increasing water temperature downstream. The decrease in BOD value was caused by the condition of the water temperature at the time of measurement. Based on the Government Regulation No.82 of 2001, the average value of BOD is above the water quality standard (<3 mg /L) for class II, which was lightly polluted, indicating that river water in the Sampean River watershed could not be used according to its designation. Based on the result of water quality monitoring, as shown in Table 15, the minimum, average and maximum COD values were 13.86 mg/L, 30.49 mg/L, and 21.72 mg/L respectively.

**Table 15.** BOD Value of Kali Bomo Watershed

No	Variable	BOD Character			Conclusion
		Minimum	Maximum	Average	
1	BOD (mg/L)	2,40	8,75	5,63	Moderately polluted

The COD value increased due to the pollution load input which above the monitoring point, such as real domestic waste and industrial waste. Compared with the data from Government Regulation No.82 of 2001, the average value of COD was still within the water quality standard (<25 mg / L), which means it is smaller than the established quality standard. This showed that river water in Kalibaru watershed

could still be used according to its designation following the criteria for water quality classes II, III, and IV, namely water whose designation could be used for water recreation infrastructure/facilities, freshwater fish cultivation, ranch, irrigation for crops, and/or other designation requiring the same water quality. Meanwhile, the requirement for the first water quality standard was 10 mg/L (Table 16).

**Table 16.** COD Value of Kali Bomo Watershed

No	Variable	COD Score (mg/L)			Conclusion
		Minimum	Maximum	Average	
1	COD	13,86	30,49	21,72	In accordance with the water quality criteria for Class II, III and IV

The minimum, average, and maximum values of Kali Bomo watershed phosphate were shown in Table 17, which are 0.10 mg/L, 0.94 mg/L, and 0.33 mg/L respectively. In comparison to the condition of water quality I with the PO<sub>4</sub>P content requirement <0.2 mg/L, Kali Bomo watershed could be used as standard water quality I, II, III, and IV. The phosphate value was constantly changing concerning various pollution inputs received by water and the width of its coverage area. The phosphate value contamination was caused by the input of the pollution load received from anthropogenic, industrial, and ranch activities. The use of detergent, shampoo, and soap from anthropogenic activities and industrial waste that were not neutralized caused foamy water condition and reduced oxygen absorption in the water. Based on the observation in the field, many people use the river for bathing, washing, and as a toilet.

**Table 17.** Phosphate Value of Kali Bomo Watershed

No	Variable	PO <sub>4</sub> P (mg/L)			Conclusion
		Minimum	Maximum	Average	
1	Total phosphate	0,10	0,94	0,33	As standard water quality II, III and IV

The result of the minimum, average, and maximum DO parameter values were shown in Table 18 as many as 6.00 mg/L, 7.00 mg/L, and 6.53 mg/L. In general, DO values were above 5 mg/L indicating that water quality had good oxygen solubility so that the population of living things was still of high quality. The high DO values were caused by the water condition in the area, which was relatively shallow and rocky, thus allowing turbulence of water movement. According to Odum (1971), the river that is relatively shallow in which turbulence exists will have high dissolved oxygen content. If DO value decreased, it was generally because of the monitoring point area was a downstream, allowing waste such as domestic, industrial, and ranch waste entered much larger than the area above. The increased DO value was due to several factors, one of which was temperature. Based on the Government Regulation no. 82 of 2001, the average DO value was still below the water quality standard (> 6 mg/L) for class I. This showed that river water in Kali Bomo watershed could be used according to its designation.

**Table 18.** Value of DO in the Kali Bomo watershed

No	Variable	DO (mg/L)			Conclusion
		Minimum	Maximum	Average	
1	DO	6,00	7,00	6,53	Meet the standard quality of water II, III and IV

The nitrate content in Kali Bomo watershed was shown in Table 19. The criteria of water quality II from the Regional Regulation of East Java Province No. 2 of 2008 stipulates the upper limit of nitrate

content is 10 mg/L. The minimum, average and maximum nitrate ( $\text{NO}_3\text{-N}$ ) content were 0.34 mg/L, 2.02 mg/L and 1.24 mg/L respectively, ranging from 1.46 to 1.95 mg/L, this value was still within the threshold for class II river water quality criteria of 10 mg/L so that the river water could be used for recreation, fish cultivation, ranch, and agriculture. The impact of agricultural activities produced runoff, nitrate and phosphate sediments, that nitrate-nitrogen levels in natural water were rarely more than 0.1 mg/L. The result of the measurement on the nitrate content in Kali Bomo watershed were relatively low even though it was not in natural condition with greater level than 0.1 mg/L so, according to the criteria for class II river water quality and following the East Java Provincial Regulation No. 2 of 2008 was 10 mg/L, then the nitrate ( $\text{NO}_3\text{-N}$ ) content of Kalibaru watershed could still be used based on to its designation.

**Table 19.** Value of  $\text{NO}_3\text{N}$  in the Kali Bomo watershed

No	Variable	$\text{NO}_3\text{N}$ (mg/L)			Conclusion
		Minimum	Maximum	Average	
1	$\text{NO}_3\text{-N}$	0,34	2,02	1,24	Meet class II river water quality criteria, can be used for recreation, fish cultivation, livestock and agriculture

The nitrite content in Kali Bomo watershed was shown in Table 20. Water quality criteria II of the Regional Regulation of East Java Province No. 2 of 2008 stipulates the upper limit of nitrate content of 0.06 mg/L.

**Table 20.** Nitrite values in the Kali Bomo watershed

No	Variable	$\text{NO}_2\text{-N}$ (mg/L)			Conclusion
		Minimum	Maximum	Average	
1	$\text{NO}_2\text{-N}$	0,01	0,10	0,04	Meet water quality II

The minimum, average, and maximum nitrite values of Kali Bomo watershed were 0.01 mg/L, 0.10 mg/L, and 0.04 mg/L. This nitrite content was below the water quality level II threshold required by the East Java Provincial Regulation No. 2 of 2008 was 0.06 mg/L. The sources of nitrite came from industrial and domestic waste. Natural water contains nitrite 0.001 mg/L and should not exceed 0.06 mg/L. Ammonia level in Kali Bomo watershed is shown in Table 21. The minimum, average, and maximum  $\text{NH}_3\text{N}$  values of Kali Bomo watershed were 0.100 mg/L; 0.030 mg/L, and 0.033 mg/L. Water quality criteria II of the Regional Regulation of East Java Province No. 2 of 2008 stipulates the upper limit of nitrate content for fisheries was 0.02 mg/L.

**Table 21.** Ammonia content in the Kali Bomo watershed

No	Variable	$\text{NH}_3\text{-N}$			Conclusion
		Minimum	Maximum	Average	
1	$\text{NH}_3\text{-N}$	0,00	0,11	0,06	Meet the water quality criteria II

The ammonia concentration value in Kali Bomo watershed ranges from 0.00 to 0.11 mg/L. The concentration of the ammonia value was avoided for aquaculture or it should not exceed the ammonia parameter value of 0.02 mg/L. Therefore, it was no longer suitable for aquaculture water. Freshwater fish, however, could still be used as raw water for consumption because the ammonia level was still

below 0.5 mg/L based on the class I water quality criteria in the East Java Provincial Regulation Number 2 of 2008.

**4.7. Microbiological Properties**

The total of coliform content in Kali Bomo Watershed is shown in Table 22. The minimum, average and maximum total of Coliform were 63 MPN/100 mL; 150 MPN/100 mL and 95,5 MPN/100 mL. The total of Coliform was still under the criteria of Class II river-water quality as much as 5.000 mg/L, so that Kalibaru river-water was used as recreational facility, freshwater fish cultivation, animal husbandry and agriculture. The coliform bacteria group was used as one of indicators on domestic waste contaminant. Several types of diseases transmitted by coliform bacteria through water, especially the diseases infecting stomach such as typhus, cholera and dysentery.

**Table 22.** Total coliform content of Bomo River watershed

No	Variable	Total coliform (MPN/100 mL)			Conclusion
		Minimum	Maximum	Average	
1	Total coliform	64,00	150,00	95,50	Class II river water quality criteria (5,000 mg / L)

The river-water was easily contaminated by pathogenic microorganism from the settlements, agriculture and animal husbandry. The analysis result of water quality on the coli total of Kali Bomo Watershed was drawn in Table 23.

**Table 23.** Contents of total coliform DAS Kalibaru Year 2016

No	Variable	Microbiological Properties (Total/100 mL)						
		January	February	March	April	Minimum	Maximum	Average
1	Total coliform	75	93,0	150,0	64	64,00	150,00	95,50
2	Fecal coli	39	39,0	43,0	39	39,00	43,00	40,00

**4.8. Water Quality Status Based on the Storet Method**

The method of measuring the overall level of pollution (physical, chemical and microbiological parameters) uses the STORET (Storage and Retrieval of Water Quality Data System) method. The principle of the STORET method is to compare the water quality data with the water quality standards that are adjusted to their designation in order to determine the water quality status.

The condition of the Kalibaru watershed water quality status in 2016 according to the STORET method with reference to the water quality standards listed in Table 24. The results of the calculation of Table 24 showed the following:

1. First class, water whose designation can be used for drinking water raw water, and / or other designations requiring the same water quality as the said use → concluded MEDIUM.
2. Second class, water designated for water recreation infrastructure / facilities, freshwater fish farming, animal husbandry, water for irrigating crops, and / or other designations requiring the same water quality as the said use → concluded MEDIUM.
3. Class three, water that can be used for the cultivation of freshwater fish, animal husbandry, water for irrigating crops, and / or other designations that require the same water quality as the said use → concluded as GOOD (meets the requirements)
4. Class four, water whose designation can be used to irrigate crops and or other uses that require the same water quality as the said use → concluded as GOOD.

According to the Water Quality Classification based on the EPA (Environmental Protection Agency) classified as class A with a total score of 0 the water quality is very good; class B quality with a total score of -1 to -10 water quality is good, class C quality with a score of -11 to -30 water quality is

moderate, and class D quality with a score of  $\geq 31$  water quality is poor. Based on the above criteria, the quality of river water in the Kalibaru watershed is classified as moderate.

**Table 24.** Water Quality Status

DAS Tlogo Ampel	Water Quality Qualifications			
	class I	class II	class III	class IV
	-48	-37	-19	-2
	medium	medium	good	good

### 5. Conclusion

From the results of this study it can be concluded:

The contamination on moderate category for first class-quality is not recommended to be used as the material of drinking water, and/or other allotments whose water quality was same as that utilization, on the second class-quality, in which the water whose allotment was for the recreation infrastructure/facility, fresh water fish cultivation, animal husbandry, irrigating the crops, and/or other allotments whose water quality was same as the utilization, the third class, the water was used for fresh water fish cultivation, animal husbandry, irrigating the crops, and/or other allotments whose water quality was same as the utilization and the good category concerning the fourth class, the water was used for irrigating the crops and/or other allotments whose water quality was same as the utilization.

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