Resistance of Loading Loads in Surabaya River and Its Branch with Qual2KW Model.

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Abstract. Pollution of Surabaya River from year to year is increasing, the increase in pollution is the main problem of Surabaya River which is caused by the entry of most of the liquid waste from industrial, agricultural, and domestic activities. Continuous pollution can reduce water quality for rivers and creeks. One solution that can be applied to reduce the level of pollution is by calculating the capacity of pollution loads. This research was conducted to find out the quality of Kali Surabaya and tributaries of Surabaya River and the calculation of pollution load capacity with the QUAL2KW model. The study analysed the parameters of DO, BOD, COD, and phosphate. From the results of the study, the water quality values for Surabaya river and its branch were above the Class I quality standard Government Regulation Number 82 of 2010 and from the calculation results obtained the maximum capacity values BOD load were 23-1355 kg/day, and COD load were 23-6830 kg/days, while phosphate load were 2.5-125 kg/day.

1. Introduction
Surabaya River was Brantas River’s creek which stretched for 41 km started from Mlirip Mojokerto DAM to Jagir DAM Surabaya, and passed through four districts / cities including Mojokerto, Gresik, Sidoarjo and Surabaya [10]. Surabaya River was the main water source for several industries on the banks of the river, but most of the liquid waste was directly emptying into Surabaya River where the waste came from many activities such as industry, agriculture and domestic which were the main problems of Surabaya River [9] [6]. If it was continuously done, it could give an impact on decreasing the water quality.

The water quality decline in rivers was caused by the entry of pollutants from various human activities [2][11]. The decline in water quality in creeks also should be given more attention, according to the previous research by Agustira and Lubis, 2013 [1] which stated that some creeks in the Padang, North Sumatra watershed produced large-scale of liquid waste which was flowed to several creeks, moreover the water quality in Surabaya River was also experiencing a decline, this was going in the same line to the research of [7][8] which stated that the decline was caused by the citizen’s activities around the Surabaya River banks.

For that reason, it was strongly needed to control the decline in water quality in both rivers and creeks. To control the decline in water quality in the Surabaya river, could be done by calculating the capacity of pollution loads that could be used as a basis for managing and improving river water quality [9]. Where in this study will be focused on using modelling methods with computerized techniques with QUAL2KW Application.
Surabaya River was one of the water resources that was located in East Java Province in Indonesia country, and was a branch of Brantas River and was separated in Mojokerto into two branches, namely Porong River and Surabaya River [9]. Surabaya river had various functions besides supporting industrial, agricultural, vacation or recreation and drinking water source as well as contributing to the life of aquatic biota [4]. Surabaya River was loaded 75.48 tons of liquid waste per day from industrial and domestic waste, which 60 percent was dominated by domestic waste [3]. The Surabaya River had several major creeks that were Kedungsumur Creek, Marmoyo Creek, Banjaran Creek, Middle Creek, and Kedurus Creek [5].

The definition of the pollution load capacity or often called as the total maximum daily load was the ability of water in a water source to gain the input of pollution loads without causing the water became polluted. Calculation of pollution load capacity could be done by three methods, that were equilibrium or mass balance method, mathematical analytical method with streeter phelps method and with computerized numeric modelling methods and suggested by Minister of Environment Regulation No. 1 of 2010 to use Software QUAL2KW version 5.1 which was developed by USEPA.

The QUAL2KW model was software that was recommended by the Regulation of the Minister of Environment No. 1 of 2010 for the calculation of the pollution loads capacity. The QUAL2Kw model had been widely used to analyse rivers in the world and could be used as the basis of policy making related to the water quality in the future [12]. The QUAL2KW model was a development of the QUAL2E model which to run this model, supporting programming language was needed, that was Visual Basic Application (VBA) which could be run with the Microsoft Excel program. The QUAL2KW was a pollution load capacity calculation model with computer-assisted method and this method was more comprehensive in river water quality modelling, this model could support various types of water quality parameters [3] [6]

2. Materials and method

2.1 Research location

Location and research time that is dry season in May until July 2019, what used in this research as follows:

![Sampling Point in Surabaya River](image)

Figure 1. Sampling Point in Surabaya River
2.2. River Segmentation
Segment classification was based on hydraulic characteristics i.e. creeks location, and the segmentation results was gained as follows:

| Segment | Upstream-Downstream | Length |
|---------|---------------------|--------|
| 1       | Tjiwi Bridge – Mojobaru Bridge | 2 km   |
| 2       | Mojobaru Bridge – Obil Bridge | 3.78 km |
| 3       | Obil Bridge – Miwon Bridge | 16.12 km |
| 4       | Miwon Bridge – Bambe Bridge | 7.30 km |
| 5       | Bambe Bridge – Joyoboyo Bridge | 11.50 km |

2.3. Research Time
The research time was related to sampling time, where sampling time was done once a week with three times repetitions. Sampling time was done from 08:00 to 10:00 WIB.

2.4. Data Collection Method
Data collection was divided into two data, that were primary data and secondary data. Primary data were obtained from the results of direct analysis in the research sites such as Surabaya River water quality data and the Surabaya river creeks for DO, BOD, COD, and phosphate parameters moreover, there were river hydraulic data such as river speed, width and depth. And there were also secondary data obtained from relevant agencies for climatological data such as air temperature, wind speed, dew point temperature, percentage of solar radiation, point sources quality and discharge data.

2.5. Data Analysis
Data analysis was performed using QUAL2KW version 5.1 software with using primary data and secondary data that were obtained. The stages were as follows.

1. Data Input
   The data that had been collected, so the next step it was entered as the input into QUAL2KW application.

2. Data Calibration
   Data calibration was done to get the matched value according to the desired model done by trial and error and repeated application running

3. Alternative Model
   Alternative model was carried out to get the value of Surabaya River capacity. which the alternative model was divided into two simulations, i.e. the first alternative model which aimed to obtain the value of pollution load that met the quality standard while for the second alternative model aimed to obtain the value of pollution load that approached quality standard.

4. Data Validation
   Data validation was purposed to provide an overview of the results from data analysis with the previous research.

3. Results and Discussions
3.1. Water Quality of Surabaya River and Surabaya River’s Creek
The discussion about quality was the quality of the existing condition in Surabaya River and its creeks, started from the Mlirip Mojokerto segment and ends at Jagir Surabaya with five creeks including Kedungsumur Creek, Marmoyo Creek, Middle Creek, Banjaran Creek, and Kedurus Creek. The following was a discussion about quality on each parameter.
Overall, the value of dissolved oxygen in the main river was higher than the value of dissolved oxygen in the creeks. This could be caused by several factors such as the mixing process, turbulence, photosynthetic activity, respiration, and the effect of the effluent influence that was entering the water [8].

Figure 1: Water Quality of Surabaya River Based on Parameter DO

From Figure 2, overall COD in creeks was higher than COD value in Main River. However, in the third and fifth segments the COD value in the main river increased when it was compared to the COD value in creeks, this was due to there were several industries around the third segment and the fifth segment. At some points, the value of COD meets the quality standards that was caused by the time when sampling was carried out in the rainy season, this was in accordance with the statement [12] which stated that in general the COD value in the dry season increased when compared to the COD value in the rainy season caused by the dilution process by the rain water.

Figure 2: Water Quality of Surabaya River, Based on Parameter COD, BOD and Phosphate
The BOD value of the creeks was higher than the BOD value in the main river; this was in line with the dissolved oxygen values in creeks that was smaller if it was compared to the main Surabaya River. However, in the third segment the BOD of main river was experiencing an increase if compared to BOD in creeks, this was caused by the pattern of the used land which was dominated by over populated settlements in addition, there were several industries in the area around the third segment. An increase in BOD could be caused by organic waste which generally the wastes were easily decomposed or degraded by microorganisms when disposed in the waters.

Overall the phosphate value in the creeks was higher when it was compared to the phosphate value in the main river. However, in the fourth and fifth segments, the phosphate value in the main river increased when compared with the value in the creeks, the increase was caused by land using patterns around the fourth and fifth segments which were dominated by population settlement due to the high intensity of detergent and soap use. This was in accordance with the statement Hendrasarie et al., 2010, [6] which stated that high phosphate level was caused by the input of domestic waste from washing activities moreover there was also a detergent industry which caused phosphate value was experienced an increase.

### 3.2. The Condition of Surabaya River Pollution Load with QUAL2KW Model

Before calculating the pollution load capacity with an alternative model that had been determined, then the data in the QUAL2KW model must be adjusted in advance previously so that it could be obtained so that the data was approaching or in accordance with the existing conditions. The following was data on the existing conditions.

| Table-2: Surabaya River Water Quality Existing Data |
|-----------------------------------------------------|
| Segment | BOD (mg/liter) | COD (mg/liter) | Phosphate (mg/liter) |
|---------|----------------|----------------|----------------------|
|         | E BM           | E BM           | E BM                 |
| 1       | 3.90 2         | 8.38 10        | 2.38 0.2             |
| 2       | 3.81 2         | 10.02 10       | 1.51 0.2             |
| 3       | 6.17 2         | 13.96 10       | 1.43 0.2             |
| 4       | 4.76 2         | 12.38 10       | 1.09 0.2             |
| 5       | 4.86 2         | 13.97 10       | 2.38 0.2             |

Note: E: Existing; BM: Quality Standard

In order to make the data model on QUAL2KW became suitable or approached the external data, it needed data calibration on worksheet point sources and diffuse sources which included quality data and pollution source discharge.

From the results of alternative models that had been done, the quality parameter range of Surabaya River were below the quality standard, for BOD parameter was 0.01-1.99 mg / L with a quality standard of 2 mg / L for COD parameter was 0.01-9.99 mg / L with a quality standard of 10 mg / L, and phosphate was 0.01-0.19 mg / L with a quality standard of 0.2 mg / L.

After obtaining the Surabaya River water quality parameter range, the next step was calculating the pollution load capacity by finding the difference when the pollution load condition was close to the quality standard (second alternative model) with pollution load condition met the quality standard (first alternative model).

| Table-3: Pollution Load Capacity of Surabaya River was under Quality Standard |
|---------------------------------|-----------------|----------------|----------------|
| Segment | Debit (m³/sec) | BOD (kg/day) | COD (kg/day) | Phosphate (kg/day) |
|---------|----------------|--------------|--------------|--------------------|
| 1       | 5.53           | 43-946       | 43-4769      | 4.8-87             |
| 2       | 4.39           | 34-751       | 34-3786      | 3.8-69             |
| 3       | 5.56           | 43-951       | 43-4795      | 4.8-88             |
| 4       | 2.92           | 23-500       | 23-2518      | 2.5-46             |
| 5       | 7.92           | 62-1355      | 62-6830      | 6.8-125             |
From the results of running the Qual2 KW program, the maximum organic load on the BOD, COD and Phosphate parameters in Kali Surabaya, is explained as follows. The load capacity, 23-1355 kg / day capacity was obtained for BOD parameter, and 23-6830 kg / day for COD parameter, while for phosphate parameter was 2.5-125 kg / day.

4. Conclusion

The quality of Surabaya River and Surabaya River Creeks were above the class I quality standard Government Regulation No. 82 of 2001, it means, the BOD, COD and phosphate content parameters have exceeded the requirements. The DO parameters was 1.16-2.43 mg / L, with a quality standard of 6 mg / L, and for COD parameter was 10.02-14.01 mg / L, with a quality standard of 10 mg / L, and for BOD of 3.02-6.17 mg / L with a quality standard of 2 mg / L and a total phosphate parameter was 1, 36-2.95 mg / L, with a quality standard of 0.6 mg / L. Setting the QUAL2KW model so it would match the existing conditions, then it must calibrate the point sources data and diffuse sources data such as the discharge/debit data and the quality of the pollution source parameters. The results were, the Surabaya River pollution load capacity value based on BOD parameter was 23-1355 kg / day, for COD parameter was 23-6830 kg / day, while for phosphate parameter was 2.5-125 kg / day.

5. References

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