ANALYSIS OF THE LOAD CARRYING CAPACITY OF BOD AND COD POLLUTANTS IN THE KRUKUT RIVER

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Abstract

Krukut River is one of the rivers that has an important role to support the activities of the residents of Jakarta City. Krukut River has a length of 44.3 km. In 2015 the Krukut River was the target of a master plan for improving river water quality in Jakarta by Regional Environmental Management Agency (BPLHD) DKI Jakarta but in fact there was a decline in river water quality due to increasing population growth so that monitoring activities are needed. The purpose of the study is to identify the polluting sources of the Krukut River, analyze the water quality of the river, determine the pollutant load. The research parameters used are Biological Oxygen Demand (BOD) and Chemical Oxygen Demand (COD). Sampling in the Krukut River was carried out using the grab sampling method in September, October, November 2021 divided into 9 segments consisting of 9 non-point sources and 5 point sources. Non-point sources of pollutants are obtained from domestic waste dominated by residential areas, as well as food stalls, point source of pollutants are obtained from drainage channels, Mampang River, Ciliwung River, Cideng Channel and Krendang River. Pollutant load carrying capacity for BOD and COD concentrations in the Krukut River were respectively 292.896-622.592 kg/day and 2440.8-13521.6 kg/day. The pollutant load for BOD and COD concentrations in the Krukut River were respectively 2601.3-13792.2 kg/day and 3139.1-16542.6 kg/day.

Keywords: *BOD, COD, carrying capacity, Krukut River, pollutant load*

Introduction

Krukut River is one of the rivers that has an important role to support the activities of the residents of Jakarta City (Rachmawati, 2017). Krukut River has an area of 84.54 km^2 and a river length of 44.3 km which flows in Situ Citayam, Cipayung, Depok City which is located in Pluit Reservoir, Penjaringan, North Jakarta. In 2015 the Krukut River was the target of the master plan for improving river water quality in Jakarta by Regional Environmental Management Agency (BPLHD) DKI Jakarta, but in fact the quality of the Krukut River water is decreasing along with the increasing number of people in DKI Jakarta and the increasing number of industrial and household activities that contribute to the decline in the water quality of the Krukut River (Rachmawati et al., 2020).

The decline in the water quality of the river goes along with the growth of its population and activity. Wastewater entering through drainage channels comes from settlements and other activities around the riverbanks. The water quality of a river can be determined by measuring several parameters of water pollutants. it is necessary to study the carrying capacity of pollutants in the Krukut River to determine the capacity of the water source

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against the influx of waste, both point sources and non-point sources. From the perspective of the causes of water pollution, with the improvement of point source pollution control capabilities, the problem of non-point source pollution has become increasingly prominent, and has become the main reason for the deterioration of environmental water quality in many areas (Zhang et al., 2014).

Research Methodology

The study was conducted from September to November 2021. The scope of the study area is the Krukut River from upstream in Cipayung, Depok City to downstream in Penjaringan, North Jakarta along 44,3 km. Research to determine the carrying capacity of the Krukut River pollutant load is divided into three stages, namely preparation for implementation, and analysis.

Sources of pollutants that have the potential to pollute the river are in the data through preliminary surveys and observations during sampling. The results of identifying the source of pollutants are then tabulated and analyzed descriptively. The sources of pollutants identified can be related to the state of water quality of the Krukut River. Identification of waste can be seen in **Table 1**.

Table 1. Identify sources of polluters

Characteristic	Point Source	Non Point Source
Domestic Waste	Household Waste Stream	Residential wastewater
Non-Domestic Waste	Industrial Wastewater, Hotel, and Motor Wash	

Sampling was carried out at 14 sampling points, namely 9 sampling points at non-point sources and 5 sampling points at point sources. Source of Pollutants Point source is a source of pollution that is discharged through a special location point using a gutter or discharge directly to the surface of a body of water. Non point source or source is not necessarily a waste stream originating from residential areas in general Sampling location can be seen in **Table 2**.

Table 2. Sampling Location

Point	Location	Upstream (km)	Downstream (km)	Coordinate LS	Coordinate BT
1	Jl. Pinggir Setu, Depok		44.30	6° 26.593'S	106° 47.995'T
2	Jl. Cagar Alam, Depok	44.30	42.16	6° 24.231'S	106° 48.490'T
3	Jl. Tridarma Raya, Jakarta Selatan	42.16	42.04	6° 18.305'S	106° 48.551'T
4A	Jl. KHM Naim III, Jakarta Selatan	36.92	36.69	6° 15.775'S	106° 48.681'T
4	Jl. Cemp III, Jakarta Selatan	42.04	36.92	6° 15.766'S	106° 48.686'T
5A	Jl. Poncol 3, Jakarta Selatan	34.2	34.07	6° 14.020'S	106° 49.054'T
5	Jl Puspa II, Jakarta Selatan	36.69	34.2	6° 13.899'S	106° 49.010'T
6A	Jl. Tenaga Listrik, Jakarta Pusat	29.80	29.61	6° 12.056'S	106° 48.912'T
6	Jl. Tenaga Listrik, Jakarta Pusat	34.07	29.80	6° 11.880'S	106° 48.614'T
7A	Jl. Kebon Sirih, Jakarta Pusat	25.04	24.99	6° 10.913'S	106° 48.988'T
7	Jl. Jati Baru Raya, Jakarta Pusat	29.61	25.04	6° 10.910'S	106° 48.873'T
8A	Jl. Perniagaan Raya, Jakarta Barat	19.19	5.37	6° 8.499'S	106° 48.408'T
8	Jl. Pekojan Raya, Jakarta Barat	24.99	19.19	6° 8.474'S	106° 48.472'T
9	Jl. Inspeksi 281-257, Jakarta Utara	5.37		6° 7.460'S	106° 48.130'T

Sampling refers to SNI 6989.57:2008 on Water and Wastewater – Section 57: Surface water sampling methods. In this study, sampling was carried out by grab sampling, namely samples taken directly from the water body being monitored, sampling with this method was carried out once per point and directly examined. Sample water was taken with a horizontal type water sampler and tools that have been sterilized first. After taking water with a water sampler, the sample water was put into a 1-liter jerry can and then the jerry can was numbered according to the sampling location. The jerry can was then placed in styrofoam containing dry ice so that it remains durable to be taken to the Environmental Laboratory of

Trisakti University for analysis as much as 2 times (duplo). Sampling was carried out at 14 points on the Krukut River which was carried out 1 time in September, October, and November 2021.

Result and Discussion

Measurements of the characteristics of the Krukut River during III Peride, namely in September, October, and November 2021 when the weather is clear. Characteristic of the Krukut River can be seen in **Table 3**.

Table 3. Characteristics of the Krukut River

Point	Measurement Location	River Width (m)	River Water Depth (m)	River Cross-sectional Area (m^2)	Flow Rate (m)	Flow Discharge (m^3/detik)	Elevation
1	Jl. Pinggir Setu, Depok	4.62	1.2	5.58	0.28	1.56	78
2	Jl. Cagar Alam,Depok	5.56	1.14	6.34	0.24	1.51	33
3	Jl. Tridarma Raya, Jakarta Selatan	3.81	1.23	4.67	0.25	1.18	20
4A	Jl. KHM Naim IIIB,Jakarta Selatan	1.95	0.38	0.741	0.086	0.46	11
4	Jl. Cemp III, Jakarta Selatan	8.15	1.34	10.98	0.18	1.97	11
5A	Jl. Gatot Subroto Kav 14	7	1.31	9.17	0.083	0.76	8
5	Jl. Puspa II No 46, Jakarta Selatan	18.37	0.75	13.72	0.22	3.03	8
6	Jl. Tenaga Listrik, Jakarta Pusat	34.74	1.47	31.5	0.11	3.36	6
6A	Jl. Tenaga Listrik, Jakarta Pusat	6	0.91	8.84	0.2	1.74	6
7A	Jl. Jati Baru Raya, Jakarta Pusat	8	0.81	6.51	0.09	0.56	3
7	Jl. Jati Baru Raya, Jakarta Pusat	12.76	1.44	18.33	0.15	2.69	3
8A	Jl. Perniagaan Raya, Jakarta Barat	13.38	1.72	23.05	0.16	3.77	2
8	Jl. Pekojan Raya, Jakarta Barat	17.6	1.13	19.95	0.14	2.81	2
9	Jl. Inspeksi 281-257,Jakarta Utara	30.69	1.53	47.1	0.13	6.28	1

The width of the river ranges from 1.95 – 34.,74 m with a river depth between 0.75 – 1.72 m. The current speed ranges from 0,083 - 0.28 m/s so that the rated discharge ranges from 0.46 – 6.28 m^3/s. River discharge is influenced by the speed of the river flow current and the cross-sectional area of the river, the value of the river discharge is obtained from the speed of the flow current × the cross-sectional area of the river, while the value of the cross-sectional area of the river is obtained from the calculation of the river width×river depth, fluctuations in the Krukut River discharge can be seen in **Figure 1**.

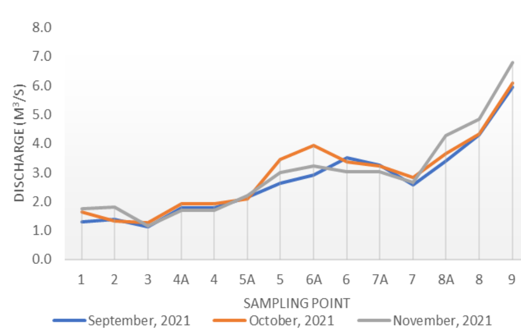

Figure 1. Krukut River Discharge Fluctuations

The results of the Grogol River sample water analysis for 3 periods, namely September October, and November 2021 using water quality standards in PP No.22 of 2021. The quality of river water tested is physics (turbidity, electrical conductivity, and water temperature) and chemistry (pH, dissolved oxygen, chemical oxygen demand, biological oxygen demand). River water quality data can be seen in **Table 4**.

Table 4. Quality of Krukut River

Point	Temperature Air (^oC)	DHL (µmhos/cm)	Turbidity (NTU)	pH	DO (mg/L)	BOD (mg/L)	COD (mg/L)
	Quality Standards of Government Regulation Number 22 of 2021						
	Deviation 3 From natural	**-**	**-**	**6 - 9**	**Class 2 :>4**	**Class 2:>3**	**Class 2:>25**
1	26.3	124.5	10.7	6.5	5.8	27.7	34.1
2	26.3	137.7	23.3	6.6	6.2	24.1	30.9
3	27.0	313.1	24.0	6.9	4.5	33.0	40.5
4A	26.7	244.2	28.7	7.1	5.3	28.6	35.2
4	27.3	217.0	24.3	7.2	5.3	28.3	33.1
5A	28.0	215.6	18.3	7.0	4.5	30.3	38.4
5	28.3	232.6	22.3	7.3	5.3	24.2	27.6
6A	29.0	373.2	41.3	6.9	3.0	33.8	40.5
6	29.3	401.5	43.0	6.5	3.1	31.2	35.2
7A	30.3	395.6	42.0	7.3	2.8	22.1	32.0
7	31.3	435.8	32.7	6.9	3.0	22.5	28.8
8A	29.7	514.4	30.3	6.5	1.5	24.4	28.8
8	30.3	539.1	32.7	6.8	3.8	21.6	25.6
9	29.3	519.1	31.0	6.5	2.0	21.4	30.9

The water temperature of the Krukut River ranges from 26^{o}C–32°C. The water temperature of the Krukut River is influenced by altitude, air circulation time, discharge, depth and the presence of pollutants in the water and water temperature greatly affects the amount of dissolved oxygen in the water.

Electrical Conductivity (DHL) obtained from observations for three periods, the DHL parameters from upstream to downstream experience an up and down state and at Point 7A to Point 8 it increases. The DHL parameter in the Krukut River was in the range of values of 116.4 µmhos/cm – 557.4 µmhos/cm.

The turbidity in the Krukut river ranges from 8 – 47 NTU. The high turbidity in photosynthesis is disturbed, which leads to disturbances in other vegetation in water.

The results of pH value analysis in the 3-period measurement were obtained on average in period 1 of 6.9, in period 2 of 6.9 and period 3 of 6.8. Each sampling point in 3 periods did not show a significant difference and still entered the range of pH values in the quality standard, namely 6-9.

The dissolved oxygen value in period 1 was recorded at 4.021 mg/L, in period 2 it was 3.95 mg/L and in period 3 it was 4.019 mg/L. The highest DO concentration during monitoring was recorded in period 1, which was 4.021 mg/L and the highest DO concentration during monitoring was recorded in period 1 which was 4.021 mg/L and the lowest point 8A was 1.35 mg/L.

BOD_5 concentration results from the analysis in 3 periods. The highest concentration value was recorded during the monitoring period 1 that point 6 of 38.9 mg/L while the lowest concentration was during the month to November at point 3 of 7.80 mg/L which was tested in the rainy season.

The concentration of COD values in the Krukut River during the 3 sampling periods ranges between 22.4 mg/L – 44.8 mg/L, COD concentrations from upstream to downstream tend to increase and decrease.

The sampling location has several confluences of water flows, namely the Krukut tributary that enters the Krukut River water body, therefore, it is necessary to measure the mass balance to determine its magnitude. Here are the concentrations of the mixtures in **Table 5.**

Table 5. Mixing Concentrations

Point	Debit (m^3/s)	COD data (mg/L)	BOD data (mg/L)	C COD (mg/L)	C BOD (mg/L)
4A	0.13	35.2	28.57	33.20	28.32
4	1.97	33.1	28.30		
5A	0.76	38.4	30.27	29.75	25.43
5	3.06	27.6	24.23		
6A	3.36	40.5	33.83	38.71	32.92
6	1.74	35.2	31.17		
7A	0.54	32.0	22.10	29.33	22.46
7	2.69	28.8	22.53		
8A	3.77	28.8	24.37	27.43	23.19
8	2.81	25.6	21.60		

After the calculation of the mixed concentration of each confluence of rivers and drainage channels. Therefore, the calculation of the capacity of polluting loads on the Krukut River is carried out. BOD and COD polluting load capacity are respectively shown in **Tabel 6** and **Tabel 7**.

Table 6 BOD Polluting Load Capacity

Segment	BOD Polluting Load	BOD Capacity
	kg/day	kg/day
1	3733.6	404.4
2	3449.0	391.4
3	2730.6	305.9
4	2601.3	292.9
5	5919.6	671.3
6	7562.1	863.1
7	6621.0	759.5
8	9191.2	1070.5
9	13792.2	1622.6

Table 7 COD Polluting Load Capacity

Segment	COD Polluting Load	COD Capacity
	kg/day	kg/day
1	4600.6	3369.6
2	4139.1	3261.6
3	3290.0	2548.8
4	3139.1	2440.8
5	7135.7	5594.4
6	9106.7	7192.8
7	7965.9	6328.8
8	11028.1	8920.8
9	16542.6	13521.6

The pollutant load capacity is determined based on the difference between the existing pollutant load in the river and the permissible pollutant load, namely the concentration of each water quality parameter according to the water class in the quality standard (Hossain et al., 2010). The calculation results use BOD and COD parameters in the Krukut River which are compared with the water quality standards of PP No.22 of 2021 in Appendix VI for class II rivers. Suppose the carrying capacity of the pollutant load is determined based on the difference between the pollutant load in the river and the allowable pollutant load. In that case, that is, the concentration of each water parameter in the quality standard. The difference can be negative or positive. If the difference between the pollutant load and its carrying capacity is negative, the pollutant load needs to be reduced. If the difference between the pollutant's load and its carrying capacity is positive, then it can be said that the river is still able to accommodate a certain amount of load before it exceeds its carrying capacity. BOD and COD excess are respectively shown in **Tabel 8** and **Table 9**.

Table 8 BOD Excess

Segment	BOD (mg/L)	BOD Quality Standards (mg/L)	BOD Excess
1	27.70	3	89%
2	24.10	3	88%
3	32.97	3	91%
4	28.32	3	89%
5	25.43	3	88%
6	32.92	3	91%
7	22.46	3	87%

Segment	BOD (mg/L)	BOD Quality Standards (mg/L)	BOD Excess
8	23.19	3	87%
9	21.43	3	86%

Table 9. Excess COD

Segment	COD (mg/L)	BOD Quality Standards (mg/L)	COD Excess
1	34.13	25	27%
2	30.93	25	19%
3	40.53	25	38%
4	33.20	25	25%
5	29.75	25	16%
6	38.71	25	35%
7	29.33	25	15%
8	27.43	25	9%
9	30.93	25	19%

Based on the results of measurements of BOD and COD parameters in **Table 8** and **Table 9**, the value obtained exceeds the quality standard. The difference between the excess BOD and COD was 86%-91% and 9%-38% respectively. Excess pollutants are caused by an increase in the population and a large number of activities over time.

Conclusions

Residential areas dominate potential non point sources of pollutants in Krukut, be it housing or villages, in addition, the existing sources of potential pollutants are also caused by restaurants, shops, and other domestic activities. The water quality of the Krukut River for BOD parameters ranges from 21.43 mg/L – 32.97 mg/L while COD ranges from 27.43 mg/L – 40.53 mg/L. According to PP No.22 of 2021, Class II River Water Quality Standards have a BOD value of 3 mg/L so that the BOD parameters exceed the quality standards and the quality standard value of class II for COD is 25 mg/L, so the COD parameters exceed the quality standards.

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