ANALYSIS OF CONTAMINANT LOAD CAPACITY OF NITRATE AND PHOSPHATE IN KRUKUT RIVER

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Abstract

The Krukut River is one of the major rivers that flow in the Jakarta area and has an essential role in supporting public activities in the city. It is designated as raw water for drinking water. The study was conducted in the 44.30 km Krukut River flow from September 2021 until February 2022. The purpose of this study was to analyze the pollutant load capacity of nitrate and phosphate. Parameters measured in this study were temperature, turbidity, DHL, pH, DO, nitrate and phosphate. Identification of pollutant sources was carried out by field surveys. Water quality analysis is carried out following SNI (Indonesian Standard) and compared with quality standards according to Government Regulation no. 22 of 2021, as well as analysis of the pollutant load capacity of nitrate and phosphate. The search results for potential pollutants in the Krukut River are dominated by domestic waste. The air quality analysis simulation results show that the phosphate curve tends to increase with increasing distance, while the nitrate concentration fluctuates. The results of water quality analysis for nitrate parameters ranged from 1.52 mg/L – 2.94 mg/L, and phosphate ranged from 0.21 mg/L – 1.37 mg/L. The pollutant load carrying capacity results a (PLCC) average for nitrate parameters is 2431.94 kg/day, and phosphate is 48.64 kg/day, with an average pollutant load for nitrate parameters 579.84 kg/day, phosphate 243.02 kg/day.

Keywords: *Krukut River, nitrate, phosphate, pollutant load, pollutant load carrying capacity*

Introduction

Krukut River is one of the major rivers that flow in the Jakarta area and has an essential role in supporting public activities in the city. It is designated as drinking and raw water (Pergub DKI Jakarta No 582/1995) managed by PT. PAM Jaya. In 2015 the Krukut River became one of the targets in the master plan for improving the quality of river water in Jakarta by the DKI Jakarta BPLHD, but in fact the water quality of the Krukut River has decreased along with the increasing number of residents in the capital and the increasing number of industrial and household activities that contribute to the declining water quality of the Krukut River (Rachmawati et al., 2020).

One of the water quality parameters in Government Regulation Number 22 of 2021 is Nitrate (NO_3) and Total Phosphate (PO_4). Nitrates and phosphates are nutrients used for the metabolism and growth of phytoplankton, but if these substances have a large concentration in the waters that also exceeds the specified quality standard value, it can cause nutrient enrichment (eutrophication) which is marked by the occurrence of phytoplankton blooms that occur, cause the death of various types of marine life (Simanjuntak, 2012). Waste flowing through rivers comes from land and is the main source of nitrate and phosphate (Risamasu and Prayitno, 2011).

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With an increase in nitrate and phosphate concentrations, the water quality of the Krukut River is increasingly polluted, leading to an increase in the pollution load. Therefore, it is necessary to know information about the capacity of the pollutant load in the Krukut River, which then becomes the basis for managing pollution control in the Krukut River. On this basis, a study was conducted to determine the water quality of the Krukut River

Methodology

Data Collection

Determination of the sampling location is data collection by the observation method. Sampling refers to SNI 6989.57:2008 concerning Water and Wastewater – Section 57: Surface water sampling method.

Measurement of the characteristics of the Krukut River was carried out at each sampling point that consist measurements of hydraulic characteristics and measurements of morphological characteristics. The hydraulic characteristics consist of river flow discharge and flow velocity, while the morphological characteristics consist of the river's width, depth and cross-sectional area. The measurement of river flow velocity is carried out by floating dredge on the river flow at a certain distance to obtain the amount of travel time. Then, the flow rate measurement is carried out using the cross-sectional method, which is connecting the data of the width and depth of the river with the velocity of the river flow. The cross-sectional area of the river is obtained from the measurement of the width and depth of the river. The width of the river is measured using a meter, while the river's depth is measured using a weighted rope and then dipped into the river. The length of the wet rope is measured as the product of the depth of the river. The formula for calculating the flow rate (Herschy, 1993):

$$Q = A \times V \quad \text{.....(1)}$$

Sites

Water sampling was carried out at 14 sampling points consisting of 9 sampling points on the main river and 5 sampling points on the Point Source, determining the sampling location based on pollutant input, changes in river dimensions and input from pollutant sources and considerations of ease of access to sampling. The sampling locations can be seen in Table 1.

Table 1. Sampling Locations

Segments	Sampling Locations	Upstream (km)	Downstream (km)
1	Jl. Pinggir Setu, Depok		44.30
2	Jl. Cagar Alam, Depok	44.30	38.93
3	Jl. Tridarma Raya, Jakarta Selatan	38.93	25.11
4	Jl. Cemp III, Jakarta Selatan	25.11	25.11
4A	Jl. KHM Naim III , Jakarta Selatan	25.11	19.31
5	Jl. Puspa II, Jakarta Selatan	19.31	19.31
5A	Jl. Poncol 3, Jakarta Selatan	19.31	14.84
6	Jl. Tenaga Listrik, Jakarta Pusat	14.84	14.84
6A	Jl. Tenaga Listrik, Jakarta Pusat	14.84	10.57
7	Jl. Jati Baru Raya, Jakarta Pusat	10.57	10.57
7A	Jl. Kebon Sirih, Jakarta Pusat	10.57	8.08
8	Jl. Pekojan Raya, Jakarta Barat	8.08	8.08
8A	Jl. Perniagaan Raya, Jakarta Barat	8.08	2.96
9	Jl. Inspeksi 281-257, Jakarta Utara	2.96	0

Data Analysis

The results of the measurement of hydromorphological samples and the quality of the analyzed river water will be poured into a graph and analyzed descriptively, with the parameters used to measure river water quality consisting of physical parameters, namely temperature, DHL, turbidity and chemical parameters, pH, phosphate (PO_4), nitrate (NO_3) and then compared with PP RI No. 22 of 2021

The magnitude of the pollutant load capacity of the Krukut River is obtained by multiplying each segment's flow rate by the standard water quality value according to its designation. Meanwhile, the magnitude of the pollutant load is obtained by multiplying the river flow discharge with the pollutant concentration at each point.

Results and Discussion

Measurement of the characteristics of Krukut River was carried out during 3 observation periods, in September, October, and November 2021, characteristics of Krukut River can be seen in Table 2.

Table 2. Characteristics of Krukut River

Points	Measurement Location	River Width (m)	River Water Depth (m)	River Cross-sectional Area (m^2)	Flow Speed (m/s)	Flow (m^3/s)	Elevation (m)
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	7	0.38	0.741	0.086	0.13	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
6A	Jl. Tenaga Listrik, Jakarta Pusat	6	0.91	8.84	0.2	1.74	6
6	Jl. Tenaga Listrik, Jakarta Pusat	34.74	1.47	31.5	0.11	3.36	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 Krukut River has a range of 3.81 m – 30.69 m, flow velocity has a value range between 0.11-0.28 m/s, In the first observation period, September 2021, the river depth is in the range of 0.39 – 1.60 m. In the second observation period, October 2021, the values ranged from 0.32 m – 1.62 m. In the third period of November 2021, the value ranges from 0.41 m – 1.53 m, and The flow rate of the Krukut River has a value range of 1.18 -6.28 m^3/s.

The water quality of the Krukut River during 3 observation periods, September, October, and November 2021 can be seen in Table 4. The physical parameters were water temperature, electrical conductivity and turbidity, while the chemical parameters were pH, Dissolved Oxygen (DO), phosphate, and nitrate.

Table 3. Krukut River Water Quality

Points	Water Temperature (°C)	Electrical conductivity (µmhos/cm)	Turbidity (NTU)	pH	Dissolved Oxygen (mg/L)	Nitrate (mg/L)	Phosphate (mg/L)
					* class 2:4	*class 2:10	* class.2: 0.2
1	26.33	124.47	10.67	6.47	5.75	2.59	0.21
2	26.33	137.67	23.33	6.63	6.21	2.41	0.23
3	27.00	313.07	24.00	6.90	4.46	2.50	0.24
4A	26.67	244.17	28.67	7.11	5.28	2.64	1.58
4	27.33	217.00	24.33	7.20	5.33	2.43	0.27
5A	28.00	215.60	18.33	7.00	4.46	2.23	1.35
5	28.33	232.63	22.33	7.30	5.27	1.88	0.33
6A	29.00	373.23	41.33	6.87	3.02	1.50	2.23
6	29.33	401.50	43.00	6.53	3.08	1.55	0.84
7A	30.33	395.57	42.00	7.30	2.77	2.65	2.49
7	31.00	435.83	32.67	6.90	2.97	1.60	0.91
8A	31.67	514.43	30.33	6.53	1.48	1.62	2.00
8	31.33	539.13	32.67	6.77	3.85	2.79	1.08
9	30.33	519.07	31.00	6.54	2.04	2.88	1.37

The water temperature of the Krukut River obtained is in the range of 26°C – 32°C, Meteorological conditions, especially air temperature, wind speed, solar radiation and humidity are the biggest factors in changes in water temperature because they determine the heat exchange and flux that occur on the river surface (Zhu et al., 2018). The electrical conductivity parameter in the Krukut River is in the range of values of 116.4 mhos/cm – 557.4. conductivity in water is affected by inorganic dissolved solids such as calcium, chloride, aluminum cations, nitrates, sulfates, iron magnesium, and sodium. Temperature and organic compounds such as oil, alcohol, phenol, and sugar can also affect the conductivity of water (Al-Badaii, 2013). The turbidity level of the Krukut River ranges from 8 NTU - 47 NTU. Turbidity is the number of particles of a substance that is submerged in water. Turbidity is caused by suspended solids (mainly soil), particles) and plankton (microscopic plants and animals) suspended in the water (Patil et al, 2015)

The Krukut River has a pH value range that ranges from 6.02-7.6. meanwhile, The DO concentration values obtained during the three sampling periods ranged from 1.35-6.26 mg/l. Dissolved oxygen (DO) is one of the most important indicators of the biological condition of rivers which shows large fluctuations at various spatial and temporal scales with levels depending on water temperature and the intensity of biological processes such as photosynthesis, respiration and decomposition of organic matter (Rajwa-Kuligiewicz et al., 2015).

The results of the analysis of nitrate concentrations in September 2021 ranged from 1.49 mg/L – 2.88 mg/L, in October 2021 it ranged from 1.38 mg/L-2.93 mg/L, in November 2021 it ranged between 1.53 mg/L – 2.84 mg/L.

Overall, this value is in accordance with the quality standard according to PP No.22 of 2021, which is 10 mg/L. The highest nitrate concentration value is at point 9 with an average of 2.93 mg/L. Meanwhile, the results of the analysis of phosphate concentrations in the Krukut River for 3 observation periods ranged from 0.18 mg/l – 1.37 mg/l. The main sources of nitrogen in water can be municipal and industrial wastewater (such as the chemical industry), septic tanks, feedlot effluents, animal waste

(livestock, birds, mammals, and fish), fertilizer fields and grass runoff. Nitrate levels in the water fluctuate with the seasons, and high nitrate levels also occur after heavy rains. Semenyih River has nitrate levels in the rainy season of 4.23 mg/L – 8.53 mg/L, while in the dry season it ranges from 1 mg/L – 6.3 mg/L (Al-Badaii et al., 2013).

The results of observations made for 3 research periods show that the concentration of phosphate in the Krukut River when compared to Government Regulation No.22 of 2021 has exceeded the quality standard of 0.2 mg/L. Phosphorus and other pollutants enters water through various sources including natural sources and anthropogenic sources (Yustiani et al., 2021). Natural sources come from deposition, weathering, decomposition, and erosion that occur around the river. Anthropogenic sources can come from household waste containing human waste. Other sources are phosphate from detergents in industrial effluents and runoff from fertilized agricultural land (Adesuyi et al., 2015).

Mixed Concentration in the Krukut River

In the sampling location, there are several confluences of water flows, namely the tributary of the Krukut River that enters the water body of the Krukut River, therefore it is necessary to measure the mass balance to determine the concentration of the mixture, the results of the mass balance can be seen in Table 5.

Table 4. Mixture Concentration Sampling Location

Points	Flow (m^3/detik)	Nitrate data (mg/L)	Phosphate data (mg/L)	C Nitrate (mg/L)	C Phosphate (mg/L)
4A	0.13	2.64	1,58	2.44	0.35
4	1.97	2.43	0.27		
5A	0.76	2.23	1.35	1.95	0.53
5	3.03	1.88	0.33		
6A	1.74	1.55	2.23	1.52	1.76
6	3.36	1.50	0.84		
7A	0.56	2.77	2.49	2.94	1.18
7	2.69	2.97	0.91		
8A	3.77	1.62	2	2.12	1.61
8	2.81	2.79	1.08		

After obtaining the concentration of the mixture from each meeting between the 2 rivers at the sampling location, the pollutant load capacity of the Krukut River was obtained, after that it was compared with the quality standard, then the percentage of excess was seen and tabulated. The pollutant load capacity of the Krukut River can be seen in Table 6.

Table 5. Pollutant Load Capacity of Krukut River

Segment	Label	Upstream (km)	Downstream (km)	Flow m^3/s	Nitrate Data mg/L	Quality Standart mg/L	PLCC kg/day	Nitrate Load kg/day
1	Headwater		44.3	1.56	2.59	10	1347.72	349.06
2	Jl Cagar Alam,Depok	44.3	38.93	1.51	2.41	10	1304.64	314.42
3	Jl tridarma raya, Jakarta selatan	38.93	25.11	1.18	2.51	10	1021.98	256.52
4	Jl Cemp III, Jakarta	25.11	19.31	1.97	2.44	10	1702.08	415.31

Segment	Label	Upstream (km)	Downstream (km)	Flow m^3/s	Nitrate Data mg/L	Quality Standart mg/L	PLCC kg/day	Nitrate Load kg/day
	selatan							
5	Jl Puspa II, Jakarta selatan	19.31	14.84	3.03	1.95	10	2617.92	510.49
6	Jl Tenaga Listrik, Jakarta pusat	14.84	10.57	3.36	1.52	10	2903.04	441.26
7	Jl Jati Baru Raya, Jakarta pusat	10.57	8.08	2.69	2.94	10	2324.16	68.3
8	Jl Pekojan Raya, Jakarta barat	8.08	2.96	3.77	2.12	10	3257.28	690.54
9	Jl Inspeksi 281-257 Jakarta utara	2.96	0	6.26	2.88	10	5408.64	157.7

Table 6. Pollutant Load Capacity of Krukut River

Segment	Label	Upstream (km)	Downstream (km)	Flow m^3/s	Phosphate Data mg/L	Quality Standart mg/L	PLCC kg/day	Phosphate Load kg/day
1	Headwater		44.3	1.56	0.21	0.2	26.954	28.30
2	Jl Cagar Alam,Depok	44.3	38.93	1.51	0.21	0.2	26.093	27.40
3	Jl tridarma raya, Jakarta selatan	38.93	25.11	1.18	0.24	0.2	20.44	24.53
4	Jl Cemp III, Jakarta selatan	25.11	19.31	1.97	0.27	0.2	34.42	45.96
5	Jl Puspa II, Jakarta selatan	19.31	14.84	3.03	0.55	0.2	52.58	143.99
6	Jl Tenaga Listrik, Jakarta pusat	14.84	10.57	3.36	1.34	0.2	58.61	389.01
7	Jl Jati Baru Raya, Jakarta pusat	10.57	8.08	2.69	1.07	0.2	46.483	248.69
8	Jl Pekojan Raya, Jakarta barat	8.08	2.96	3.77	1.56	0.2	65.146	508.14
9	Jl Inspeksi 281-257, Jakarta utara	2.96	0	6.26	1.37	0.2	108.17	740.98

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 difference can be negative or positive. If the difference between the pollutant load and the carrying capacity is negative, it is necessary to reduce the pollutant load. Suppose the difference between the pollutant load and the carrying capacity is positive. In that case, it can be said that the river can still accommodate some loads before exceeding its capacity. Based on Table 6, nitrate's pollutant load carrying capacity ranged from 1021.98 – 5408.64 kg/day and phosphate ranged from 20.44 – 108.17 kg/day. After obtaining the value of the pollutant load's carrying capacity, it is compared with the pollutant load of phosphate and nitrate. The excess of phosphate and nitrate in the Krukut River can be seen in Table 7 and Table 8.

Table 7. Nitrate Excess

Points	Nitrate (Mg/L)	Nitrate Quality Standart	Nitrate Excess
1	2.59	10	0%
2	2.41	10	0%
3	2.51	10	0%
4	2.44	10	0%
5	1.95	10	0%
6	1.52	10	0%
7	2.94	10	0%
8	2.12	10	0%
9	2.88	10	0%

Table 8. Phosphate Excess

Points	Phosphate (Mg/L)	Phosphate Quality Standart	Phosphate Excess
1	0.21	0.2	5%
2	0.23	0.2	13%
3	0.24	0.2	17%
4	0.35	0.2	43%
5	0.53	0.2	62%
6	1.31	0.2	85%
7	1.12	0.2	82%
8	1.61	0.2	88%
9	1.37	0.2	85%

Based on Table 7, the excess of nitrate is 0 (zero), it can be said that the nitrate parameter does not exceed the quality standard, while in Table 8 there is an excess of phosphate at all points. The low phosphate concentration at each point 1-3 is due to the lack of domestic waste entering these two points. At points 4-9 it is caused by dense population activities and also comes from domestic waste originating from residential activities.

Conclusion

The pollutant load capacity of nitrate ranged from 1021.98 – 5408.64 kg/day and phosphate ranged from 20.44 – 108.17 kg/day. the nitrate parameter does not exceed the quality standard, but the value of the phosphate pollutant load has exceeded the pollutant load capacity. Sources of pollutants that have the potential to contaminate the waters of the Krukut River are settlements, and other domestic activities such as stalls, shops, and restaurants. The condition of water quality in the Krukut River exceeds the standard limit permitted and necessary river quality reducing the pollution load so that the quality of river water can still meet the quality standards of water bodies, reducing phosphate pollutant loads can be done by installing wastewater treatment plants and river cleaning activities on riverbanks.

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