Pollutant Index Method in Determining the Water Quality Status of the Cimahi River in West Bandung Regency

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Pollutant Index Method in Determining the Water Quality Status of the Cimahi River in West Bandung Regency

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Abstract. Cimahi River is one of the sub-watersheds of the Citarum River. The upstream of the Cimahi River is located in the West Bandung Regency area through 7 villages namely Karyawangi, Cihanjuang, Cihanjuang Rahayu, Sukajaya, Padaasih, Jambudipa, and Kertawangi. The research was carried out at 3 points, namely monitoring point 1 at coordinates E 107°34'41.01" S 06°47'51.29", point 2 at coordinates E 107°34'24.36" S 06°48'54.09", and point 3 at coordinates E 107°33'58.28" S06°50' 05.33". The purpose of this study is to determine the status of the water quality of the Cimahi River so that the level of water pollution that occurs can be known. The method used to calculate the status of water quality is the Pollutant Index which refers to the Decree of the State Minister of the Environment Number 115 of 2003 concerning Guidelines for the Status of Water Quality. Based on the research results, there are 6 main parameters that cause water pollution, namely TSS, BOD_5, COD, Nitrite, Free Chlorine, and Total Detergent. The Pollutant Index results obtained in the Upper Cimahi River are categorized as heavily polluted with a significant increase from point 1 to 3, respectively 13.38 at point 1, 14.99 at point 2, and 15.36 at point 3. Source potential pollutants in this river are the domestic sector, agriculture, and livestock.

Keywords: Upstream Cimahi River Pollution, Quality Status, Pollutant Index, West Bandung Regency

1. Introduction

The Cimahi River is a tributary of the Citarum River which flows through three areas from the upstream of the river which is located in the central part of West Bandung Regency through Cimahi City, and downstream through Bandung Regency before empties into the Citarum River [11]. Based on the status of water quality in the downstream area that enters the Cimahi City area, the quality of river water is categorized as heavily polluted, one of which is due to the pollutant load flowing from the upstream of the Cimahi River. Based on this, it is necessary to study the status of water quality in the upstream area of the Cimahi River which is located in the West Bandung Regency area [6].

The watershed of the Upper Cimahi River flows through 3 sub-districts, namely Parongpong, Cisarua, and Lembang. The villages that enter the watershed are Karyawangi, Cihanjuang, Cihanjuang Rahayu, Sukajaya, Padaasih, Jambudipa, and Kertawangi villages. The area of the Upper Cimahi River watershed is 2,746 Ha. Details of the area of the sub-districts that enter the upstream Cimahi River watershed are Parongpong 2,223 Ha, Lembang 95 Ha, and Cisarua 429 Ha. This river has a length of 15 km with a surface width of 15 m, a base width of 10 m, a depth of 7 m. The maximum discharge is 1.5 m^3/s and the minimum discharge is 0.9 m^3/s. Damage to watersheds causes high fluctuations between the rainy and dry seasons [11].

River pollution is the result of human activities. Disposal of domestic wastewater into rivers can increase the concentration of BOD which causes a decrease in the concentration of oxygen in the water, causing aquatic life to be disrupted [9]. Pollution that occurs in the Cimahi River has a high contribution to water pollution in the Citarum River [10].

Environmental changes that occur in West Bandung Regency are in line with the growth of the tourism area in this region. The development of tourism areas and their facilities and infrastructure places great pressure on the environment. The development of the region and the low level of service for the domestic solid and liquid waste management system have become the driving force for the decline in river water quality in this region [11].

In an effort to improve water quality, the West Bandung Regency Government has a mission for 2009-2029 with a main focus on environmental developments and changes based on priority issues, including the availability of clean water, solid waste, and water pollution. Efforts to overcome the issue of water pollution, one of the programs is to be actively involved in the process of “Citarum Harum Bestari”. Development of a technology-based water quality monitoring system, and application of digital-based environmental document reporting with the main target of reducing pollution levels and improving the status of Citarum River water quality. Determining the quality of river water is the first step in controlling river water pollution [11].

The purpose of this study was to determine the status of the water quality of the upstream Cimahi River entering the West Bandung Regency area based on the results of monitoring the quality of river water in 2020. The study of water quality monitoring was carried out in 3 parts, namely upstream, middlestream and downstream which refers to the quality standards of Government Regulation no. 22 of 2021 concerning the Implementation of

Environmental Protection and Management. Calculation of river water quality status refers to the Decree of the Minister of the Environment No. 115 of 2003 concerning Guidelines for Determining the Status of Water Quality.

2. Materials and Methods

The data used is monitoring the water quality of the upstream Cimahi River in 2020. The data is analyzed based on parameters that exceed the class II quality standard, referring to Government Regulation no. 22 of 2021 concerning the Implementation of Environmental Protection and Management [3]. The following is a general description of the surrounding environmental conditions at each coordinate point in the Cimahi watershed in West Bandung Regency, presented in Table 1 and Figure 1. The flow chart for calculating water quality refers to Figure 2.

Table 1. Environmental Condition of Sampling Location

Sampling Points	Coordinate	Environmental Setting
Upstream	S 06º 47' 51,29" E 107º 34' 41,01"	Tourist attractions Ciwangun Camp Cimahi (CIC), residential areas, livestocks, and agricultures
Middlestream	S 06º 48' 54,09" E 107º 34' 24,36"	Residential areas, livestocks, and agricultures
Downstream	S 06º 50' 05,33" E 107º 33' 58,28"	There are densely populated settlements, plantations, and several industries

Based on the surrounding environmental conditions that can be opened in the Table 1, it is certain that the pollutant parameters will increase due to the organic carrier pollutant load from upstream to downstream and seen by the conditions around the sampling point.

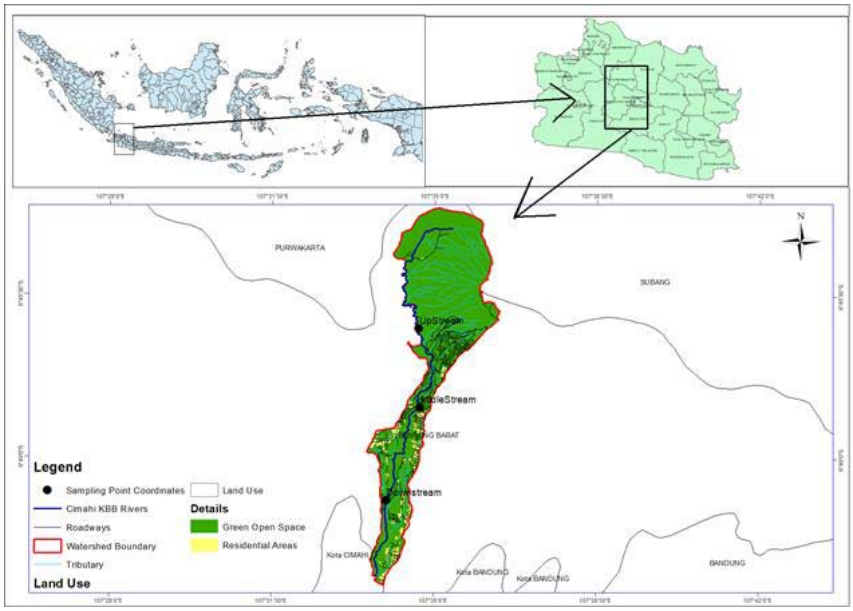

Figure 1. Sampling Point Map [11]

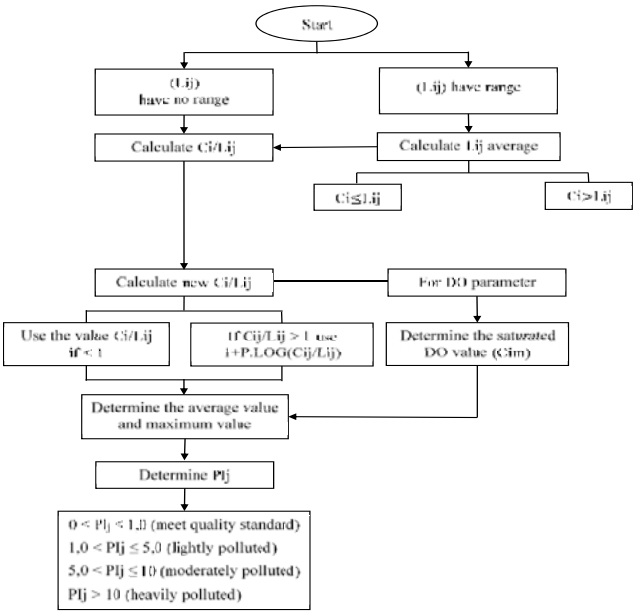

Figure 2. Flowchart of Pollutant Index Calculation Method [2]

Explanation of the flow chart presented in Figure 2 [2], namely:

- Lij express the concentration of water quality parameters listed in the Water Quality Standard
- Ci states the concentration of water quality parameters obtained from the measurement results of a sample of river water.
- Pij states Pollution Index
- If the Standard ValueLi ij has a range
  - For $C_i \leq L_ij$ average

    $$(C_i/L_{ij})_{baru} = \frac{[C_i - (L_{ij})_{average}]}{\{(L_{ij})_{minimum} - (L_{ij})_{average}\}} \quad (1)$$
  - For $C_i > L_{ij}$ average

    $$(C_i/L_{ij})_{new} = \frac{[C_i - (L_{ij})_{average}]}{\{(L_{ij})_{maximum} - (L_{ij})_{average}\}} \quad (2)$$
- If the parameter concentration value decreases, the level of pollution increases, for example Dissolved oxygen. Determine the theoretical value or maximum value of Cim (eg for Dissolved oxygen, then Cim is the value of Dissolved oxygen saturated). In this case the Ci/Lij value of the measurement results is replaced by the Ci/Lij value calculated, namely:

  $$(C_i/L_{ij})_{new} = \frac{C_{im} - C_{i\,measurement\ result}}{C_{im} - L_{ij}} \quad (3)$$
- P is a constant and its value is determined freely and adjusted according to the results of environmental observations and or the desired requirements for a designation (use value 5).
- Determining the PIj

  $$PI_j = \sqrt{\frac{(C_i/L_{ij})^2{}_M + (C_i/L_{ij})^2{}_R}{2}} \quad (4)$$

3. Result and Disusscion

Based on the results of the comparison between the water quality monitoring data of the Cimahi River in West Bandung Regency with reference to the quality standard of Government Regulation no. 22 of 2021 concerning the Implementation of Environmental Protection and Management of water classification for class II. It is known that there are 6 parameters that exceed the quality standard so that it affects the water quality of the Cimahi River in West Bandung Regency. The following is a description of the discussion of the analysis of water quality that exceeds the quality standard on the Cimahi River in West Bandung Regency.

3.1 TSS (Total Suspended Solid)

Based on the measurement results, the concentration of TSS at the upstream point was 3 mg/L, the midpoint was 26 mg/L, and the downstream point was 88 mg/L. The comparison of the quality standard values with the results of measurements of TSS concentrations in Cimahi River water in West Bandung Regency is presented in Figure 3. Based on Figure 3, the high concentration of TSS in the lower reaches of the Cimahi River in West Bandung Regency is caused by domestic waste, livestock, agriculture, as well as the erosion process. soil and sedimentation that occurs along the river flow. The concentration value has increased significantly from upstream to downstream. This is due to the cumulative value according to the direction of flow towards the downstream point as the end point of receiving the pollutant load.

Concentrations of TSS that exceed the quality standard will result in inhibition of light penetration into the air which can reduce plant activity, so that the oxygen produced by plants is reduced and causes air biota such as fish to die [4].

3.2 Biochemical Oxygen Demand (BOD_5)

Based on the measurement results, the concentration of BOD_5 at the upstream point was 1.72 mg/L, at the midpoint 5.64 mg/L, and at the downstream point 9.19 mg/L. Comparison of quality standard values with BOD_5 concentration in Cimahi River water in West Bandung Regency is presented in Figure 4. Based on Figure 4, the concentration value of BOD_5 has increased significantly due to the cumulative value of the pollutant load flowing from the upstream to the downstream point as well as the surrounding environmental conditions that affect the presence of pollutant sources. The high value of BOD_5 indicates high organic waste in river bodies, as a result of domestic waste disposal, agricultural and livestock activities. The Cimahi watershed in West Bandung Regency in the upper and middle parts is dominated by agriculture and animal husbandry, while the downstream point is dominated by agriculture and dense settlements.

High concentrations of BOD that exceed quality standards cause microbes to become active and decompose organic matter biologically, producing foul-smelling CH_4, NH_3, and H_2S gases [12].

3.3 Chemical Oxygen Demand (COD)

Based on the measurement results, the concentration of COD at the upstream point was 7.19 mg/L, at the midpoint 23.04 mg/L, and at the downstream point

36.75 mg/L. Comparison of quality standard values with COD concentration in Cimahi River water in West Bandung Regency is presented in Figure 5. Based on Figure 5, the concentration value of BOD_5 has increased significantly due to the cumulative value of the pollutant load flowing from the upstream to the downstream point as well as the surrounding environmental conditions that affect the presence of pollutant sources. The high levels of COD are due to the large number of organic and inorganic substances contained in wastewater from agriculture, animal husbandry and residential areas.

A high concentration of COD that exceeds the quality standard in water bodies causes the oxygen content in the water to be low, as a result the aquatic biota lacks oxygen or oxygen needs are not met so that they can die [5].

3.4 Nitrite (NO_2-N) as N

Based on the measurement results, the concentration of Nitrite at the upstream point was 0.0051 mg/L, at the midpoint 0.4385 mg/L, and at the downstream point 0.0307 mg/L. Comparison of quality standard values with Nitrite concentration in Cimahi River water in West Bandung Regency is presented in Figure 6. Based on Figure 6, the concentration of nitrite in the Cimahi River at the upstream, middle and downstream points fluctuates. The lowest concentration of nitrite is at the upstream and downstream points while the highest concentration is at the midpoint. Generally, the value of nitrite in water is small because it is oxidized to nitrate. The high levels of nitrite indicate that the water conditions are not in natural conditions. Sources of nitrite pollutants are high due to high organic matter.

The impact of high concentrations of nitrite if consumed in excess for humans and animals will be toxic resulting in disruption of the oxygen binding process by blood hemoglobin, then forming methaemoglobin which is unable to bind oxygen [1].

3.5 Free Chlorine

Based on the measurement results in 2020, the concentration value of Free Chlorine in the Cimahi River at the upstream point is 8.1 mg/L, at the midpoint 14.49 mg/L, and at the downstream point is 17.24 mg/L. Comparison of quality standard values with Free Chlorine concentration in Cimahi River water is presented in Figure 7. Based on Figure 7, the high concentration of free chlorine in the Cimahi River is caused by waste from the domestic sector such as cleaning agents that enter the river body, also from the agricultural

sector where most of the population in the West Bandung Regency area is a source of economic production in the agricultural sector. with the use of pesticides which then flows into river bodies. The increase in the concentration of free chlorine occurred significantly from the upstream point to the downstream due to the cumulative value carried following the direction of the river flow and the addition of pollutant loads by the surrounding environmental conditions.

Impact on human health on the effect of several levels of chlorine concentration when consumed on health [7].

3.6 Total Detergent

Based on the measurement results, the detergent concentration value in the Cimahi River at the upstream point was 0.11 mg/L, at the midpoint 0.19 mg/L, and at the downstream point was 0.32 mg/L. Comparison of the quality standard value with the concentration of Total Detergent in Cimahi River water is presented in the total detergent content increases significantly from the upstream point to the downstream point. This is due to the pollutant load carried by the flow direction and the surrounding conditions that affect the high concentration. The highest concentration is found at the downstream point due to the cumulative load of pollutants and household waste in the use of detergents as cleaners. The impact on the environment on the use of detergents with high phosphate content will cause eutrophication.

The impact on the environment on the use of detergents with high phosphate content will cause eutrophication. If the water becomes cloudy and foamy, it can affect the contact of the air with the detergent so that the aerobic decomposition process is hampered, as a result the degradation does not run perfectly [8].

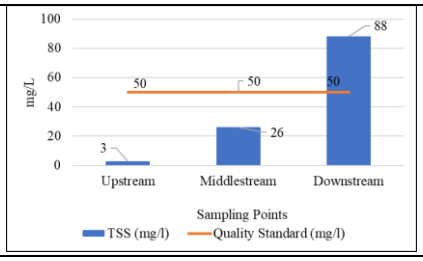

Figure 3. TSS

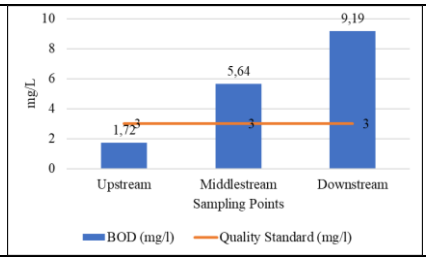

Figure 4. BOD_5

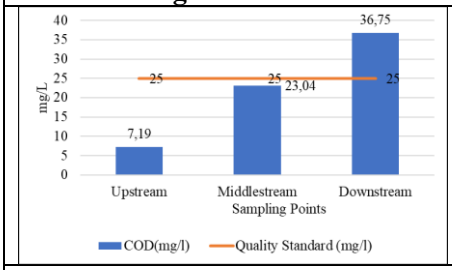

Figure 5. COD

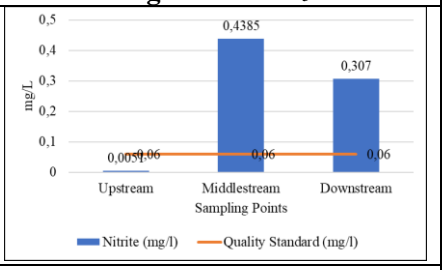

Figure 6. Nitrite (NO2-N) as N

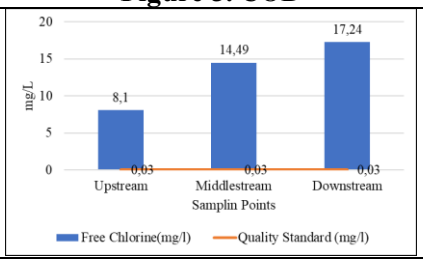

Figure 7. Free Chlorine

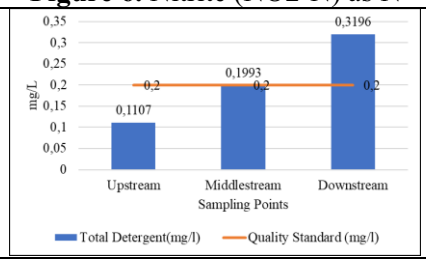

Figure 8. Total Detergent

Based on the results of the analysis, the status of the water quality of the Cimahi River in West Bandung Regency is classified as heavily polluted, the high value of water quality with the pollutant index method is known that there are 6 parameters that exceed the water quality standard, namely TSS, BOD_5, COD, Nitrite , Free Chlorine and Total Detergent. Poor water quality has increased significantly, this is due to the cumulative pollutant load from upstream to downstream. The cause of poor water quality at the research location is the upstream point being dominated by the agricultural and livestock sectors, while at the middle point it is dominated by the residential and agricultural sectors, then at the downstream point is dominated by densely populated settlements. The poor quality of this river water causes the function of the river to be reduced, the river cannot be used as a source of raw water.

Table 2. Classification of Cimahi River Pollution Index Values in West Bandung Regency

Sampling Point	Pollution Index	Classification
Upstream	13.38	Heavy Polluted
Middle	14.99	Heavy Polluted
Downstream	15.36	Heavy Polluted

4. Conclusion

Based on the research results, there are 6 main parameters that cause water pollution, namely TSS, BOD_5, COD, Nitrite, Free Chlorine, and Detergent as MBAS. The Pollutant Index results obtained on the Upper Cimahi River are categorized as heavily polluted with a significant increase from point 1 to 3, respectively 13.38 at point 1, 14.99 at point 2, and 15.36 at point 3. Source Potential polluters in this river are the domestic sector, agriculture, and livestock.

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