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Regional Case Study

Assessment of Cihampelas River Water Quality Status using STORET Method and Pollution Index

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Abstract

The Cihampelas River is one of river that crosses the Regency and City of Bandung, West Java, with a length of 8.5 km. This study aims to assess the water quality status of Cihampelas River based on the STORET method and Pollution Index. The research was conducted at four stations based on the level of anthropogenic activity from July to September 2016. Measurements of the physical and chemical parameters of the waters were carried out five times at two-week intervals. Water quality status was assessed using the STORET method and Pollution Index based on the parameters TDS, TSS, pH, DO, BOD, COD, nitrate, nitrite, ammonia, and total phosphorus (TP). Using the STORET method, shows a score of -20 to -46 in the category of moderately to severely polluted waters. Based on the Pollution Index method, the waters of the Cihampelas River show lightly to severely polluted conditions with a score of 1.14 to 44.66. The water quality status of the Cihampelas River shows a decreasing trend from the upstream to the downstream.

Keywords: Pollution index; river; STORET; total phosphorus; water quality

1. Introduction

Rivers are aquatic resources that are essential for human life and other living things. The rapid population growth increases the demand for raw water for various uses. On the other hand, water resources tend to experience a decline in both quality and quantity. As an essential aquatic resource, river waters are susceptible to anthropogenic influences such as domestic, industrial, and agricultural, as well as the impact of natural factors such as precipitation, erosion, and material weathering (Hamid et al., 2020). The level of water pollution due to various pollutants can indicate the status of ecosystem health, which also affects aquatic biodiversity, such as changes in species composition from sensitive species to tolerant species (Xu et al., 2014).

The Citarum watershed is the largest on West Java Province. It is a significant concern because its condition is worsening, and it is ranked among the most polluted rivers in the world (Cavelle, 2013). Citarum watershed degradation is affected by changes in function and land use in the upstream Citarum River, which impact decreasing water quality. Most of the upstream Citarum watershed is used for agriculture (65%), built-up land (15%), and forests (10%), and the rest is for other uses (10%) (Agaton et al., 2016). The Upper Citarum River shows moderate to severe levels of pollution based on the Pollution Index from 2002 to 2010 (Marganingrum et al., 2013). Kurniawan (2014) reported that the upstream Citarum River showed a quality status of heavily polluted when compared to National Water Quality Standards for Indonesia (class 2) based on the STORET method.

The government has attempted restoration of the quality of the Citarum River through various programs such as Citarum Harum, which is listed in Presidential Regulation of Indonesia Number 15 of 2018. Class 2 water quality as an achievement target in the Citarum Watershed Management Action Plan can be assessed using the methods listed in Decree the State Minister of Environment of Indonesia No. 115/2003 and Regulation of the Minister of Environment and Forestry No. 27/2021. Achievement of important targets is achieved through monitoring the water quality of the tributaries of the Citarum River, which also contribute pollutants in addition to the main river flow.

The quality of water bodies can be assessed using conventional methods, namely by comparing the measured parameter values with the established water quality standards. However, this method cannot provide overall information on water quality spatially and temporally (Nayak & Patil, 2015). The quality status of river waters can also be assessed through index calculations such as the STORET index (Storage and Retrieval of Water Quality Data System) and the Pollution Index, which are popular in Indonesia and listed in Decree of the State Minister of Environment of Indonesia No. 115/2003. The two indices combine several measured water quality parameters into a single value based on water quality standards and determine the water quality status (Gummadi et al., 2015). Thus, using these two indices can facilitate the interpretation of water quality status.

The STORET Index and the Pollution Index provide flexibility in using the number and type of water quality parameters and using quality standard regulations according to local needs (Aristawidya et al., 2020). The use of the STORET method in assessing the quality status of rivers has been carried out by Sulthonuddin et al. (2019), Luvitasari (2021), Mudjiardjo (2021), and Ramadhawati et al. (2021). The use of the Pollution Index method has been carried out, among others, by Djoharam (2018), Machairiyah et al. (2020), Hermawan & Wardhani (2021), and Suriadikusumah et al. (2021). The STORET Index and Pollution Index methods that are widely used generally still refer to the water quality standards listed in Government Regulation (GR) of Indonesia No. 82/2001 concerning Water Quality Management and Water Pollution Control. Thus, the two indices can be used appropriately by referring to the river water quality standards in GR No. 22/2021 concerning the Implementation of Environmental Protection and Management. The use of these standard and the observation of trends in water quality parameters, from upstream to downstream, in locations with diverse anthropogenic activities are novel aspect of this study.

Cihampelas River is one of the rivers in West Java Province which flows along 8.5 km and crosses two administrative areas, namely Bandung Regency and Bandung City. The upstream part of this river is at the foot of Mount Manglayang, Cilengkrang District, Bandung Regency, while the downstream region is in Gedebage District, Bandung City, which will join Cipamulihan river to Cisaranten river and Citarik sub-watershed as part of the Citarum watershed. The local community uses this river as a water source to support tourism, domestic, agricultural, and fishing activities. Anthropogenic activities along Cihampelas River can reduce river water quality, making it unsuitable for its designation. This study aims to assess the water quality status of Cihampelas River using the STORET method and Pollution Index. Research conducted on Cihampelas River is expected to be helpful in efforts to manage water resources.

2. Methods

This study was conducted using primary and secondary data. The primary data consists of field observations and river water quality measurements. The secondary data consists of a thesis from the Department of Environmental Engineering, Bandung Institute of Technology and documents from the Agency of Water Resources and Highways, Bandung City. The study was conducted on Cihampelas River at four observation stations based on the level of anthropogenic activity (Table 1 and Figure 1). Sampling was performed five times at two-week intervals from July to September 2016 (Table 2).

Table 1. Research location in cihampelas river

Location	Coordinate	Information
St1 (Cilengkrang)	6°53'23.8" S 107°43'53.5" E	Hills and waterfall tourism
St2 (Cisurupan)	6°54'19.9" S 107°43'27.1" E	Settlements, farms, and agriculture
St3 (Pasanggrahan)	6°55'05.4" S 107°42'29.6" E	Dense settlement and industry
St4 (Mekarmulya)	6°56'02.0" S 107°41'58.2" E	Industry

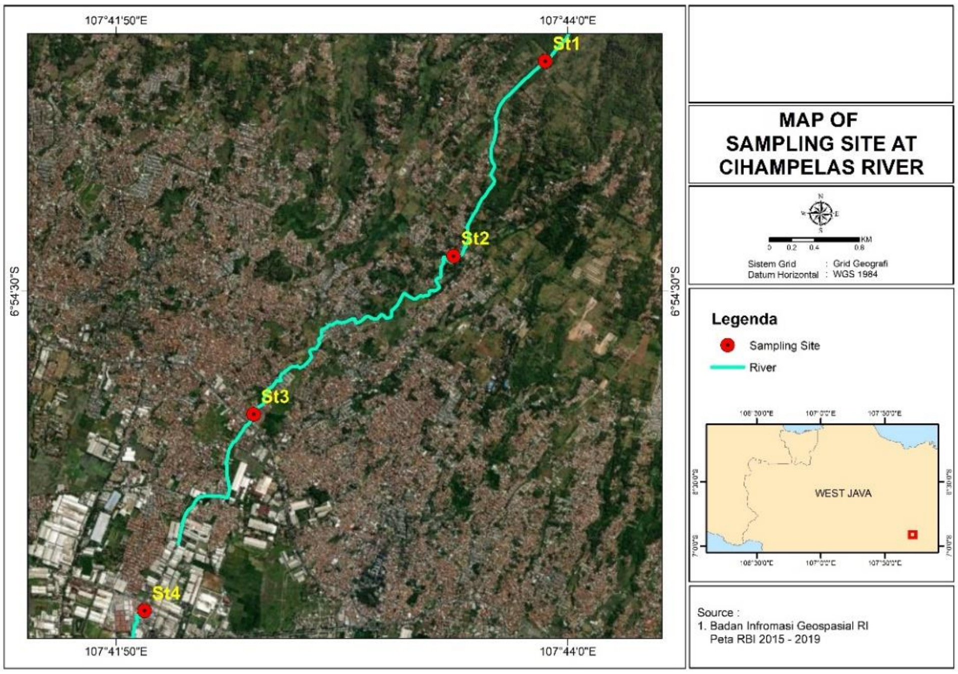

Figure 1. Research location map in Cihampelas River

Table 2. The dates of the sampling campaigns

Date	Weather			
	St1	St2	St3	St4
July 30, 2016	Sunny	Sunny	Sunny	Sunny
August 13, 2016	Cloudy	Cloudy	Sunny	Cloudy
August 27, 2016	Moderate rain	Light rain	Cloudy	Sunny
September 10, 2016	Cloudy	Cloudy	Sunny	Sunny
September 24, 2016	Light rain	Cloudy	Sunny	Sunny

Measurement of the chemical and physical parameters of the waters was carried out in situ and the laboratory. Parameters measured in-situ included water temperature, TDS, pH, and dissolved oxygen levels. Parameters analyzed in the laboratory include TSS, BOD, COD, nitrate, nitrite, ammonia, and TP.

The TSS analysis was done by filtering water samples using glass-fiber filters and drying them at 103^0C-105^0C to reach a constant weight (SNI 06-6989.3-2004). The BOD analysis calculated the difference between the initial DO concentration and DO on Day 5 of the water samples incubated in a dark room for 5 days at 20°C ± 1°C (SNI 6989.72:2009). The COD analysis was performed using a closed reflux method, where 2.5 mL of the water sample, 1.5 mL of the digestion solution, and 3.5 mL of a sulfuric acid solution were added into ampoule tubes and homogenized. The tubes were then placed on a COD block digester heated to 150°C and refluxed for 2 hours. The absorbance of the test samples was measured using a spectrophotometer at a wavelength of 420 nm (SNI 6989.2:2009).

Nitrate parameters were analyzed using the brucine method per SNI 06-2480-1991. 2 mL of NaCl and 10 mL of H_2SO_4 were added to a 10 mL water sample. After cooling, 0.5 ml of a mixed solution of brucine sulfate acid was added to the mixture. It was then stirred and heated at 95°C for 20 minutes. The absorbance of the solution was measured using a spectrophotometer at a wavelength of 410 nm. The nitrite analysis was conducted by adding 1 mL of sulfanilamide solution to 50 mL of the water sample, shaking the mixture, and leaving it for 2-8 minutes. The mixture was then added with 1 mL of dihydrochloride NED solution, shaken, and left for 10 minutes. Next, the solution was measured using a spectrophotometer at a wavelength of 543 nm (SNI 06-6989.9-2004).

For the ammonia test, 50 mL of the water sample was added with 1 mL of Nessler's solution, shaken, and left for at least 10 minutes. The absorbance of the solution was measured using a spectrophotometer at a wavelength of 400-500 nm (SNI 06-2479-1991). For the TP test, 100 mL of the water sample was added with 1 mL of H_2SO_4 and 5 mL of HNO_3 and heated until a volume of 1 mL remains. After cooling, 20 mL of water, 1 drop of phenolphthalein, and a few drops of NaOH 1 N was added. Water was added to the solution until it reached a volume of 100 mL. Next, 1 drop of phenophthalein and 8 mL of a mixed solution (ammonium molybdate solution and ascorbic acid solution in a ratio of 5:1) was added. After stirring, the absorbance of the solution was measured using a spectrophotometer at a wavelength of 880 nm (SNI 19-2483-1991).

The water quality tests were performed in the laboratory using calibrated measuring instruments, contamination-free glassware, and pro-analysis chemicals. In addition, the analyses were conducted twice (duplo) to control the accuracy of the analysis where the Relative Percent Difference (RPD) was < 30% for the BOD and < 10% for the COD. The Relative Percent Difference (RPD) in TSS and nitrite testing is <5%, nitrate and ammonium are 2%, and TP is 3%.

The STORET method is used to determine water quality status regarding class 2 river water quality standards according to GR No. 22/2021. The STORET method listed in Decree of the State Minister of Environment of Indonesia No. 115/2003. The parameters calculated in calculating the STORET index include TDS, TSS, pH, DO, BOD, COD, nitrate, nitrite, ammonia, and TP. Determination of water quality status using the STORET method is carried out in the following steps.

a. The maximum, minimum, and average values of the measurement results of each parameter were compared with the quality standard values according to the water class.
b. A score of 0 was given for water parameters that meet water quality standards.
c. For water parameters that do not meet water quality standards are scored according to Table 2.
d. Calculation of the negative number of all parameters and determination of the water quality status from the total score obtained were used the United States Environmental Protection Agency (US-EPA) value system (State Minister of Environment of Indonesia,2003)

Table 3. The scoring system in the STORET method

Number of sample	Score	Parameter		
		Physical	Chemical	Biological
<10	Maximum	-1	-2	-3
	Minimum	-1	-2	-3
	Average	-3	-6	-9
≥10	Maximum	-2	-4	-6
	Minimum	-2	-4	-6
	Average	-6	-12	-18

Table 4. Water quality criteria based on the STORET method

Score	Class	Category
0	A	Good condition
-1 - -10	B	Lightly polluted
-11 - -30	C	Moderately polluted
< -30	D	Severely polluted

Table 5. Water quality criteria based on Pollution Index

Score of PIj	Categori
0<PIj<1.0	Good condition
1.0<PIj<5.0	Lightly polluted
5.0< PIj<10	Moderately polluted
PIj>10.0	Severely polluted

The Pollution Index (IP) method is used to determine water quality status regarding class 2 river water quality standards according to GR No. 22/2021. The Pollution Index method listed in Decree of the State Minister of Environment of Indonesia No. 115/2003. The parameters calculated in the Pollution Index include TDS, TSS, pH, DO, BOD, COD, nitrate, nitrite, ammonia, and TP. The pollution index following in equation (1) is as follows.

$$PIj = \frac{\sqrt{\left(\frac{Ci}{Lij}\right)_M^2 + \left(\frac{Ci}{Lij}\right)_R^2}}{2} \qquad \text{(1)}$$

Information:

PIj	=	Pollution index
Ci	=	Water analysis parameter value
Lij	=	Standard of water quality parameter
(Ci/Lij)M	=	The maximum value of Ci/Lij
(Ci/Lij)R	=	The average value of Ci/Lij

3. Result and Discussion

3.1. Distribution of Water Quality Values

3.1.1. Temperature, TDS, and TSS

Temperature values tend to rise from station 1 to station 4 (Table 6). This is related to differences in measurement time, site elevation, and vegetation cover. Sinambela and Sipayung (2015) state that water temperature can fluctuate by following air temperature patterns, sunlight intensity, geographical location, vegetation cover, and internal water conditions. The measured temperature values are still in the range of 18-30 °C, which supports the life of aquatic organisms, according to Effendi's statement (2003).

Total Dissolved Solids (TDS) measured in Cihampelas River showed an increase from upstream to downstream with a value of 84 mg/L to 303.2 mg/L (Table 6). The high TDS value in the downstream or station 4 because of domestic, agricultural, fishery, and industrial waste flows from upstream to downstream. The TDS values measured at the four sampling locations are still in the category of natural waters, which are usually less than 500 mg/L (Moran, 2018). In addition, TDS value in Cihampelas River was still below the class 2 river water quality standard of 1000 mg/L in GR No. 22/2021.

High Total Suspended Solids (TSS) inhibit the entry of sunlight into the water so that it will interfere with the process of photosynthesis in water. High TSS also causes a decrease in water clarity

(Syawal et al., 2020). TSS values in the waters of Cihampelas River ranged from 10.64 mg/L – 19.74 mg/L (Table 6), with the highest values being in station 2 and lowest in station 3. The relatively high TSS value at station 2 is due to the large number of soil particles or organic matter carried by runoff water due to heavy rain before sampling. The measured TSS value in Cihampelas River was still below the standard value of 50 mg/L in GR No. 22/2021 (class 2).

Table 6. Values of physicochemical parameters of water samples from Cihampelas River

Parameter	Unit	Location				
		St1 Cilengkrang	St2 Cisurupan	St3 Pasanggrahan	St4 Gedebage	Water Quality Standard (class 2)*
Water Temperature	°C	21.88 ± 1.05	23.87 ± 1.53	27.22 ± 1.35	26.83 ± 1.78	Deviation 3
TDS	mg/L	84.0 ± 21.26	108.4 ± 27.76	167.8 ± 48.41	303.2 ± 178.73	1000
TSS	mg/L	13.64 ± 19.33	19.74 ± 29.24	10.64 ± 3.38	17.60 ± 14.32	50
pH		6.89 ± 0.85	6.83 ± 0.41	6.44 ± 0.52	7.11 ± 1.02	6-9
DO	mg/L	6.87 ± 0.74	6.57 ± 0.88	5.42 ± 0.28	4.32 ± 0.37	4
BOD	mg/L	4.57 ± 3.76	5.05 ± 3.75	8.01 ± 4.57	14.87 ± 6.42	3
COD	mg/L	23.16 ± 32.36	28.12 ± 40.79	20.90 ± 14.64	38.80 ± 16.71	25
Nitrate	mg/L	0.480 ± 0.91	0.880 ± 1.14	0.538 ± 0.68	0.296 ± 0.32	10
Nitrite	mg/L	0.01 ± 0.00	0.18 ± 0.25	0.01 ± 0.00	0.07 ± 0.13	0.06
Ammonia	mg/L	0.073 ± 0.03	0.950 ± 1.00	3.854 ± 2.18	12.542 ± 6.58	0.2
Total Phosphorus	mg/L	0.278 ± 0.44	0.172 ± 0.19	0.458 ± 0.32	0.849 ± 0.68	0.2

3.1.2. pH, DO, BOD, and COD

The average pH value along Cihampelas River, with a range of 6.44-7.11, still meets class 2 water quality standards (pH value 6-9). According to Effendi (2003), most aquatic biota are sensitive to changes in pH and prefer a pH of around 7 – 8.5. Water conditions with strong acids or bases will disrupt the biota's metabolic processes and respiration (Sinambela & Sipayung, 2015).

The measured DO values in the Cihampelas River meet the class 2 water quality standards which requires a minimum DO of 4 mg/L. The DO value in Cihampelas River decreased from upstream (6.87 mg/L) to downstream (4.32 mg/L). A decrease in DO values was also reported in research on the upstream to downstream segments of Cibeureum River during the dry season, from 5.35 mg/L to 2.97 mg/L (Hermawan & Wardhani, 2021). The relatively high DO values in the two upstream rivers are influenced by the minimal pollution load that enters the river flow. In addition, the collision of the river water with rocks could be increase the transfer of oxygen from the atmosphere to the water body in upstream Cihampelas River. The DO value, which tends to decrease downstream in Cihampelas River is related to the increasing number of organic compounds decomposed by decomposer microbes. This also causes a decrease in DO values in Cibeureum River.

The results of BOD measurements in Cihampelas River show values ranging from 4.57 to 14.87 mg/L. The higher BOD value from upstream to downstream indicates the increasing amount of organic waste in the waters due to anthropogenic activity oxidized by aerobic bacteria. The measured BOD value has exceeded the required river water quality standard of 3 mg/L (class 2). This is in line with the research by Mailisa et al. (2021) on Sani River, which shows the BOD exceeds the standard value with increasing trend from upstream to downstream.

Based on the measurement results, COD values obtained showed variations in the range of 20.9 – 38.8 mg/L and an average value of 27.75 mg/L. COD Value in station 1 and station 3 has fulfilled the river water quality standard of 25 mg/L (class 2). The high value of COD in station 4 is thought to be due to the large amount of organic matter carried from upstream to downstream and industrial waste around the river. COD values at station 1 and station 2 were slightly higher than station 3 is thought to be related to the addition of organic material carried by rainwater runoff in the third sampling. The COD value in Cihampelas River is lower than that of the upstream, middle, and downstream segments of Cisangkan River, with the concentration of 90 mg/L, 150 mg/L, and 85 mg/L respectively (Rosmeiliyana & Wardhani, 2021). This is related to the sources of organic pollutants in Cisangkan River, which are more numerous than the Cihampelas River. Residential, agricultural, and industrial areas that are found starting from the upper reaches of Cisangkan River has the potential to produce more organic waste, which affects the high demand for dissolved oxygen for the oxidation process.

3.1.3. Nitrate, Nitrite, Ammonia, and Total Phosphorus

The nitrate values in the Cihampelas River varied from 0.296 to 0.880 mg/L, with an average of 0.55 mg/L. Station 2 recorded the highest nitrate value, while station 4 showed the lowest. The recorded nitrate values meet the class 2 water quality standards (10 mg/L). According to Effendi (2003), nitrate values exceeding 0.2 mg/L could lead to eutrophication.

During observations, the nitrite levels were 0.01 to 0.18 mg/L. However, at station 2 (0.18 mg/L) and station 4 (0.07 mg/L), the nitrite levels exceeded the water quality standard of 0.06 mg/L. Despite this condition, the recorded nitrite levels were lower than those found in the Cibeureum River during the dry season (0.211 to 0.54 mg/L). Following Rjaiz et al. (2020) suggest that microorganisms' oxidation and reduction processes of nitrogen compounds, dependent on oxygen availability, contribute to nitrite content in water bodies.

Ammonia levels in the Cihampelas River ranged from 0.073-12.542 mg/L, with the highest level recorded downstream. Except for station 1 (0.07 mg/L), all other stations show ammonia exceeded the standard value of 0.2 mg/L. Similarly, in the Cisangkan River, ammonia levels increased from upstream to downstream at 1.8 to 16.6 mg/L. This rise in ammonia levels in both rivers is attributed to pollutants introduced by agricultural, industrial, domestic, and livestock activities. Natural factors, such as nitrogen fixation, metabolism, and organism decomposition, can also contribute to ammonia presence in natural waters (USEPA, 2013; Ni'am et al., 2021).

Regarding total phosphorus (TP), Cihampelas River exhibited levels below 1 mg/L, indicating natural water condition, as stated by Boyd (1988). However, except for station 2 (0.172 mg/L), TP levels exceeded the class 2 water quality standards of 0.2 mg/L. In the Cisangkan River, TP levels increased from upstream (0.40 mg/L) to downstream (1.05 mg/L) during the dry season (Rosmeiliyana & Ramdhani, 2021). Both river showed an upward trend in TP levels from upstream to downstream due to the accumulation of organic pollutants. The Cisangkan River had higher organic pollutant than the Cihampelas River, corresponding to its higher TP content, along with the ammonia content.

3.2. Water Quality Status of Cihampelas River

The STORET index, utilized to assess water quality, is derived from maximum, minimum, and average values of measured parameters within a specific time series. A lower STORET index value signifies higher pollution levels in the water body. In the case of the Cihampelas River between July and September

2016, the STORET method generated values ranging from -20 to -46 (Figure 2). According to the STORET index, Station 1 is classified as moderately polluted, while stations 2, 3, and 4 are graded as severely polluted. Station 1 attained the highest STORET index value (-20) in the moderately polluted category due to maximum and average values of BOD and total phosphorus that exceeded class 2 water quality standards. Additionally, the maximum value of COD and the minimum value of pH that did not meet the water quality standards also contributed to the water quality status at Station 1. At Station 2, the severely polluted status was influenced by maximum and average values of BOD, COD, nitrite, and ammonia that exceeded the water quality standards. Furthermore, TSS and TP with maximum values that exceeded the quality standard also contribute to the water quality status in St. 2.

Parameters, such as BOD, ammonia, and TP significantly impacted the severely polluted status at station 3. Similarly, these parameters strongly influenced the severely polluted status at Station 4, which recorded the lowest STORET index value (-46), along with COD and nitrite parameters. The minimum values of the BOD and ammonia also affect severely polluted status of St. 3 and St. 4. Overall, the water quality status of Cihampelas River, as determined by the STORET index was largely dependent on chemical parameters like BOD, COD, and TP. Except for Station 1, the ammonia parameters measured at all stations also contributed to a decreased STORET index value. Water quality parameters, including BOD, COD, TP, and ammonia, related with the presence of organic pollutants from various sources such as domestic, agricultural, livestock, and industrial activities. Organic matter in the waters, as represented by COD and BOD values, is decomposed by microbes, leading to the production of compounds like ammonia and phosphorus. An increase in organic pollutants results in higher levels of these parameters, which may exceed water quality standards and subsequently decrease the STORET index value. In the Cibaligo River, the STORET index value decreased due to BOD and COD parameters (Yustiani et al., 2020). Ammonia influenced the STORET index value in the Cihideung River (Effendi et al., 2013).

The Pollution Index is calculated based on the maximum and average ratios of the measured water quality parameter values to water quality standards. This index reflects the instantaneous condition of the water body and a higher Pollution Index value indicates a greater pollution level. During the observation, the Pollution Index values ranged from 1.14 to 44.66 (Figure 3), categorizing the waters of the Cihampelas River as ranging from lightly to severely polluted. Stations 1 and 2 were classified as lightly polluted, whereas stations 3 and 4 were classified as severely polluted. The severely polluted status at stations 3 and 4 was primarily due to the measured ammonia level ratio to class 2 water quality standard. Moreover, other parameters such as BOD, COD, and TP, which exceeded water quality standards, also contributed to the increase in the Pollution Index value, further affecting the decrease in the STORET index value.

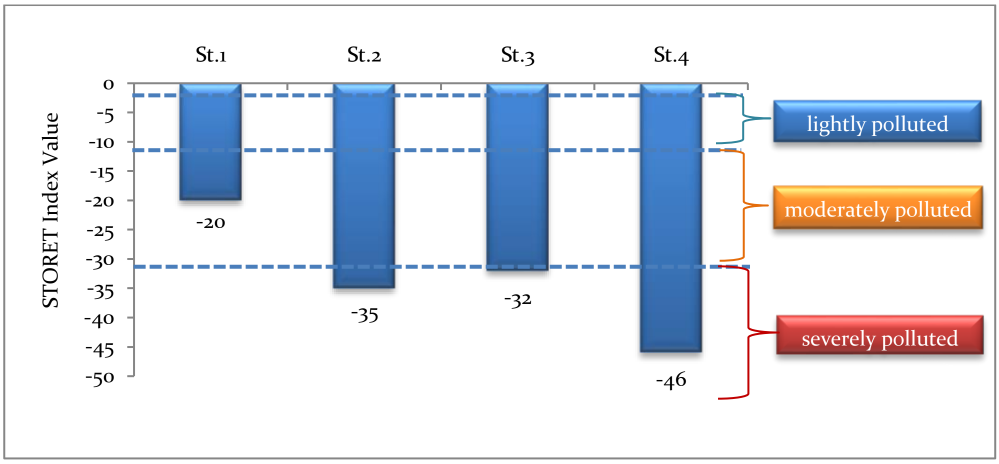

Figure 2. The value and water quality status of the Cihampelas River using the STORET Index

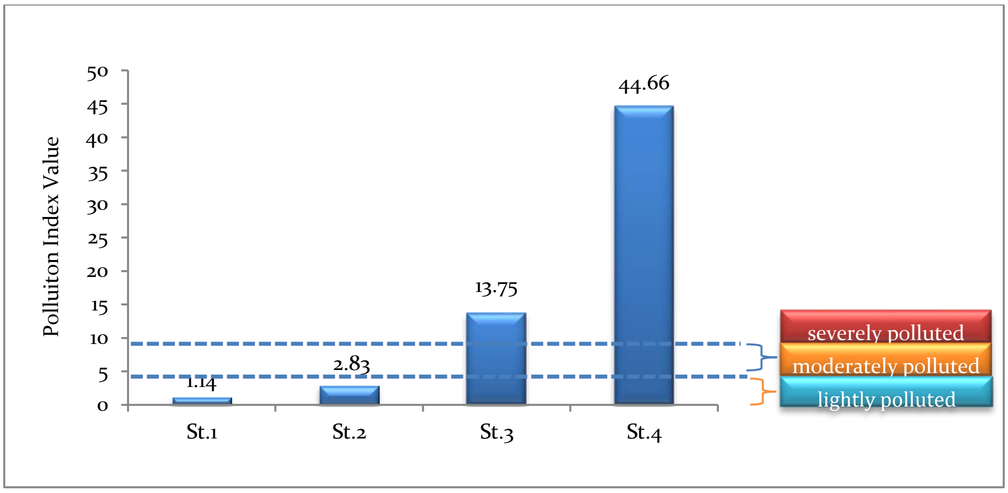

Figure 3. The value and water quality status of the Cihampelas River using the Pollution Index

The water quality status found to be similar at Stations 3 (severely polluted) when assessed using both the STORET index and the Pollution index. However, as per the Pollution index, St. 1 and St. 2 showed lightly polluted criteria. According to Suwari et al. (2010), the Pollution index has a relatively high tolerance to pollution. The Pollution Index is influenced by the ratio of measured parameter values to water quality standards, while, the STORET index is based on water quality parameter scores failing to meet the standards. As a result, the condition of water quality deteriorates with an increasing number of water quality parameters failing to meet the quality standards.

During observation, both STORET and Pollution indices revealed a continuous increase in pollution from upstream to downstream. This deterioration is influenced by changes in anthropogenic activity levels from suburban to downtown areas, where population density has increased. The presence of dense settlements, agricultural activities, and industries has an unfavorable effect on the water quality status of the Cihampelas River.

The feasibility of a body of water for a particular use can be assessed by calculating the pollution index or STORET regarding the national water quality standard. The measured water quality parameters can be supplemented with other parameters such as detergents, fatty oils, heavy metals, pesticides, and even biological parameters adjusted to anthropogenic activity or the function of the surrounding land use. Biological parameters generally limited to *Escherichia coli* and total coliforms can also be equipped with other biological parameters, such as macrozoobenthos or periphyton, which can reflect the health condition of the river over times. Thus, it is essential to evaluate the health condition of water bodies in an integrated manner with periodic measurements during the rainy and dry seasons.

4. Conclusions

The utilization of the STORET index indicates that the water quality of Cihampelas River falls within the criteria of moderately to severely polluted, categorized under class 2 designation according to Government Regulation of Indonesia No. 22/2021. Similarly, the application of the Pollution Index reveals that the Cihampelas River exhibits lightly to severely polluted waters. Changes in the value of both indices are primarily due to parameters such as BOD, COD, and TP, which have exceeded class 2 river water quality standards. This indicates that anthropogenic activities surrounding the river contributed to the increase in the values of these parameters. Further research can be conducted by measuring other physical, chemical, and biological parameters during the rainy and dry seasons.

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