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Study of Water Quality Index of Cilamaya Watershed Before and During The COVID-19 Pandemic

Nur Fitri[1], Wisnu Prayogo[2*], Rachmat Mulyana[2], M. Faisi Ikhwali[3], Sitepu Amrina Rosyada[4], Ahmad Zulfikar[2]

[1]Department of Chemistry, Universitas Islam Negeri Sunan Gunung Djati, Bandung 40614, Indonesia
[2]Department of Building Engineering Education, Universitas Negeri Medan, Medan 20221, Indonesia
[3]Department of Environmental Engineering, Universitas Islam Negeri Ar-Raniry, Banda Aceh 23111, Indonesia
[4]Department of Architecture, Universitas Negeri Medan, Medan 20221, Indonesia
*Corresponding author: wisnuprayogo@unimed.ac.id

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Abstract

Due to the Covid-19 pandemic, the impact of the lockdown on the water quality of major rivers due to restrictions on activities within the country will have an effect. This research compared the Cimalaya Watershed water quality index values before and during the Covid-19 pandemic. River status was conducted using STORET and Pollution Index based on 2019 and 2020 river quality data. Calculations for each method use the same amount of data and parameters, including TSS DO, BOD, COD, TP, Fecal Coliform, and Total Coliform. The results showed a decrease in concentration for water quality parameters in 2020 or during the Covid-19 pandemic compared to 2019. The parameters that experienced a reduction included TSS, DO, BOD, and COD. But besides that, there has been an increase in water quality parameters in 2020, namely the parameters TP, Fecal Coliform, and Total Coliform. The average STORET and Pollution Index values in 2020 indicated that the river is getting moderately polluted than in 2019. This research can be a preliminary study, but using more parameters and methods will make the analysis more comprehensive.

Keywords: COVID-19 Pandemic, STORET, Pollution Index, River Quality.

Introduction

The global havedemic COVID-19, caused by the new coronavirus, was considered one of the deadliest diseases humanities has ever suffered. According to the World Health Organization (WHO), cases of the SARS-CoV-2 virus were first detected in December 2019, in China's Hubei province, then declared a Public Health Emergency of International concern. With infections rapidly escalating and no vaccine/treatment formulated, most countries have called for an immediate and widespread lockdown to curb transmission of the virus (Siregar et al., 2016; Mulyana et al., 2021). The source of COVID-19 is reported from the novel coronavirus (SARS-CoV-2) and will be generated from other mammals (Villeneuve & Goldberg, 2021). On 6 March 2020, the Indonesian government announced the first case of Covid-19 in Indonesia. Outbreak control to reduce transmission needs to be carried out thoroughly. At-risk populations must receive serious attention to remain protected from the spread of Covid-19 (Prayogo et al., 2020). All efforts related to the lockdown policy to stop transmission must be carried out, especially in Indonesia as a tropical country with a large population and mobility that has the potential to be infected with Covid-19 (Prayogo et al., 2021; Yacub et al., 2022).

During the lockdown period, human activities were restricted, and most activities stopped. Given the restrictions on industrial operations, industrial discharges are expected to be reduced to a minimum in most areas. In addition, the lockdown period offers a unique situation for assessing the quality of surface water bodies including major rivers in Indonesia. On March 4, 2020, the Governor of West Java, Ridwan Kamil, together with the West Java Regional Leadership Communication Forum (Forkopimda) launched the Real Action Movement for Pollution and Damage Control (PPK) for the Cilamaya Watershed (DAS) in Barugbug Dam, Jatisari District, Karawang Regency. Based on data from the West Java Province Environmental Service as of 2020, the quality status of the Cilamaya Watershed is Moderately Polluted due to environmental damage (land use change and land damage), domestic waste (domestic wastewater pollution and waste accumulation), industrial waste (high BOD and COD values and low dissolved oxygen), and livestock waste (animal carcasses and animal waste) (Subroto et al., 2022; Ikhwali et al., 2022; Azizah et al., 2022). Due to the Covid-19 pandemic, the impact of the lockdown on the water quality of major rivers due to restrictions on activities within the country will have an effect, which is an effort to try to see the status and improvement of water quality (Prayogo et al., 2023; Luthan et al., 2022). Water quality parameters were compared between the periods before and during the Covid-19 pandemic. Four main locations in the Cimalaya watershed will be analyzed, which will show the status of water quality during the Covid-19 pandemic compared to the status of water quality before the Covid-19 pandemic (Fitria et al., 2022). The purpose of this study was to compare the results of several water quality parameters for the Cimalaya Watershed before and during the Covid-19 pandemic and to determine and compare the Cimalaya Watershed Water Quality Index before and during the Covid-19 pandemic.

Material and Method

Research Location

The Cilamaya Watershed is a river with a length of about 97 km^2, which is in West Java Province, Indonesia. This river divides into three districts: Karawang district, Purwakarta district, and Subang district. The Cilamaya Watershed flows south to north, ending at Mount Sunda or Mount Tangkuban Parahu, and empties into the Java Sea. This river spring is in Curug Cilamaya, Parakaneuri Village, Kiarapedes, Purwakarta district. The Cilamaya Watershed (DAS) area is 390.01 km^2 covering the districts of Karawang, Purwakarta, Subang, and a small part of Bandung. The shape of the watershed is elongated and has a topography that varies from mountain slopes and hills, wavy to flat. The upstream area of the river is on the border of Subang Regency and Purwakarta Regency, while the river mouth is near Cilamaya Wetan, Karawang Regency. Figure 1 is a site map of Cilamaya Watershed.

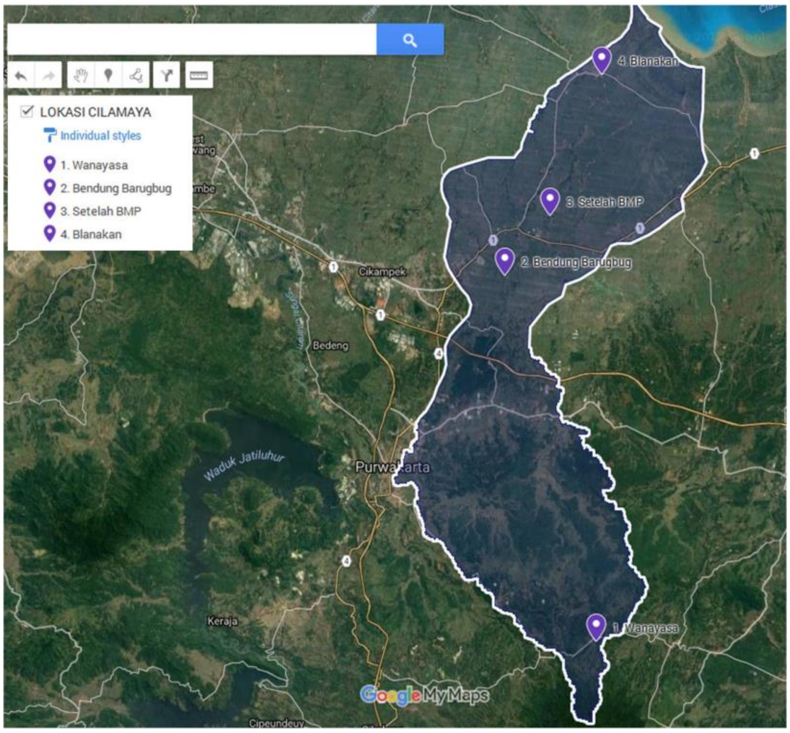

Figure 1. Research Site Map

The Cilamaya Watershed is divided into 2 (two) segments, which consist of: (a). segment 1A, namely the upstream part of the Cilamaya Watershed and its tributaries in the Purwakarta Regency area bordering Subang Regency, including Wanayasa District, Pasawahan District, Campaka District, and Purwakarta District; (b). segment 1B, namely the upstream part of the Cilamaya Watershed and its tributaries in the Subang Regency area, which borders on Purwakarta Regency, including

Serangpanjang District, Cipeundeuy District, and Pabuaran District; (c). segment 2A, namely the downstream part of the Cilamaya Watershed in the Karawang Regency area, which borders Subang Regency, including Jatisari District, Banyusari District, and Cilamaya Wetan District; And (d). segment 2B, the downstream Cilamaya Watershed in the Subang Regency area, borders Karawang Regency, covering Patokbeusi District, Ciasem District, and Blanakan District 9 (Pasaribu et al., 2022).

Collecting Data

Study of the Water Quality Index method using secondary monitoring data carried out by the West Java Environmental Service at monitoring point locations in the Cilamaya Watershed area. There are 4 monitoring points with 2 upstream and 2 downstream in different districts, namely (1) Wanayasa, (2) Barugbug Weir, (3) after BMP, and (4) Blanakan, as shown in Figure 1.

Data Analysis

1. STORET

Determination of water quality status using the STORET method is carried out in the following steps: (1) Collect data on water quality and discharge periodically to form data from time to time (time series data), (2) Compare the measurement data for each water parameter with the quality standard value according to the water class, (3). If the measurement results meet the water quality standard value (measurement results < quality standard), then a score of 0 is given, (4) If the measurement results do not meet the water quality standard values (measurement results > quality standards), then a score is given as in Table 1, (5) The negative number of all parameters is calculated, and the quality status is determined from the total score obtained using the value system (Suhardono et al., 2023).

Table 1. Standart Evaluation for STORET

Number of Parameters	Standart	Parameter		
		Physics	Chemistry	Biology
<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

2. Pollution Index

If Lij represents the concentration of water quality parameters listed in the Quality Standard of a Water Use (j), and Ci represents the concentration of water quality parameters (i) obtained from the analysis of water samples at a sampling location from a river channel, then PIj is the index. Pollution for designation (j) which is a function of Ci/Lij. The Pollution Index j score can be determined by: (1). Select the parameters. If the price of the parameter is low, then the water quality will improve, (2). Select the concentration of a standard quality parameter with no range, (3). Calculate the Ci/Lij values for each parameter at each sampling location, (4). If the parameter concentration value decreases, the pollution level increases, for example, DO. Determine the theoretical value or maximum value of Cim (e.g., for DO, then Cim is the value of DO saturation). In this case, the measured Ci/Lij value is replaced by the calculated Ci/Lij value, as shown by equation (1).

$$\left(\frac{C_i}{L_{ij}}\right)_{new} = \frac{C_{im}-C_{i\ (measurement\ results)}}{C_{im}-L_{ij}} \quad (1)$$

(5) Determine the average and maximum values of all Ci/Lij ((Ci/Lij)R and (Ci/Lij)M), and (6) Determine the price of the Pollution Index j, as shown by equation (2).

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

Result and Discussion

Cilamaya Watershed Water Quality

In this study, the quality status of the Cilamaya Watershed before and during the Covid-19 pandemic was studied by calculating the Water Quality Index using the STORET method and the Pollution Index. The Cilamaya Watershed is divided into 2 segments, namely segment 1A, which is included in class 2 water criteria, then segment 1B, 2A, and 2B, which are included in class 3 water criteria. Livestock and animal husbandry. Reported on March 4, 2020, the Governor of West Java, Ridwan Kamil, together with the West Java Regional Leadership Communication Forum (Forkopimda), launched the Real Action Movement for Pollution and Damage Control for the Cilamaya Watershed in the Barugbug Dam, Jatisari District, Regency Karawang. Based on data from the West Java Province Environmental Service as of 2020 states that the quality status of the Cilamaya Watershed is Moderately Polluted. This condition needs immediate action before the quality of the Cilamaya watershed worsens. To determine the quality of the Cilamaya watershed, it is necessary to measure various physical, chemical, or biological parameters. The results of measuring the quality of the Cilamaya Watershed from multiple segments in 2019 and 2020 are in Tables 2 and 3.

Table 2. Cilamaya Watershed Quality in 2019

Sampling Location	Unit	Parameter	Standart	April	June	Agustus	November
Wanayasa	mg/L	TSS	50	14	3	2.5	2.5
	mg/L	DO	4	5.4	6	6	4.2
	mg/L	BOD	3	2	2.6	2	2
	mg/L	COD	25	12	14	12	11
	mg/L	TP	0.03		0.1	0.1	0.08
	/100 mL	Fecal Coli	1000	870	5600	42	230
	/100 mL	Total Coli	5000	10100	510000	12133	13675
Barugbbug weir	mg/L	TSS	400	820	24	8	11
	mg/L	DO	3	3	1	0	0
	mg/L	BOD	6	3.5	28	41	58
	mg/L	COD	40	34	91	107	173
	mg/L	TP	0.1	-	0.26	0.3	0.2
	/100 mL	Fecal Coli	2000	0340	1240	2000	4900
	/100 mL	Total Coli	1000	10000	580000	70000	13000
After BMP	mg/L	TSS	400	480	36	114	23
	mg/L	DO	3	3	0	0	0
	mg/L	BOD	6	3.9	62	64	281
	mg/L	COD	40	110	164	288	459
	mg/L	TP	0.1	-	1.01	6	14
	/100 mL	Fecal Coli	2000	600	1800	4500	9400
	/100 mL	Total Coli	1000	9000	160000	45000	540000
Blanakan	mg/L	TSS	400	1930	24	38	7
	mg/L	DO	3	4	4	0.6	3.4
	mg/L	BOD	6	4	15	9	2
	mg/L	COD	40	75	46	34	17
	mg/L	TP	0.1	-	0.37	1	3
	/100 mL	Fecal Coli	2000	410	1700	1300	17000
	/100 mL	Total Coli	1000	14000	230000	17000	160000

Table 3. Cilamaya Watershed Quality in 2020

Sampling Location	Unit	Parameter	Standart	April	June	Agustus	November
Wanayasa	mg/L	TSS	50	11	2	5	Wanayasa
	mg/L	DO	4	8	4.4	7	4.2
	mg/L	BOD	3	0.43	4	7	2
	mg/L	COD	25	6.22	5	38	11
	mg/L	TP	0.03	0.14	0.1	0.08	0.08
	/100 mL	Fecal Coli	1000	28799	30589	4600	230
	/100 mL	Total Coli	5000	103703	204766	13000	13675
Bendung Barugbbug	mg/L	TSS	400	48.3	11	133	Bendung Barugbbug
	mg/L	DO	3	2	0.5	3.4	0
	mg/L	BOD	6	3.45	13	22	58
	mg/L	COD	40	74.84	35	29	173
	mg/L	TP	0.1	0.15	0.1	0.2	0.2
	/100 mL	Fecal Coli	2000	169000	52000	4500	4900
	/100 mL	Total Coli	1000	546000	70300	31000	13000
Setelah BMP	mg/L	TSS	400	49.22	33	101	Setelah BMP
	mg/L	DO	3	2.7	0	4	0
	mg/L	BOD	6	2.73	10	45	281
	mg/L	COD	40	17.4	131	60	459
	mg/L	TP	0.1	0.3	1.69	0.09	14
	/100 mL	Fecal Coli	2000	663000	121000	2000	9400
	/100 mL	Total Coli	1000	1870000	158000	250000	540000
Blanakan	mg/L	TSS	400	48.81	107	177	Blanakan
	mg/L	DO	3	3.9	0	1	3.4
	mg/L	BOD	6	3.43	30	39	2
	mg/L	COD	40	13.61	49	150	17
	mg/L	TP	0.1	0.17	0.61	0.09	3
	/100 mL	Fecal Coli	2000	35900	298700	49000	17000
	/100 mL	Total Coli	1000	310000	620000	230000	160000

Based on data from Tables 2 and 3, the concentration of each parameter varies from time to time. The quality of the river in Wanayasa, or segment 1A, is lower than the other segments because it is included in class 2 water quality status compared to different segments in class 3 water quality status. Segment 1A is also an upstream location where the possibility of pollution will be less than in other areas. To see the water quality of the Cilamaya watershed in each segment, each measured parameter is compared with the quality standard that adheres to Governor Regulation no. 12 of 2003 concerning "Water Quality Standards and Water Pollution Control of the Cimanuk River, Cilamaya Watershed, and Bekasi River" according to their respective classes. Not all the parameters in the table are shown, but these are the dominant parameters in exceeding the quality standard.

Segment 1A is the upstream located in Kab. Purwakarta has several problems. Namely, the first is the problem of resident waste, where there is still a need to use communal septic tanks so that people dispose of their waste directly into water bodies. Second, the large volume of waste in rivers increases water pollution, so it is necessary to increase public awareness of environmental care. Third, several industries still need to get permits for disposing of liquid waste, requiring monitoring of industry compliance with applicable laws and regulations. Pollution of the Cilamaya Watershed water in segment 1A results in being unable to use for residents' activities with heavily polluted water quality. Segments 1B and 2B are in Kab. Subang has problems. Namely the first is the resident waste problem, like the situation with segment 1A. Secondly, many industries that have waste quality still need to meet the quality standards, which require supervision and law enforcement on sectors that are not compliant. Third, many breeders still need to understand education about waste management which results in environmental pollution, especially in water bodies by this livestock waste. Pollution of the Cilamaya Watershed water in segments 1B and 2B has resulted in many complaints from the public and farmers regarding river pollution, which is detrimental to the health of residents who use river water, and there is damage to pond fishery production due to heavily polluted water quality. Segment 2A, which is in Kab. Karawang has problems. Namely, the first is the population waste problem, like the issues with other segments. Second. Secondly, many industries that have waste quality still need to meet the waste quality standards, which are identical to the problems with segments 1B and 2B. Third, pollution originating from agricultural waste because of chemical fertilizers and pesticides, which the government needs to educate farmers to use environmentally friendly fertilizers and pesticides. Due to the occurrence of the Covid-19 pandemic in early 2020, water quality from upstream to downstream before and during the pandemic can be compared as shown in Figure 2 and 3.

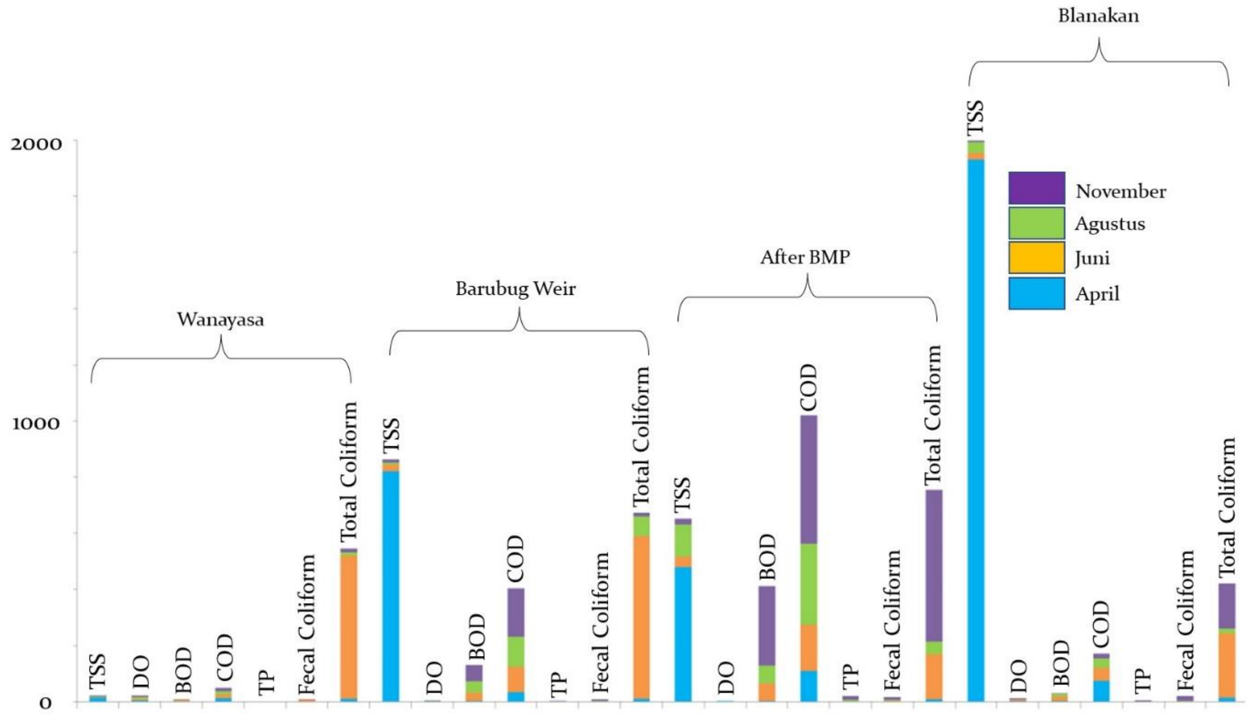

Figure 2. Water quality 2019

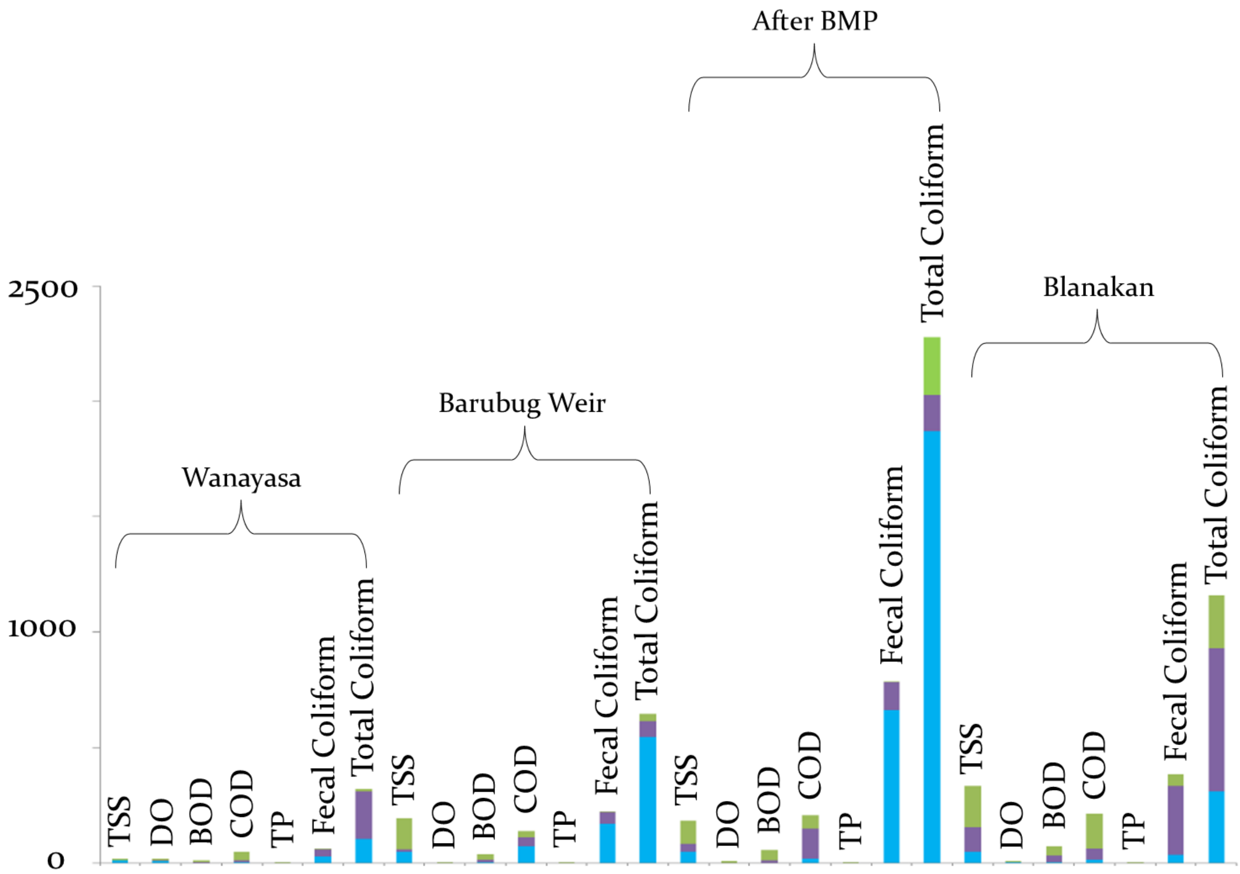

Figure 3. Water quality 2020

Weighting in the STORET method is carried out by dividing each parameter group based on its type, namely physics, chemistry, and biology. This method is not determined by the size of the concentration value of each parameter in the group, which means that each parameter in each group has the same value when compared to the quality standard. Based on the analysis of determining the water quality index using the STORET method, the quality status of each segment shows that the STORET score varies and tends to increase in each sequence of elements. The value of the quality status is compared with the quality category of the STORET score, which produces a score exceeding -31, which can be categorized as heavily polluted, as shown in Tables 2 and 3. Below, Figure 4 shows the quality status of the Cilamaya watershed in each segment in 2019 and 2020 using the STORET.

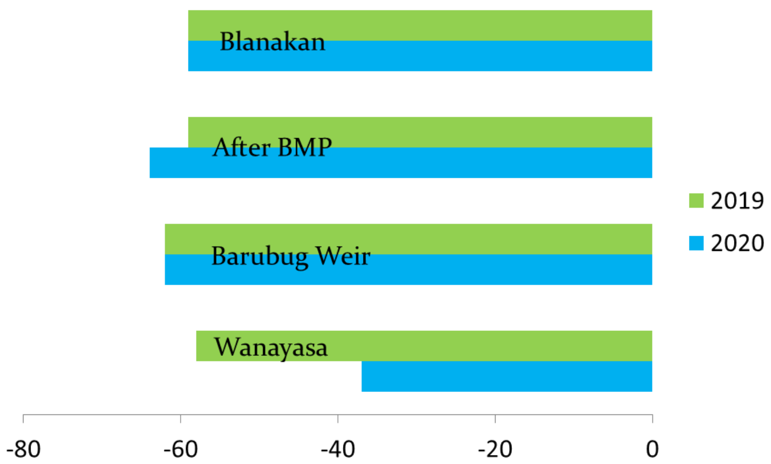

Figure 4. Quality Status Based on the STORET

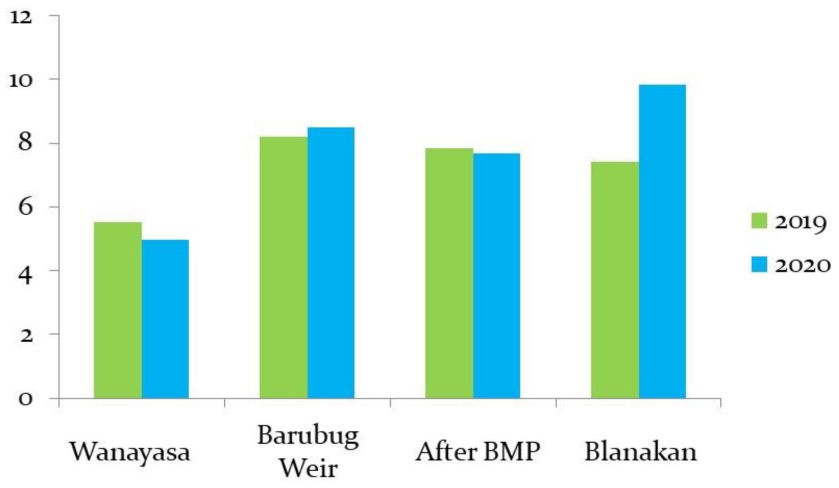

Figure 5. Quality Status Based on the STORET

Based on Figure 5 shows that the Pollution Index value with the highest pollution that occurred in 2019 was in segment 1B or at the Barugbug Weir location with a Pollution Index value of 8,196 and the average IP for the Cilamaya Watershed in 2019 was 7,250, which means that the Cilamaya Watershed in 2019 experienced moderately polluted. Whereas in 2020, the highest pollution occurred in segment 2B or at the Blanakan location, with a Pollution Index value of 9,837 and an average Pollution Index for the Cilamaya Watershed 2020 of 7,748, which indicates that the river is getting moderately polluted than in 2020.

Comparison Study of the STORET and Pollutin Indec

The STORET and Pollution Index methods have in common that they provide flexibility in determining the number and type of significant parameters used to calculate the index. However, this flexibility can lead someone to choose parameters and impact water quality status conclusions. Given that someone with limited water quality/environmental knowledge will not fully understand the significant/meaningful parameters that need to be measured to describe the variability and problems of existing water quality. The Pollution Index is calculated by considering the ratio of the concentration of a parameter to its maximum quality standard (Ci/Lij) and the average ratio of several water quality parameters only from one or a single time of water quality specimen collection activity. The STORET index is calculated based on the maximum, minimum, and average data from several water quality specimens. As is known, the water quality (physical, chemical, bacteriological) of rivers has very high variability, which is influenced by climatic phenomena and the hydrological cycle, geographical conditions, nutrient cycles, the life of aquatic organisms, and natural and anthropogenic disturbances (Lewis, 2008). Thus, the water quality data measured from a single water quality sampling is the momentary condition data. According to Metcalf, the nature and purpose of environmental monitoring are not to detect minor fluctuations that quickly disappear but to detect significant changes in ecosystems, so water quality needs to be measured spatially temporally (periodically and time series). From the study of equation 3 of the water quality index method, the STORET method is considered more logical. The water quality index is calculated and concluded from a series of data from several water quality specimen collections.

The Pollution Index with a few or many water quality parameters (3, 4, or 9 parameters that do not meet quality standards) is not sensitive enough to distinguish the class of water quality status at each sample location and when sampling the water quality. It is because in the Pollution Index method, what is considered necessary in determining the Pollution Index score is a parameter with the maximum (Ci/Lij) compared to the average of all water quality parameters. Parameters that sometimes or often do not meet the class I surface water quality standards, where the maximum (Ci/Lij) value of each of these parameters ranges from 0.4 to 6.2 while the average (Ci/Lij) of all parameters (3 to 9 parameters do not meet quality standards) ranging from 0.4 to 3. Status of water quality with the Pollution Index, only from one (single) water quality sampling. The STORET index with only 2-3 significant parameters, the total score, average concentration, maximum, and minimum of these water quality parameters is quite large relative to the total STORET score, making it a heavily polluted status. The STORET index is sensitive enough to respond to the dynamics of the water quality index at each location with a few or many parameters. The more water quality parameters are measured, the more parameters that do not meet the quality standard are monitored (from the maximum and minimum parameter values). The more often these parameters need to meet the threshold, the worse the water quality status will be. However, the status of the STORET index is greatly influenced by the weight of biological (bacteriological) parameters compared to chemistry and physics. The positive thing about the STORET index is that this water quality index does not reflect instantaneous water quality data (short-term effects). It shows that the greater the number and types of water quality parameters measured in water quality monitoring, the more likely parameters that do not meet quality standards are identified. Thus, the index calculated from many parameters will be better/more comprehensive in concluding the water quality status. However, remember that a large amount of water quality data can interfere with the statistical analysis of the data to produce quality assurance data for calculating the water quality index. As a developing country and to maintain continuity and consistency of long-term program measurements, water quality monitoring with the number and type of water quality parameters that are manageable but of better quality is recommended.

Conclusion

The results show a decrease in concentration for water quality parameters in 2020 or during the Covid-19 pandemic compared to 2019 or the period before the Covid-19 pandemic occurred (Awfa et al., 2022). The parameters that experienced a decrease included TSS, DO, BOD, and COD. But besides that, there has been an increase in water quality parameters in 2020, namely the parameters TP, Fecal Coliform, and Total Coliform. Based on the calculation of the STORET method, it is known that the average STORET score for the Cilamaya Watershed in 2019 was -55.5, which means that the Cilamaya Watershed in 2019 was heavily polluted. The average STORET score for the Cilamaya Watershed in 2020 is -59.5, which indicates that the river is getting more heavily polluted than in 2020. Meanwhile, based on the calculation of the Pollution Index method, it is known that the average IP value for the Cilamaya Watershed in 2019 is 7,250, which means that the Cilamaya watershed in 2019 is moderately polluted. In 2020, the average IP value for the Cilamaya Watershed 2020 is 7,748, which indicates that the river is getting moderately polluted than in 2020. This research requires more annual data and direct checking of the condition of the Cilamaya watershed to find out the current water quality situation and various pollution sources (Imami et al., 2022).

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