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Water Quality of The Karedok Weir in Kecamatan Jatigede, Kabupaten Sumedang, West Java Province as a Source of Raw Water for Drinking Water

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Abstract: Clean water is a basic human need that can be sourced from both groundwater and surface water, such as from weirs or lakes. The Karedok weir in Kecamatan Jatigede, which receives water from the Jatigede Hydroelectric Power Plant outlet and the Cimanuk River, has high potential to be used as a raw material for clean water. This study aims to assess the water quality at the Karedok Weir in Kecamatan Jatigede, Sumedang Regency, West Java Province. The sample collection method was conducted through grabe sampling, and the testing and analysis followed the water quality standards outlined in Appendix VI of Government Regulation No. 22 of 2021, Class 1, regarding the Implementation of Environmental Protection and Management. The parameters tested include physical, chemical, and bacteriological factors. The study was conducted at four locations: upstream of the Cimanuk River, downstream of the Cimanuk River, Karedok Weir 1, and Karedok Weir 2. All data from the testing of these parameters at all sampling sites were analyzed using the STORET method developed by the US EPA. The result showed that the water downstream of the Cimanuk River and the Karedok Weir 2, classified as Class A, are of very good quality and meet the water quality standards.
Keywords: surface water quality, Karedok weir water, water quality status, best location

1. Introduction

Clean water is a basic human necessity [1]. Everyone uses clean water for a variety of purposes, such as drinking, cooking, cleaning household appliances, sanitation, and so on [1]. People obtain clean water from groundwater and surface water. Groundwater is water that exists below the surface of the ground, while surface water is water that exists above the surface of the ground [2] . Examples of surface water are river water, springs, lakes, or ponds. Groundwater is the main source of drinking water on earth, 62% of urban households in 10 South East Asian and Pacific countries use groundwater as a source of clean water [3], but access to groundwater is not easy [4].

Population growth, climate change, and unsustainable water management are putting increasing pressure on water resources in many developing countries [5]. The Sustainable Development Goals (SDGs) in Goal 6 is to obtain safe and affordable water [6]. In Indonesia, 82% of people have access to improved drinking water, but only 9% of people drink water from safely managed sources [6]. The sustainable provision of clean water is one of the efforts to realize the ideals of independence as enshrined in the preamble of the 1945 Constitution in the fourth paragraph, which is, among others, to achieve general welfare [7].

The provision and sustainable management of clean water is essential for improving economic growth and community welfare [8]. Safe, clean water also plays an important role in maintaining public health, especially in preventing the spread of diseases caused by polluted water. Therefore, cooperation between the government, communities, and the private sector is needed to improve access to safe and affordable clean water for all Indonesians.

In addition to groundwater, another source of clean water that can be used is surface water [9]. Although surface water is not as good as groundwater [10], it can be used if it is treated properly beforehand. Surface water sources that can be used are lake water, springs, Weir water, and river water [11].

Karedok Weir is a relatively new Weir that will be completed in early 2024 [12]. The weir is located on the Cimanuk River in Kecamatan Jatigede, Kabupaten Sumedang, West Java Province. The water in Karedok Weir is collected from the outlet of the Jatigede hydropower plant and from the flow of the Cimanuk River [12]. The water from Karedok Weir is to be used as a source of raw drinking water for the needs of the community around Kecamatan Jatigede or other areas. This study aims to determine the quality of Karedok Weir water at several locations to determine whether the water from Karedok Weir is suitable for drinking water raw water.

2. Material and Method

2.1. Material

The equipment used to collect surface water samples are buckets for collecting water samples with ropes, plastic dippers, pH meters, sample cooling boxes, plastic canisters for storing water samples, NaOH for preserving cyanide test samples, HNO_3 for preserving metal test samples, H_2SO_4 for preserving nitrate and nitrite test samples [13] and certified water sampling officers [14].

2.2. Method

The method used for sampling the water quality of Karedok Weir refers to SNI 8995: 2021 [13] which includes taking water samples from various locations around Karedok Weir to be analyzed at a laboratory that has accreditation from The National Accreditation Committee (KAN) [15].

Sampling sites in the Cimanuk River and Karedok Weir are:

- Cimanuk Upstream (S 06°49'58,8" ; E 108°06'08,92")
- Cimanuk Downstream (S 06°49'27,59" ; E 108°06'39,40")
- Karedok Weir 1 (S 06°48'52,6" ; E 108°06'06,60")
- Karedok Weir 2 (S 06°48'52,82" ; E 108°06'16,00")

The reason for this sampling location is that the upstream of the Cimanuk River is the river flow that has not been disturbed by the inflow from the Jatigede hydroelectric power plant outfall, while the downstream of the Cimanuk River is the river flow that has been disturbed by the inflow from the Jatigede hydroelectric power plant outfall into the Cimanuk River. Karedok Weir 1 is a location near the end of the weir that will return to the Cimanuk River flow, while Karedok Weir surrounding activities. The reason for sampling at Karedok Weir 1 and Karedok Weir 2 is that Karedok Weir 1 is close to the Karedok Village settlement and the road access to the sampling location is easy. Ease of road access is a consideration for sampling. Karedok Weir 2 is far from the settlement near the production forest area but the road access to the sampling location is easy. Ease of road access and areas away from residential pollutant sources are sampling considerations. The sampling map is shown in the figure below

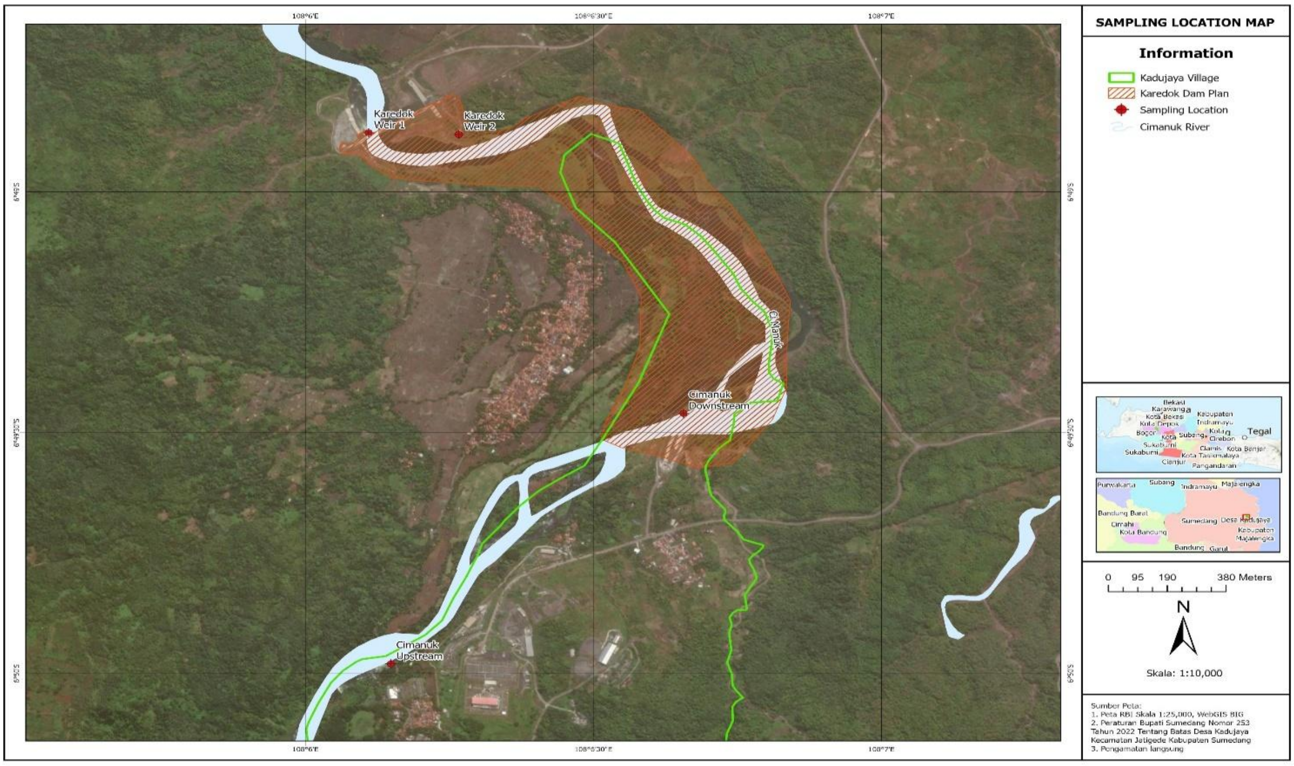

Figure 1: Map of sampling locations

The water quality parameters tested include TDS, water color, pH, sulfate, nitrate, nitrite, fluoride, cyanide, mercury, arsenic, selenium, cadmium, zinc, lead, detergent, fecal coliform and total coliform [5]. These parameters are very important in determining the level of contamination and pollution in the waters around the Karedok Weir [16].

2.3. Analysis Data

The water samples collected were analysed by a laboratory with KAN accreditation [15] using nationally recognized standard analytical methods, namely PT Adhikari Lab Laboratory with KAN accreditation number LP-720-IDN Testing Laboratory [12][17][18][19]. The results of the laboratory analysis were then compared with the surface water Regulatory Limit set out in Government Regulation (PP) of the Republic of Indonesia 22 of 2021 Appendix VI Class 1 [20].

Data series taken from April, May, and July 2024 according to research results. All data series of test results for all parameters at all sampling sites were status analyzed using the Storet method developed by the US EPA (Environmental Protection Agency). This method provides scores for physical, chemical, and biological parameters. Where the number of samples tested is greater than 10, a score is assigned to the test data series for each parameter. For physical parameters, if the minimum and maximum test results are greater than the quality standard, a score of -2 is assigned and if the average test result is greater than the quality standard, a score of -6 is assigned. For chemical parameters, if the minimum and maximum test results are greater than the quality standard, a score of -4 is assigned and if the average test result is greater than the quality standard, a score of -12 is assigned. For biological parameters, if the minimum and maximum test results are above the quality standard, a score of -6 is given and if the average test result is above the quality standard, a score of -18 is given.

All assessed values are summed up and evaluated: if the total score is 0, the water quality status at that location is said to be good or in compliance with the Regulatory Limit, if the total score is between -1 and -10, the water quality status is said to be slightly polluted, if the total score is between -11 and -30, the water quality status is said to be moderately polluted, and if the total score is above 30, the water quality status is said to be severely polluted' [21][22][23][24].

Table 1: Score based on the Storet method

Number of samples	Sample value	Parameter		
		Physics	Chemistry	Biology
<10	Minimum	-1	-2	-3
	Maximum	-1	-2	-3
	Average	-3	-6	-9
>10	Minimum	-2	-4	-6
	Maximum	-2	-4	-6
	Average	-6	-12	-18

Table 2: Water Quality Status Criteria Based on Storet Score

Class	Storet Score	Status
A	0	Good, fulfill Regulatory Limit
B	-1 to -10	Lightly Polluted
C	-11 to -30	Moderately Polluted
D	>-30	Heavily Polluted

The results of this analysis of the water quality status will be used to evaluate whether the water from Karedok Weir and its surroundings can be used as raw water for drinking water, and the most suitable location for the raw water source intake.

3. Results and Discussion

The results of laboratory testing at four sampling locations for 3 months in 2024 [24] and the calculation of water quality status using the Storet method can be seen in the tables below.

Table 3: Results of Laboratory Testing in the Upstream Cimanuk River for 3 Months in 2024 and Calculation of Water Quality Status with the Storet Method [12][17][18][19]

No	Parameters	Quality Standards mg/L	Laboratory Test Results			Evaluation						
			April	May	July	Max		Min		Avg		Sum
1	TDS	1000	277	250	297	297	0	250	0	275	0	0
2	Color	15 Pt-Co Unit	15	10	10	15	0	10	0	11.7	0	0
3	pH	6,0 - 9,0	8.05	8.1	8.19	8.19	0	8.05	0	8.11	0	0
4	Sulfate	300	15.3	9.62	13.6	15.3	0	9.62	0	12.8	0	0
5	Nitrate	10	2.05	1.13	2.05	2.05	0	1.13	0	1.74	0	0
6	Nitrite	0,06	0.04	0.02	0.05	0.05	0	0.02	0	0.04	0	0
7	Flouride	1	0.16	0.1	0.36	0.36	0	0.1	0	0.21	0	0
8	Cyanide	0,02	<0.003	<0.003	<0.003	<0.003	0	<0.003	0	0	0	0
9	Mercury	0,001	< 0.001	< 0.001	< 0.001	< 0.001	0	< 0.001	0	0	0	0
10	Arsen	0,05	<0.002	<0.002	<0.002	<0.002	0	<0.002	0	0	0	0
11	Selenium	0,01	<0.006	<0.006	<0.006	<0.006	0	<0.006	0	0	0	0
12	Cadmium	0,01	<0.001	<0.001	<0.001	<0.001	0	<0.001	0	0	0	0
13	Zinc	0,05	<0.008	<0.008	<0.008	<0.008	0	<0.008	0	0	0	0
14	Lead	0,03	<0.002	<0.002	<0.002	<0.002	0	<0.002	0	0	0	0
15	Detergent	0,2	0.046	0.083	0.04	0.083	0	0.04	0	0.06	0	0
16	Fecal Coliforms	100 MPN/ 100 mL	130	110	79	130	-6	79	0	106	-18	-24
17	Total Coliforms	1000 MPN/ 100 mL	280	210	170	280	0	170	0	220	0	0
										Total score		-24

Laboratory analysis results for the parameters TDS, color, pH, Sulphate, Nitrate, Nitrite, Flouride, Cyanide, Mercury, Arsenic, Selenium, Cadmium, Zinc, Lead, Detergent, and Total Coliform during the measurement time from April to July showed concentrations below the quality standards of Government Regulation (PP) of the Republic of Indonesia 22 of 2021 Appendix IV Class 1. [20]. Fecal Coliform in April and May measured above the quality standard. Fecal coliform is an indicator of pollution, the presence of fecal coliform indicates there is a possibility that water is polluted by feces sourced from human and animal waste. The highest Fecal Coliform concentrations measured in the Upstream Cimanuk River in April and May were due to domestic waste contamination from sewer flows entering the Cimanuk River. Considering that the sampling point of the Cimanuk Hulu River is located adjacent to the residential area of Desa Kadujaya RW 03.

Based on the results of scoring the water quality status using the Storet method as shown in Table 3 above, it was found that the water quality at the Hulu Cimanuk River location obtained a score of - 24. According to the water quality status criteria based on Storet score in Table 2, scores of -11 to -30 are included in the category of class C, moderately polluted.

Table 4. Results of Laboratory Testing in the Downstream Cimanuk River for 3 Months in 2024 and Calculation of Water Quality Status with the Storet Method [12][17][18][19]

No	Parameters	Quality Standards mg/L	Laboratory Test Results			Evaluation						
			April	May	July	Max		Min		Avg		Sum
1	TDS	1000	286	95	111	286	0	95	0	164	0	0
2	Color	15 Pt-Co Unit	10	10	10	10	0	10	0	10	0	0
3	pH	6,0 - 9,0	8.11	7.47	7.72	8.11	0	7.47	0	7.767	0	0
4	Sulfate	300	21.36	12.11	9.75	21.36	0	9.75	0	14.41	0	0
5	Nitrate	10	1.24	0.85	1.03	1.24	0	0.85	0	1.04	0	0
6	Nitrite	0,06	0.02	<0.004	<0.004	0.02	0	<0.004	0	0.007	0	0
7	Flouride	1	0.37	0.4	0.16	0.4	0	0.16	0	0.31	0	0
8	Cyanide	0,02	<0.003	<0.003	<0.003	<0.003	0	<0.003	0	0	0	0
9	Mercury	0,001	< 0.001	< 0.001	< 0.001	< 0.001	0	< 0.001	0	0	0	0
10	Arsen	0,05	<0.002	<0.002	<0.002	<0.002	0	<0.002	0	0	0	0
11	Selenium	0,01	<0.006	<0.006	<0.006	<0.006	0	<0.006	0	0	0	0
12	Cadmium	0,01	<0.001	<0.001	<0.001	<0.001	0	<0.001	0	0	0	0
13	Zinc	0,05	<0.008	<0.008	<0.008	<0.008	0	<0.008	0	0	0	0
14	Lead	0,03	<0.002	<0.002	<0.002	<0.002	0	<0.002	0	0	0	0
15	Detergent	0,2	0.036	0.026	0.034	0.036	0	0.026	0	0.032	0	0
16	Fecal Coliforms	100 MPN/ 100mL	79	33	70	79	0	33	0	60.67	0	0
17	Total Coliforms	1000 MPN/ 100mL	170	84	120	170	0	84	0	124.7	0	0
									Total score			0

The test results at the Cimanuk River Downstream location showed that for all parameters tested, the concentrations were below the quality standard. Although the TDS measured in April was higher than in May and July, it was still below the quality standard.

Based on the scoring results of the water quality status using the Storet method as shown in table 4 above, information was obtained that the water quality at the Cimanuk Hilir River location obtained a score of 0. According to the criteria for water quality status based on the Storet score in Table 2, a score of 0 is included in the class A or Excellent category or meets the quality standards.

Table 5: Results of Laboratory Testing in the Karedok Weir 1 for 3 Months in 2024 and Calculation of Water Quality Status with the Storet Method [12][17][18][19]

No	Parameters	Quality Standards mg/L	Laboratory Test Results			Evaluation						
			April	May	July	Max		Min		Avg		Sum
1	TDS	1000	471	280	302	471	0	280	0	351	0	0
2	Color	15 Pt-Co Unit	60	20	15	60	-1	15	0	31.67	-3	-4
3	pH	6,0 - 9,0	7.91	8.51	7.95	8.51	0	7.95	0	8.123	0	0
4	Sulfate	300	10.25	9.53	18.62	18.62	0	9.53	0	12.8	0	0
5	Nitrate	10	5.16	1.05	2.41	5.16	0	1.05	0	2.873	0	0
6	Nitrite	0,06	0.72	0.12	0.04	0.72	-4	0.04	0	0.293	-12	-16
7	Flouride	1	0.13	0.43	0.22	0.43	0	0.13	0	0.26	0	0
8	Cyanide	0,02	<0.003	<0.003	<0.003	<0.003	0	<0.003	0	0	0	0
9	Mercury	0,001	< 0.001	< 0.001	< 0.001	< 0.001	0	< 0.001	0	0	0	0
10	Arsen	0,05	<0.002	<0.002	<0.002	<0.002	0	<0.002	0	0	0	0
11	Selenium	0,01	<0.006	<0.006	<0.006	<0.006	0	<0.006	0	0	0	0
12	Cadmium	0,01	<0.001	<0.001	<0.001	<0.001	0	<0.001	0	0	0	0
13	Zinc	0,05	0.12	<0.008	0.012	0.12	-4	0.012	0	0.044	0	-4
14	Lead	0,03	0.01	<0.002	<0.002	<0.002	0	<0.002	0	0.003	0	0
15	Detergent	0,2	0.326	0.055	0.038	0.326	-4	0.038	0	0.14	0	-4
16	Fecal Coliforms	100 MPN/ 100mL	540	130	170	540	-6	130	-6	280	-18	-30
17	Total Coliforms	1000 MPN/ 100 mL	1100	220	350	1100	-6	220	0	556.7	0	-6
											Total Score	-64

The results of water quality testing at the Karedok 1 weir as shown in Table 5 above, in April and May the color parameter was measured above the quality standard. Even in April, it was measured 4 times higher than the quality standard. The high color in April and May was caused by the high TDS measured in these months, although TDS did not exceed the quality standard but was higher than in July.

In May, the color was measured at a high 20 Pt-Co Units even though the measured TDS was smaller than in the other months. This was due to the accumulation of inorganic and organic parameters, i.e. in that month even though TDS was the lowest, Nitrite and Fecal Coliform were measured above the quality standard, thus affecting the color of the water. Nitrite in April and May was measured above the quality standar, this was due to contamination from waterways/sewers entering the Karedok Weir from Desa Karedok. The sampling point of Karedok Weir 1 is close to Desa Karedok, which is the northern boundary of Karedok Weir. According to observations, the rice fields in Desa Karedok are fertile. High Nitrite concentrations are caused by agricultural waste from the use of nitrogen fertilizers.

From the test results, it can be seen that the concentration of Zinc in the Karedok 1 weir in April was measured above the quality standard. April was measured 240% above the quality standard but in May and July, it was again measured below the quality standard. Zinc in surface water can come from natural and human sources. Natural sources include weathering of rocks and minerals containing zinc that enter water bodies. Human sources include industrial, agricultural, and domestic waste. Agricultural waste comes from the use of fertilizers and pesticides that contain zinc. Domestic waste comes from household waste such as batteries and electronic equipment containing zinc.

The high concentration of Zinc at the Karedok 1 weir sampling point is caused by domestic waste and agricultural waste considering that the location of the Karedok 1 weir is near the residential area of Karedok Village, Jatigede Subdistrict, the water channel from this village flows directly into the Karedok weir. The land of Karedok Village is fertile land, the people of Karedok Village utilize the land for farming. The use of fertilizers and pesticides carried by the water flow to the Karedok Dam causes high concentrations of Zeng at the sampling point of Karedok Weir 1.

Based on the results of detergent testing at Karedok 1 weir in April, May, and July measured concentrations above the quality standard. In April it was 540% above the quality standard but in May and July, it dropped to 130% and 170% above the quality standard. Detergent in surface water is caused by sewage discharge from various sources such as domestic waste, industrial waste, and livestock. Domestic waste and detergents used in washing clothes, dishes, and other household purposes are often discharged into drains that eventually end up in rivers, lakes, or the sea. Waste from farms, such as animal feces and food waste, may contain detergents used to clean cages and equipment. The high concentration of detergent at the Karedok 1 weir sampling point was caused by domestic waste from the activities of Karedok villagers and from chicken and duck farming waste. The water channel from Karedok Desa flows directly to Karedok Weir. Residents in this village besides cultivating crops some of them raise livestock such as chickens and ducks.

The results of fecal coliform testing at all sampling locations showed that Karedok Weir 1 had concentrations above the regulatory limit in April, May, and July. In April it increased to 540% above the regulatory limit, but in May and July, it decreased to 130% and 170% above the regulatory limit.

Fecal coliform is an indicator of pollution, the presence of fecal coliform means there is a possibility that water is polluted by feces sourced from human and animal waste. The highest concentration of Fecal Coliform in April and May at the Cimanuk Hulu point is due to the contamination of domestic waste from sewer flows entering the Cimanuk River. Given that the Cimanuk Hulu River point is located adjacent to the residential area of Kadujaya Village RW 03.

Fecal Coliform at the Karedok 1 weir location was measured high due to domestic waste contamination because the Karedok 1 weir point is located close to the residential area of Karedok Village. Total Coliform test results at Karedok 1 weir in April, measured concentrations above the quality standard. The total coliform concentration was 110% above the quality standard. Total coliform is coliform that results not only from human feces but a combination of other sources such as decay processes, industrial waste, and manure. The high concentration of total coliform at the Karedok 1 weir site in April was caused by the accumulation of fecal coliform from domestic waste and agricultural waste, fertilizers, and pesticides used by residents of Karedok desa considering that the sampling location of Karedok 1 weir is close to this settlement and the channel from this village empties into Karedok weir.

Based on the results of scoring the water quality status using the Storet method as shown in Table 5 above, it was found that the water quality at the Bendung Karedok 1 obtained a score of - 64. According to the water quality status criteria based on Storet score in Table 2, scores of > -30 are included in the category of class D, Heavily Polluted.

Table 6: Results of Laboratory Testing in the Karedok Weir 2 for 3 Months in 2024 and Calculation of Water Quality Status with the Storet Method [12][17][18][19]

No	Parameters	Quality Standards mg/L	Laboratory Test Results			Evaluation						
			April	May	July	Max		Min		Avg		Sum
1	TDS	1000	210	210	227	227	0	210	0	129.4	0	0
2	Color	15 Pt-Co Unit	10	10	5	10	0	5	0	5	0	0
3	pH	6,0 - 9,0	8.19	8.19	8.03	8.19	0	8.03	0	4.88	0	0
4	Sulfate	300	16.2	16.2	9.36	16.2	0	9.36	0	8.35	0	0
5	Nitrate	10	0.43	0.43	1.21	1.21	0	0.43	0	0.414	0	0
6	Nitrite	0,06	<0.004	<0.004	0.02	0.02	0	<0.004	0	0.004	0	0
7	Flouride	1	0.2	0.2	0.17	0.2	0	0.17	0	0.114	0	0
8	Cyanide	0,02	<0.003	<0.003	<0.003	<0.003	0	<0.003	0	0	0	0
9	Mercury	0,001	< 0.001	< 0.001	< 0.001	< 0.001	0	< 0.001	0	0	0	0
10	Arsen	0,05	<0.002	<0.002	<0.002	<0.002	0	<0.002	0	0	0	0
11	Selenium	0,01	<0.006	<0.006	<0.006	<0.006	0	<0.006	0	0	0	0
12	Cadmium	0,01	<0.001	<0.001	<0.001	<0.001	0	<0.001	0	0	0	0
13	Zinc	0,05	<0.008	<0.008	<0.008	<0.008	0	<0.008	0	0	0	0
14	Lead	0,03	<0.002	<0.002	<0.002	<0.002	0	<0.002	0	0	0	0
15	Detergent	0,2	0.022	0.022	0.016	0.022	0	0.016	0	0.012	0	0
16	Fecal Coliforms	100 MPN /100 mL	94	94	79	94	0	79	0	53.4	0	0
17	Total Coliforms	1000 MPN /100 mL	150	150	110	150	0	110	0	82	0	0
								Total Score				0

The test results at the Karedok Weir 2 location showed that for all parameters tested, the concentrations were below the quality standard. Based on the scoring results of the water quality status using the Storet method as shown in table 6 above, information was obtained that the water quality at the Karedok Weir 2 obtained a score of 0. According to the criteria for water quality status based on the Storet score in Table 2, a score of 0 is included in the class A or Excellent category or meets the quality standards

4. Conclusion

Based on the results of laboratory analysis, it was found that the water quality in the upstream of the Cimanuk River was classified as class C or moderately polluted with a score of -24, Karedok Weir 1 was classified as class D, heavily polluted with a score of -64, in the downstream of the Cimanuk River was and Karedok Weir 2 was classified as class A, very good or in compliance with the regulatory limit with a score of 0. It is concluded that the water quality of downstream of the Cimanuk River (S 06°49'27,59"; E 108°06'39,40") and Karedok Weir 2 (S 06°48'52.82'; E 108°06'16.00') are suitable for raw water for drinking water.

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