Geology and Groundwater Quality Analysis for Clean Water and Irrigation of Sanga-Sanga District, Kutai Kartanegara Regency, East Kalimantan Province

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Abstract. The research location is in two sub-districts, namely Sanga-sanga District, Samarinda City and Palaran District, Kutai Kartanegara Regency, East Kalimantan Province. This research was conducted with the aim of knowing the quality of ground water in the study area. The research method used in this research is laboratory analysis and direct survey in the field. The well water sample data used are 2 water samples which are considered to represent the research area by using purposive sampling method. The groundwater quality assessment for clean water shows that all samples are within the permissible threshold and are included in the clean water quality standard value. Then the assessment of groundwater for irrigation shows the quality of the groundwater, which is very good to good. So it meets the requirements for use as irrigation. And the groundwater assessment for the pollution index obtained the status of water quality which also meets the quality standard (good condition).

Keywords: Groundwater · Pollution Index · Clean Water · irrigation

1 Introduction

Matters related to geology such as water are strongly influenced by the geological environment such as geomorphology, geological structure, and lithology [1]. One source of water that can be used to meet daily needs is ground water. Groundwater can be used as clean water and irrigation.

The increase in population and economic activities (industry, mining, etc.) in the Kutai Kartanegara Regency area directly causes the increasing demand for clean water. The fulfillment of clean water needs directly affects and is influenced by the availability of water quantity and quality in the Kutai Kartanegara Regency area [2].

The use of water for needs must pay attention to water quality standards that are in accordance with predetermined quality standards. The level of water quality required for each particular activity has different quality parameters, so testing must be carried out to determine the suitability of the quality with its designation. One aspect that needs to be

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considered in its management efforts is the physical, chemical and biological properties of groundwater. This is because these properties will have a positive or negative effect on the recipient of the groundwater supply.

So this research was conducted in the Sanga-sanga area (Fig. 1) to determine the suitability of groundwater quality with PERMENKES No. 32 of 2017 [3] and determine the quality of irrigation based on the parameters of SAR, %NA and Wilcox classification and determine the status of groundwater quality to be compared with PERDA KALTIM No. 02 of 2011 [4].

2 Methods

2.1 Research Location

In Fig. 1 the research area is in Sanga-Sanga District, Kutai Kartanegara Regency. Geographically, it is located at 117°12'31.8"–117°14'46.2" East Longitude and 0°38'22.8"–0°14'46.3" South Latitude. The research location is ±30 km from Mulawarman University using a land route to Sanga-Sanga District, Kutai Kartanegara Regency, East Kalimantan Province, it takes approximately 57 min by using motorbikes.

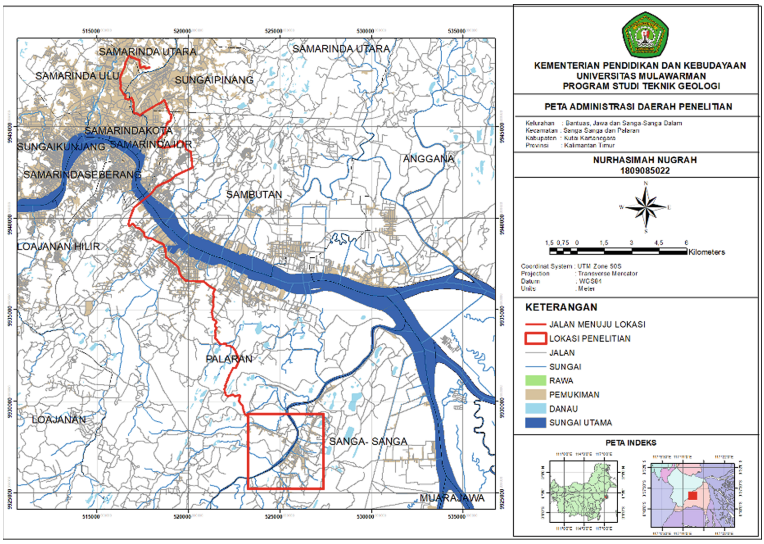

Fig. 1. The research location is in Sanga-sangan and its surroundings

2.2 Research Procedures

The method in this research is a direct field survey method for laboratory analysis. The stages and research methods used consist of 3 (Three) stages, namely the preliminary stage, the data collection stage, the data processing and analysis stage.

Preliminary Stage
This stage is the preparatory stage carried out before entering the field work stage. This stage consists of background, literature study and research planning.

Stages of Data Collection
The data used in this study is groundwater data by taking groundwater data including the location of the well coordinates and well water sample data which will later be analyzed for groundwater quality. The well water sample data used are 2 water samples which are considered representative of the research area.

2.3 Data Analysis

a. Physical analysis, carried out in the field and in the laboratory of PT. Sucofindo analysis results from physical parameters in the form of color, temperature, taste, odor and turbidity.
b. The analysis of the chemical properties of groundwater was carried out at the Laboratory of PT. Sucofindo and some are also carried out in the field to determine the quality of groundwater that meets health requirements and can be used based on PERMENKES N0. 32 of 2017 [3]. This analysis will obtain three (3) results where the allocation is intended for clean water, irrigation and pollution index.
c. The analysis of the biological properties of groundwater was carried out at the Laboratory of PT. Sucofindo to determine the quality of ground water that meets health requirements and can be used based on PERMENKES N0. 32 of 2017 [3]. Covers E.Coli and Total Coliform.
d. Groundwater analysis for irrigation was carried out based on the calculation of the sodium hazard (SH) value assessed by evaluating the percentage of dissolved sodium and the sodium absorption ratio consisting of NA% and SAR.
e. Pollution Index (IP) analysis was used to determine the level of pollution relative to the permitted water quality parameters. The IP calculation is in accordance with the guidelines contained in the Decree of the State Minister of the Environment No. 115 year 2003.

3 Results and Discussion

Based on the results of laboratory analysis conducted at PT. Sucofindo and the results of tests carried out in the field, obtained the results of research analysis which will later be divided into 3 topics, namely the designation of groundwater as clean water, the designation of groundwater as irrigation water, and the status of water quality using the Pollution Index method.

Table 1. Results of Physical Analysis of Groundwater in the Research Area.

No	Physical Parameter	Unit	Code Sample		Threshold (PERMENKES No. 32 Tahun 2017)
			NS-1	NS-3	
1	Suhu	°C	27	29	±3
2	Rasa	mg/L	Tasteless	Tasteless	-
3	Bau	-	Odorless	Odorless	-
4	Warna	-	1	1	1
5	Kekeruhan	NTU	0,03	1,59	25

3.1 Groundwater Quality Analysis for Clean Water

There are two locations for groundwater sampling which were analyzed for the biological, chemical and physical content of the water. This analysis is assessed with standards according to the Regulation of the Minister of Health of the Republic of Indonesia No. 32 of 2017.

1. Physical Properties of Groundwater

The physical quality of groundwater can be determined based on indicators of temperature, taste, smell, turbidity and color (Table 1).

2. Chemical Properties of Groundwater

In general, the chemical properties of groundwater can describe the condition of the groundwater. Human activities and regional geological conditions are the two most important factors affecting hydrogeology and groundwater quality. The results of the analysis that have been carried out can be seen in (Table 2) with several parameters.

3. Biological Properties of Groundwater

The biological condition of bacteria in groundwater is a condition in which groundwater, containing Entamoeba coli bacteria, is often spread through human/animal waste. The results of the analysis that have been carried out are presented in Table 3.

3.2 Groundwater Quality for Clean Water

The results of the assessment of the physical, chemical and biological parameters of groundwater are compared using quality standards based on the Regulation of the Minister of Health no. 32 of 2011 concerning Environmental Health Quality Standards and Water Health Requirements for Sanitary Hygiene Needs, all groundwater samples showed that in the research area they were within the permitted threshold and could be used as clean water.

Table 2. Results of Chemical Analysis of Groundwater Research Area

No	Physical Parameter	Unit	Code Sample		Threshold (PERMENKES No. 32 Tahun 2017)
			NS-1	NS-3	
1	pH	-	6,1	6,9	6,5–8,5
2	Total Dissolved Solids (TDS)	mg/L	18	23	1000
3	DHL (Daya Hantar Listrik)	µS/cm	50	24	20–200
4	Iron Dissolved (Fe)	mg/L	0,03	0,03	1
5	Fluoride (F)	mg/L	0,81	0,64	1,5
6	Total Hardness ($CaCO_3$)	mg/L	2,84	5,9	500
7	Manganese Dissolved (Mn)	mg/L	0,02	0,02	0,5
8	*Nitrite* (NO_2)	mg/L	0,02	0,02	1,0
9	Nitrate (NO_3)	mg/L	0,12	0,12	10
10	Cyanide (CN)	mg/L	0,02	0,02	0,1
11	Mercury (Hg)	mg/L	0,0005	0,0005	0,001
12	Arsenic (As)	mg/L	0,001	0,001	0,05
13	Cadmium Dissolved (Cd)	mg/L	0,001	0,005	0,1
14	Chrom Hexavalen (Cr(VI))	mg/L	0,02	0,02	0,05
15	Selenium (Se)	mg/L	0,001	0,001	0,01
16	Zinc Dissolved (Zn)	mg/L	0,02	0,02	15
17	Sulphate (SO_4)	mg/L	0,33	4,61	400
18	Lead Dissolved (Pb)	mg/L	0,01	0,01	0,05
19	Organic Matter ($KMNO_4$)	mg/L	6,32	4,74	10
20	Metiline blues (MBAS)	mg/L	0,006	0,006	0.05

Table 3. Results of Biological Analysis of Groundwater Research Area

No	Biological Parameter	Unit	Code Sample		Threshold
			NS-1	NS-3	
1	Total Coliform	CFU/100 ml	17	7	50
2	E. Coli	CFU/100 ml	0	0	0

3.3 Groundwater Quality Analysis for Irrigation

Based on taking 2 groundwater samples which were then carried out laboratory tests, the results of the values of cations and anions in meq/liter (Table 4) were as follows:

The assessment was carried out on the quality of groundwater for irrigation using the sodium hazard (SH) parameter. This assessment was carried out by evaluating the

Table 4. Results of Biological Analysis of Groundwater Research Area

Ion	Konsentrasi (mg/L)	Valensi	Berat Atom (g)	Konsentrasi (meq/L)	
				NS-1	NS-3
Na	0,55	1	23	0,024	Na
K	0,15	1	39	0,004	K
Ca	0,87	2	40	0,044	Ca
Mg	0,16	2	24,3	0,013	Mg
Cl	3,04	1	35,5	0,086	Cl

percentage of dissolved sodium and the ratio of sodium absorption. Based on the results of the calculation of groundwater for irrigation, the results obtained (Table 5) classification of groundwater for irrigation.

1. Percentage of Sodium (%Na)

Based on the percentage of sodium (%Na) to 2 samples of groundwater obtained through calculations using the value of the ion values of Na, K, Ca, and Mg. The results obtained from the calculation with a range of sodium percentage values between 27.60% to 32.94% (Table 5). So it is included in the criteria for Good irrigation. Sodium is an important aspect to know because later sodium will react to soil conditions which can reduce permeability.

2. Sodium Adsorption Ratio (SAR)

Based on the results of the calculation of the SAR value of the 2 groundwater samples obtained through calculations using the values of the Na, Ca, and Mg ions. The calculation results are obtained with a range of SAR percentage values between 0.142 to 0.269 (Table 5). So it is included in the criteria for Very Good irrigation. So based on this SAR value 2 samples of groundwater will not damage the soil structure, so that it is

Table 5. Classification of Calculation Results of Groundwater Samples for Irrigation

Klasifikasi	Rentang	Kualitas Air	Nilai	Kode Sampel
SAR (meq/L) (Richards, 1954)	<10 10 – 18 18 – 26 > 26	Sangat Baik Baik Meragukan Tidak Cocok	0,142 0,269	NS -1 NS – 3
Na% (%) (Wilcox, 1955)	< 20 20 – 40 40 – 60 60 – 80 > 80	Sangat Baik Baik Dibolehkan Meragukan Tidak Cocok	32,94 27,60	NS – 1 NS – 3

still able to optimize plant growth. This is because the adsorption of sodium by the soil is very low, so the danger of Na or alkali does not occur significantly so it is still good.

3. Classification Wilcox

In the Wilcox classification, the quality of water taken from groundwater is only based on the percentage of sodium and also DHL. DHL was used to measure the salinity hazard involved in using water for irrigation (Wilcox, 1955). The classification of suitability of irrigation water in the two groundwater samples according to the Wilcox diagram shows that all samples are classified as excellent to good (Fig. 3). This condition can be seen from the DHL value in both samples which is not high. Thus, all groundwater samples are suitable for use as irrigation water.

Based on the results of the analysis of 2 water samples in the Sanga-Sanga area, it was found that groundwater where the water can be used for irrigation purposes. This grouping is based on a combination of the previous classifications that have been analyzed, such as the SAR classification, %Na and also using the Wilcox classification (Table 6). The goal is to show groundwater that can be used optimally for irrigation purposes and does not cause problems for plants based on several parameters that have been tested (Suhana and Cahyadi, 2018), resulting in a grouping of groundwater with good quality for irrigation purposes.

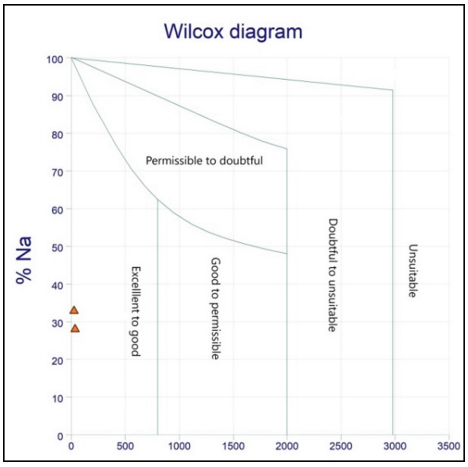

Fig. 3. Wilcox Diagram

Table 6. Results of the Suitability of Groundwater Samples for Irrigation

No	Code Sample	%NA	SAR	Wilcox Classs	Quality Irrigation
1	NS – 1	Very Good - Fine	Very Good	Excellent to Good	Excellent to Good
2	NS - 3	Very Good - Fine	Very Good	Excellent to Good	Excellent to Good

Based on Table 6, it is found that the results of the suitability of groundwater quality for irrigation in the NS-1 sample code are very good to good, and the NS-3 sample code also shows the suitability of groundwater quality, which is very good to good. So that all groundwater samples that have been analyzed in the study area meet the requirements for use as irrigation.

3.4 Analysis of Groundwater Quality Status

In this study the parameters used to analyze the status of water quality are Temperature, Color, Turbidity, pH, TDS, Fe, F, $CaCO_3$, Mn, NO_2, NO_3, CN, Hg, As, Cd, CrVI, Se, Zn, SO_4, Pb, $KMNO_4$, MBAS, Total Coliform and E. Coli compared with class I water quality criteria based on East Kalimantan Provincial Regulation No. 2 of 2011. Analysis of the status of water quality is carried out based on the guidelines for determining the status of water quality established by the Ministry of the Environment No. 115 of 2003 using the Pollution Index (IP).

Calculation of Comparative Value of Analysis Results with Water Quality Standard Values (Ci/Li) Groundwater Quality

The IP method will compare the value of each parameter with its quality standard. If the IP value is less than 1.0, then the sample meets the quality standard. Meanwhile, if it is greater than 1.0, the sample is declared not to meet the quality standard. The IP recap results for each parameter are presented in Table 7.

If the standard value of the Quality Standard is 0 then the Ci/Lij value is the value of the existing test results automatically becomes the Ci/Lij value.

Calculation of the Comparative Value of the Analysis Results with the Water Quality Standard Value (Ci/Li) Whose Quality Standard Value has a Range of

In this study, there are 2 parameters that have a range, namely pH and temperature, so it is necessary to calculate the new Ci/Lij value. So that the results of the calculation in Table 8 are as follows:

Calculation of (Ci/Lij) Maximum and (Cij/Lij) Average Values

Based on the calculation results that have been obtained from the comparison value between the test results in the laboratory and the Quality Standard which refers to the Regional Government Regulation of the Province of East Kalimantan No. 02 of 2011, regarding water quality management and water pollution control, the maximum (Ci/Lij) and average (Ci/Lij) values can be determined (Table 9).

Calculation of Pollution Index Value

From the results of the calculation of the Pollution Index value on the Status of Groundwater Quality in the samples NS-1 and NS-3 for the designation of clean water which can be determined in accordance with the Decree of the State Minister of the Environment No. 115 of 2003 can be categorized based on the table which can be see before and for the status of water quality for the designation of clean water can be seen in Table 10, as follows:

Table 7. Calculation of Ci/Lij for each parameter of NS-1 and NS-3 Tanah Groundwater Samples

No	Chemical Parameter	Unit	Code Sample		Threshold	Calculating (Cii/Lij)	Result
			NS-1	NS-3		NS-1	NS-3
1	Suhu	°C	25	25,4	Air temperature ±3	-	-
2	Warna	TCU	1	1	50	0,02	0,02
3	Kekeruhan	NTU	1,59	8,06	25	0,0636	0,3224
4	pH	-	6,1	6,9	6–9	-	-
5	Total Dissolved Solids (TDS)	mg/L	18	23	1000	0,018	0,023
6	Iron Dissolved (Fe)	mg/L	0,03	0,03	1	0,03	0,03
7	Fluoride (F)	mg/L	0,81	0,64	15	0,054	0,04266
8	Total Hardness ($CaCO_3$)	mg/L	2,84	5,9	500	0,00568	0,0118
9	Manganese Dissolved (Mn)	mg/L	0,02	0,02	0,5	0,04	0,04
10	Nitrite (NO_2)	mg/L	0,02	0,02	1	0,02	0,02
11	Nitrate (NO_3)	mg/L	0,12	0,12	10	0,012	0,012
12	Cyanide (CN)	mg/L	0,02	0,02	0,1	0,2	0,2
13	Mercury (Hg)	mg/L	0,0005	0,0005	0,001	0,5	0,5
14	Arsenic (As)	mg/L	0,001	0,001	0,05	0,02	0,02
15	Cadmium Dissolved (Cd)	mg/L	0,001	0,001	0,1	0,01	0,01
16	Chrom Hexavalen (Cr(VI))	mg/L	0,02	0,02	0,05	0,4	0,4
17	Selenium (Se)	mg/L	0,001	0,001	0,05	0,02	0,02
18	Zinc Dissolved (Zn)	mg/L	0,02	0,02	15	0,00133	0,00133
19	Sulphate (SO_4)	mg/L	0,33	4,61	400	0,000825	0,011525
20	Lead Dissolved (Pb)	mg/L	0,01	0,01	0,05	0,2	0,2
21	Organic Matter ($KMNO_4$)	mg/L	6,32	4,74	10	0,632	0,474

Based on Table 10 on the status of water quality for the designation of clean water, the results show that the NS-1 sample with a pollution index value of 0.463 has a water

Table 8. Calculation of New Ci/Lij for each Parameter of NS-1 and NS-3. Groundwater Samples

No	Chemical Parameter	Unit	Code Sample		Threshold	Calculating (Cii/Lij)	Result
			NS-1	NS-3		NS-1	NS-3
1	Suhu	°C	25	25,4	Air Temperature ±3	0,5	0,5
2	Warna	TCU	1	1	50	0,02	0,02
3	Kekeruhan	NTU	1,59	8,06	25	0,0636	0,3224
4	pH	-	6,1	6,9	6–9	0,1	0,4
5	Total Dissolved Solids (TDS)	mg/L	18	23	1000	0,018	0,023
6	Iron Dissolved (Fe)	mg/L	0,03	0,03	1	0,03	0,03
7	Fluoride (F)	mg/L	0,81	0,64	15	0,054	0,04266
8	Total Hardness ($CaCO_3$)	mg/L	2,84	5,9	500	0,00568	0,0118
9	Manganese Dissolved (Mn)	mg/L	0,02	0,02	0,5	0,04	0,04
10	Nitrite (NO_2)	mg/L	0,02	0,02	1	0,02	0,02
11	Nitrate (NO_3)	mg/L	0,12	0,12	10	0,012	0,012
12	Cyanide (CN)	mg/L	0,02	0,02	0,1	0,2	0,2
13	Mercury (Hg)	mg/L	0,0005	0,0005	0,001	0,5	0,5
14	Arsenic (As)	mg/L	0,001	0,001	0,05	0,02	0,02
15	Cadmium Dissolved (Cd)	mg/L	0,001	0,001	0,1	0,01	0,01
16	Chrom Hexavalen (Cr(VI))	mg/L	0,02	0,02	0,05	0,4	0,4
17	Selenium (Se)	mg/L	0,001	0,001	0,05	0,02	0,02
18	Zinc Dissolved (Zn)	mg/L	0,02	0,02	15	0,00133	0,00133
19	Sulphate (SO_4)	mg/L	0,33	4,61	400	0,000825	0,011525
20	Lead Dissolved (Pb)	mg/L	0,01	0,01	0,05	0,2	0,2
21	Organic Matter ($KMNO_4$)	mg/L	6,32	4,74	10	0,632	0,474

Table 9. Calculation of (Ci/Lij) Maximum and (Cij/Lij) Average values

No	Chemical Parameter	Unit	Test Results		Threshold	Calculating (Cii/Lij)	Result
			NS-1	NS-3		NS-1	NS-3
1	Suhu	°C	25	25,4	Air temperature ±3	0,5	0,5
2	Warna	TCU	1	1	50	0,02	0,02
3	Kekeruhan	NTU	1,59	8,06	25	0,0636	0,3224
4	pH		6,1	6,9	6–9	1,45	1,54
5	Total Dissolved Solids (TDS)	mg/L	18	23	1000	0,018	0,023
6	Iron Dissolved (Fe)	mg/L	0,03	0,03	1	0,03	0,03
7	Fluoride (F)	mg/L	0,81	0,64	15	0,054	0,04266
8	Total Hardness ($CaCO_3$)	mg/L	2,84	5,9	500	0,00568	0,0118
9	Manganese Dissolved (Mn)	mg/L	0,02	0,02	0,5	0,04	0,04
10	Nitrite (NO_2)	mg/L	0,02	0,02	1	0,02	0,02
11	Nitrate (NO_3)	mg/L	0,12	0,12	10	0,012	0,012
12	Cyanide (CN)	mg/L	0,02	0,02	0,1	0,2	0,2
13	Mercury (Hg)	mg/L	0,0005	0,0005	0,001	0,5	0,5
14	Arsenic (As)	mg/L	0,001	0,001	0,05	0,02	0,02
15	Cadmium Dissolved (Cd)	mg/L	0,001	0,001	0,1	0,01	0,01
16	Chrom Hexavalen (Cr(VI))	mg/L	0,02	0,02	0,05	0,4	0,4
17	Selenium (Se)	mg/L	0,001	0,001	0,05	0,02	0,02
18	Zinc Dissolved (Zn)	mg/L	0,02	0,02	15	0,00133	0,00133
19	Sulphate (SO_4)	mg/L	0,33	4,61	400	0,00082	0,01152
20	Lead Dissolved (Pb)	mg/L	0,01	0,01	0,05	0,2	0,2
21	Organic Matter ($KMNO_4$)	mg/L	6,32	4,74	10	0,632	0,474
Total						4,197	4,399
Ci/Lij Maximum						0,632	0,474
Ci/Lij Average						0,174	0,183

Table 10. Groundwater Quality Status for Clean Water

Kode Sampel	Nilai Indeks Pencemaran	Status Mutu Air
NS-1	0,463	Memenuhi Baku Mutu (Kondisi Baik)
NS-3	0,359	Memenuhi Baku Mutu (Kondisi Baik)

quality status that meets the quality standard (good condition) and in the NS-3 sample with a pollution index value of 0.359 with a pollution index value of 0.359 having a water quality status that also meets the quality standard (good condition), which means that all samples in the research area have a water quality status that meets the quality standard.

4 Conclusion

The results of the assessment of the physical, chemical, and biological parameters of groundwater are compared using quality standards based on the Regulation of the Minister of Health no. 32 of 2011 concerning Environmental Health Quality Standards. All groundwater samples show that in the research area they are within the permissible threshold and are included in the standard value for clean water that can be used for clean water.

Based on the SAR classification, %Na, and also using the Wilcox classification, it was found that the results of the suitability of groundwater quality for irrigation in the NS-1 sample code were very good to good, and in the NS-3 sample code the results of the suitability of groundwater quality were very good. Until good. So that all groundwater samples that have been analyzed in the research area meet the requirements for use as irrigation.

Based on the results of the calculation of the Pollution Index value on Groundwater Quality Status, the results obtained that the NS-1 sample with a pollution index value of 0.463 has a water quality status that meets the quality standard (good condition) and the NS-3 sample with a pollution index value of 0.359 has a water quality status which also meets the quality standard (good condition), which means that all samples in the research area have good water quality status.

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