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Potential of Water Pollution in Girimulyo, West Progo

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Abstract. Hydrogeological survey activities have been carried out to identify potential water pollution in the Girimulyo area, West Progo. The research method was conducted with a field hydrogeological survey to get hydrogeological data and water quality in the form of pH and TDS. Water quality status evaluation is to determine the pollution index based on water quality standards. The results showed that the water in the study area was generally colorless, tasteless, and odorless and transparent (not turbid). The pH value of water measured in the field is 7 - 8.1, while the TDS is 15 - 305 ppm. The results of the water chemistry laboratory test show that groundwater quality is quite good with a pH of 7 - 8.1 and TDS 112-240 ppm. Groundwater violence is in the middle to medium class - hard, as is river water. Chemical types develop as groundwater Ca - bicarbonate and Ca, Mg - bicarbonate. The index of water pollution studied is in the mildly polluted category (Pollution Index of 1,81 – 4,81), with the highest level of pollution found in river water is in Niten.

1. Introduction

The Girimulyo area is one of the sub-districts in the Kulon Progo District, which occupies the morphology in the physiography of the West Progo Hills [1] (Fig. 1). This area is composed of sedimentary rocks from the Old Andesite and Jonggrangan Formations. Surface and groundwater are obtaining in inadequate amounts. The water quality needs to be identified, considering this area is starting to develop, along with the advancement of geo-tourism in the West Progo Hills.

Although the water in the West Progo Hills is generally clear [2],[3] pollution identification needs to be done. Identification of water pollution as one part of the environmental component needs to be done, especially in fast-growing areas. Periodic data on environmental pollution is very well known about population growth and regional development. If pollution has not occurred at present, then use quality data from environmental components can be a benchmark for further environmental data.

This research is intended as a hydrogeological and hydrochemical survey conducted by geological mapping and groundwater/surface water sampling. The objectives include:

- Knowing the hydro-chemical characteristics of water in the Girimulyo area
- Recognizing the potential pollution that occurs based on the hydro-chemical characteristics of the water.
- Benchmarking of any possible pollution data for the development area in 2019.



2. Method

The study began by carrying out hydrogeological surveys in the field supplemented by surface and groundwater sampling. Two groundwater samples were taken at Ngelo and Mudal springs, while two river water samples from Kahyangan and Niten sites represented surface water. Then the four samples were tested physically / chemically at the BTKL chemistry laboratory in Yogyakarta.

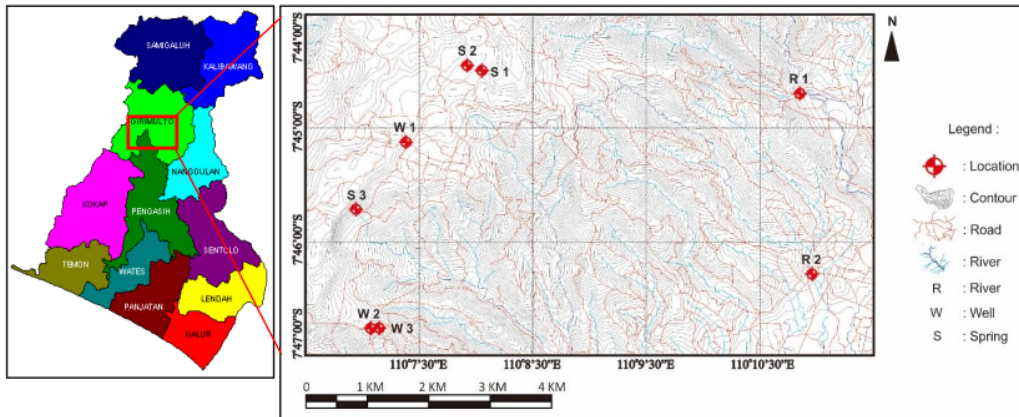


Figure 1. Location of the research area (left: index map [4]).

Water quality evaluation can be done by comparing the results of water quality analysis of water samples taken in the field with quality criteria based on the Republic of Indonesia Government Regulation No. 82 [5]. Evaluate water quality status using the Pollution Index Method using Kep. Men LH No. 115 [6], i.e., by comparing the concentration of each parameter with the water quality standard. Then, the Pollution Index (IP) value obtained is compared with the criteria of its quality status.

The steps to determine the status of water quality are as follows [5]. If L_{ij} states the concentration of water quality parameters listed in the Water Quality Standard (j), and C_i states the concentration of water quality parameters (i) obtained from the analysis of water samples at a location, then IP_j is the Pollution Index for the designation (j) which is C_i / L_{ij} function. The IP_j value is determined by:

1. Calculate the value of C_i / L_{ij} for each parameter in each example.
2. If the C_i / L_{ij} value < 1.0 , use the measured (C_i / L_{ij}) value; if $C_i / L_{ij} > 1.0$, use the new (C_i / L_{ij}) value. The formula is:

$$(C_i / L_{ij})_{\text{new}} = 1.0 + P \log (C_i / L_{ij})_{\text{measurement results}} \quad (1)$$

P = a constant that is usually determined to be 5.

3. Determine the average value (C_i / L_{ij}) R and the maximum value (C_i / L_{ij}) M overall.
4. The formula determines the IP_j value:

$$IP_j = \left[\frac{(C_i/L_{ij})^2 M + (C_i/L_{ij})^2 R^{1/2}}{2} \right] \quad (2)$$

3. Result and analysis

3.1. Geology of Girimulyo area

The research area is part of the dome and hills physiographic zone in the Central Depression, namely the South Serayu Zone, specifically the West Progo Hills [1]. The regional stratigraphy of the West Progo Mountains from the oldest to the young is composed of the Nanggulan, Old Andesite, Jonggrangan, Sentolo Formations, and the Alluvial sediments. The most extensive rock outcrops in the study area are rocks from the Old Andesite Formation, which are dominated by volcanic breccias. Geological structures such as joints, fault, and fold are often found in the study area. The geological structure was formed by tectonics in the past. Tectonic in this area is also developing today as neotectonics. This active tectonic affects the geomorphological formation of the West Progo Mountains [7].

Rocks that consist of the study area include alluvial/colluvial deposits, tuffs, sandstones, carbonate sandstones, andesite breccias, and limestone. Some of these rocks have become weathered land covering the research area.

The rocks that generally can be aquifers are andesite breccias (Fig. 2) carbonate sandstones (Fig. 3), and limestone. These aquifer rocks typically have moderate porosity and moderate permeability, supported by grains and cracks porosity types. Rocks started to weathered or even become soil or alluvial/colluvial deposits sometimes also grown as aquifers, especially in lowlands or valleys.



Figure 2. Andesite breccias at the Kahyangan Dam can be groundwater aquifers supported by crack porosity.

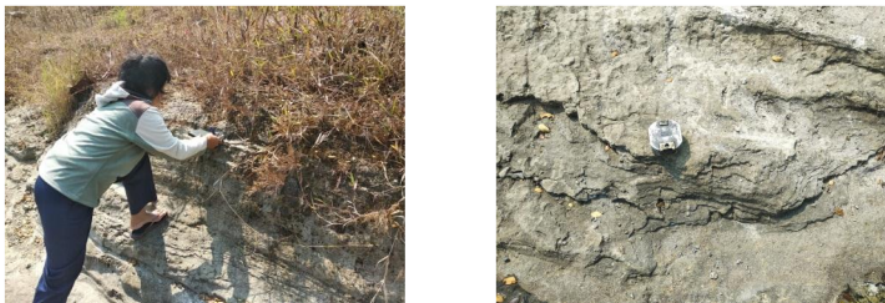


Figure 3. The calcareous sandstone outcrop found in Niten can be an aquifer because of its good porosity and permeability.

3.2. Hydrochemical characteristics

A survey of eight selected locations was carried out to see the characteristics of water in the field (Table 1). From these eight locations, two groundwater samples were taken from springs (S2 & S3) and two river water samples (R1 & R2) for physical/chemical tests in the laboratory. Laboratory test results are presented in Table 2.

Table 1. Water quality data measured in the field.

No	Loc.	pH	TDS	Color	Taste	Odor	Turbidity
1	S1	7.1	305	Colorless	Tasteless	Odorless	Clear
2	S2	7.2	250	Colorless	Tasteless	Odorless	Clear
3	S3	8.1	230	Colorless	Tasteless	Odorless	Clear
4	W1	8.1	180	Colorless	Tasteless	Odorless	Clear
5	W2	7	15	Brownish	Tasteless	Odorless	Turbid
6	W3	7	65	Colorless	Tasteless	Odorless	Clear
7	R1	7,2	229	Colorless	Tasteless	Odorless	Clear
8	R2	7.1	221	Colorless	Tasteless	Odorless	Almost turbid

Table 2. Physical/chemical laboratory of water samples.

No	Parameter	S2	S3	R1	R2
PHYSICAL					
1	Color (TCU)	<1	<1	9	14
2	Odor	no	no	no	no
3	Taste	no	no	no	no
4	Turbidity (NTU)	2	1	1.1	1.5
CHEMICAL					
1	TDS (mg/l)	240	229	112	178
2	pH	7.1	7.0	8.1	8.1
3	Hardness (Hr *)	137.8	218.8	90.97	150.246
4	Ion content (mg/l)				
Cation					
a	Ca	36.00	80.40	23.76	30.89
b	Na	5	6	20	25
c	K	1	1	2	3
d	Mg	11.66	4.35	7.70	17.81
e	Fe	< 0.0162	< 0.0162	0.0292	0.0390
f	Mn	< 0.0101	0.0188	< 0.0101	0.0188
g	Zn	< 0.0083	< 0.0083	< 0.0083	< 0.0083
Anion					
a	NO ₃	1.2	2.23	0.07	0.16
b	HCO ₃	122	302.8	164.7	213.5
c	SO ₄	5	6	13	26
d	Cl	2.5	2.0	4.0	14.0
e	SiO ₂	9.042	11.354	13.376	24.699

*) Hr value calculated from formula Hr = 2.5Ca + 4.1 Mg [8].

3.2.1. Physical properties of water.

The color of groundwater and surface water is generally clear/transparent/ colorless, except in well W2 (brownish), indicating the presence of substances contained in it (colloid/suspension/ solute), which are not saturated the gives a transparent effect. Laboratory test results also show transparent/colorless (<1 TCU - 14 TCU). Water in the study area is odorless and tasteless. This excellent quality indicates the absence of substances or gases that give aroma contained in water. It means that salt or other substances which suspended or dissolved are relatively few. Laboratory test results showed that the turbidity of the water was 1-2 NTU (not turbid) except for the W2 sample. It shows the content of substances that are not dissolved only a little, which means groundwater has not been polluted by clay, silt or organic substances and microorganisms. Anomaly in W2 shows the presence of clay colloids / other contaminants.

3.2.2. Chemical properties of water

Laboratory results show carbonate hardness/groundwater hardness of 137.8 - 218.8 ppm (moderately hard - hard). This groundwater comes from limestone aquifers of the Jonggrangan Formation. Meanwhile, river water hardness is calculated as 90.97 - 150.2 ppm, (moderately hard - hard) as well. This river water flows over the volcanic breccia and calcareous sandstones. Groundwater TDS measured in the field is 65 - 305 ppm while in the laboratory is 229-240 ppm. Meanwhile, river water shows TDS value in the field of 94 - 127 ppm and in the laboratory of 112 - 178 ppm. Both groundwater and river water is freshwater [8]. The acidity of the water being studied is 7 - 8.1 (standard) both in the field and the laboratory. It means that the water in Girimulyo meets water quality standards (pH 6-9) [2]. Based on the acidity, water pollution in the study area is not apparent. A large amount of nitrate also supports it as an indication of pollution, which only reaches 2.23 mg/l.

3.2.3. Ion content and facies of water.

Major cations that contain the water under study include Na^+ , K^+ , Ca^{2+} , Mg^{2+} , while major anions include Cl^- , SO_4^{2-} , and HCO_3^- . Some additional ions contained include Fe^{2+} , Mn^{2+} , Zn^{2+} , NO_3^- , and silica (SiO_2). The content of minor ions Fe^{2+} , Mn^{2+} , and Zn^{2+} are only small (<0.05 ppm) so that its presence can be ignored. The content of nitrate (NO_3^-), sulfate (SO_4^{2-}), and silica is also low. The ion content shows that the dissolution of minerals/silica rocks (feldspar, quartz, clay minerals, volcanic rocks) has not been intensive. It indicates that the groundwater flow process has not been long in geological formations, while river water also flows in a short time. Groundwater and surface water facies develop as the bicarbonate type (Table 3). This type indicates that water is strongly influenced by rainwater or is still in the catchment zone.

3.3. Indication of pollution

Evaluation of water quality status by the Pollution Index Method in this study uses Kep. Men LH No. 115 [6]. Namely, by comparing the concentration of each parameter with PP RI Water Quality Standard No. 82 (Table 15) [5]. The determination of water quality status is presented in the following Table 5. Furthermore, the calculation of the Pollution Index (IP) value can be determined from the water quality status.

Indications of pollution are apparent in all samples, namely at slightly polluted levels. Potential pollutants may come from agricultural waste caused by the use of fertilizers and pesticides or household waste. Some of the fertilizers and pesticides used are absorbed into the soil and can contaminate groundwater.

Of the four samples tested, river water in Niten was the most polluted water, although it was still in the mild polluted category. This can be understood because the river water samples in Niten are located downstream compared to river water samples in Kahyangan. The more downstream, the river water tends to be more polluted.

Table 3. Groundwater chemical facies in the research area.

Ion (%)	No	Parameter	S2	S5	D8	D9
Cation	1	Ca ²⁺	60.70252	87.85086	49.04123	40.81564
	2	Na ⁺	4.444569	3.360177	21.15757	16.9305
	3	K ⁺	1.511811	0.952464	3.598352	3.455323
	4	Mg ²⁺	33.3411	7.836497	26.20284	38.79854
Anion	1	Cl ⁻	3.243842	1.096806	3.660295	8.904352
	2	HCO ₃ ⁻	91.96822	96.47485	87.56045	78.89154
	3	SO ₄ ²⁻	4.787934	2.428341	8.77926	12.20411
Chemical Facies			Ca, Mg Bicarbonate	Ca Bicarbonate	Ca, Mg Bicarbonate	Ca, Mg Bicarbonate

Table 4. Indications of water pollution in the study area.

No	Parameter	Groundwater		River Water		Quality Standard (PP 82 / 2001)	Note
		S2	S3	R1	R2		
1	pH (field/lab)	7.2/7.1	8.1/7	7/8.1	8.1/8.1	6 - 9	Normal
2	Fe ²⁺ (mg/l)	< 0.0162	< 0.0162	0.0292	0.039	0.3	Normal
3	Mn ²⁺ (mg/l)	< 0.0101	0.0188	<0.0101	0.0188	1	Normal
4	Zn ²⁺ (mg/l)	< 0.0083	< 0.0083	<0.0083	<0.0083	0.05	Normal
5	NO ₃ ⁻ (mg/l)	1.2	2.23	0.07	0.16	10	Normal
6	SO ₄ ²⁻ (mg/l)	5	6	13	26	400	Normal
7	Cl ⁻ (mg/l)	2.5	2	4	14	1	Polluted
8	TDS (mg/l)	240	229	112	178	1000	Normal

Table 5. Determination of water quality status and pollution index.

No	Parameter	Lij	Ci/Lij new			
			S2	S3	R1	R2
1	TDS	1000	0.24	0.23	0.11	0.18
2	Cl ⁻	1	2.99	2.51	4.01	6.73
3	SO ₄ ²⁻	400	0.01	0.02	0.03	0.07
4	Fe ²⁺	0.3	0.05	0.05	0.10	0.13
5	Zn ²⁺	0.05	0.17	0.17	0.17	0.17
6	Mn ²⁺	1	0.01	0.02	0.01	0.02
7	NO ₃ ⁻	10	0.12	0.22	0.01	0.02
8	pH	9	0.79	0.78	0.90	0.90
Total			4.38	3.99	5.34	8.20
Average			0.55	0.50	0.67	1.03
Max			2.99	2.51	4.01	6.73
IP			2.15	1.81	2.87	4.81
Pollution			Slightly polluted			

Of the four samples tested, river water in Niten was the most polluted water, although it was still in the mild polluted category. It can be understood because the river water samples in Niten are

located downstream compared to river water samples in Kahyangan. The more downstream, the river water tends to be more polluted.

In general, water pollution in the study area is caused by chloride content. This element can be obtained from household waste or agricultural waste. Chloride elements can also be derived from weathering and dissolving marine sedimentary rocks in the study area, for example, those from the Nanggulan Formation.

But in general, the level of water pollution in the study area is not yet in the worrying category. However, the potential for pollution can increase along with the increase in the population in the local area. Therefore, periodic monitoring is important because the research area is somewhat developed.

The protection of water is critical. This protection can be done for water sources, both groundwater and surface water, associated with increased human activity. Also, springs need to be maintained, even given a sanctuary related to climate change [9]. Water quality monitoring is one of the critical activities to support the sustainability of water quality by its quality standards.

4. Conclusion

Water in the study area generally has physical characteristics that are relatively clear/colorless/transparent, tasteless, odorless, and not turbid. The chemical properties of groundwater/river water measured both in the field and in the laboratory show a relatively normal acidity (7 - 8.1). Groundwater hardness calculated from the Ca^{2+} and Mg^{2+} content of laboratory test results shows medium to hard hardness. The amount of dissolved salt (TDS) in the field shows a value of 15 - 305 ppm, while the results of laboratory tests of 112-240 ppm. This value indicates that the groundwater studied is fresh. The groundwater ion content is dominated by bicarbonate anions, while the cations vary, namely Ca^{2+} and Mg^{2+} . The identification of pollution indicated by the groundwater samples studied shows a slightly contaminated class. Although pollution is still in a mildly contaminated level, monitoring of water quality needs to be done periodically, so that the potential for pollution is easily recognized and its effects can be anticipated immediately.

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