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RESEARCH ARTICLE

Characteristics of Groundwater on the Eastern Slope of Mount Ciremai, Kuningan Regency, West Java, Indonesia

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Abstract

Water is a very important component for the survival of living things. Groundwater is water that has better quality compared to other water types, so groundwater is widely used to meet the needs of clean water. The research area is located on the eastern slope of Mount Ciremai which is a volcanic area that has great groundwater potential, it is seen from the many springs with large groundwater discharge. The study aims to determine the physical and chemical characteristics of groundwater on the eastern slopes of Mount Ciremai which also the district of Kuningan. The research method is done by collecting geological data and hydrogeological data. To find characteristics of groundwater chemistry, groundwater sampling was taken at 10 locations, and then tested the laboratory to determine the chemical content of groundwater. Based on the results of the research, the physical characteristics of water were shown with EC values ranging from 76,8 to 228 µS/Cm, TDS from 50 to 151 mg/L, pH value from 6.4 to 7.65, water temperature 19.3 to 25.9 °C. While one of the observation location is HC. 11 is a hot spring that has a water temperature of 36.1 °C, EC 832 µS/Cm, TDS 428 mg/L and pH 6.8. Chemical analysis results from pipe diagram show the developing facies are Ca: HCO_3, Ca. Mg: HCO_3, Na.K:Cl..

Keywords: Groundwater, Volcano, Geology, Hydrogeology, Physical properties, Facies

1. Introduction

Water in the volcano region generally has a very good quality and has interesting characteristics to be studied. Volcano area is a high altitude, is a catchment area as well as absorption of rain water is good. The research area is located on the eastern slope of Mount Ciremai which is a volcanic area that has great groundwater potential, it is seen from the many springs with large groundwater discharge. The type of spring that appears generally is the fracture type and depression type (Irawan et al., 2006). Mount Ciremai has a height of 3072 meters from sea level, located 10 kilometers to the south of the Cirebon Regency, with radius from peak to foot mountain as far as 10 kilometers. Surrounded by three areas: Kuningan Regency from the east, Majalengka Regency from the west, and Cirebon Regency from the north. Mount Ciremai keeps abundant natural resources besides it's springs, such as minerals, fertile soils, and functions as nature conservation area and water catchment zone area.

2. Slope of Research Area

Volcanoes are generally cone-shaped by division starting from central facies, proximal facies, medial facies, and distal facies (Bronto, 2006). Research area is located at the proximal facies and the medial facies with elevation at 425 – 1312.5 masl. The slope is divided become two types, namely:

i. Decline area (2° - 4°)
ii. rather steep and steepest (4° - 16°)

3. Field Location and Geology

To determine the characteristics of groundwater, geological and hydrogeological data collection methods are used (Hadian et al., 2017). Geological data obtained by means of geological mapping of lithology data. Hydrogeological data is done by means of hydrogeological mapping in form of measurement of physical properties of groundwater and groundwater sampling which will then be analyzed cation and anion content in the laboratory. The types of cations and anions analyzed are Na, K, Ca, Mg, HCO_3, Cl and SO_4 (Kumaresan & Riyazuddin P., 2006). To determination of groundwater chemical analysis by using piper diagram to find out groundwater facies that developed in the research area.

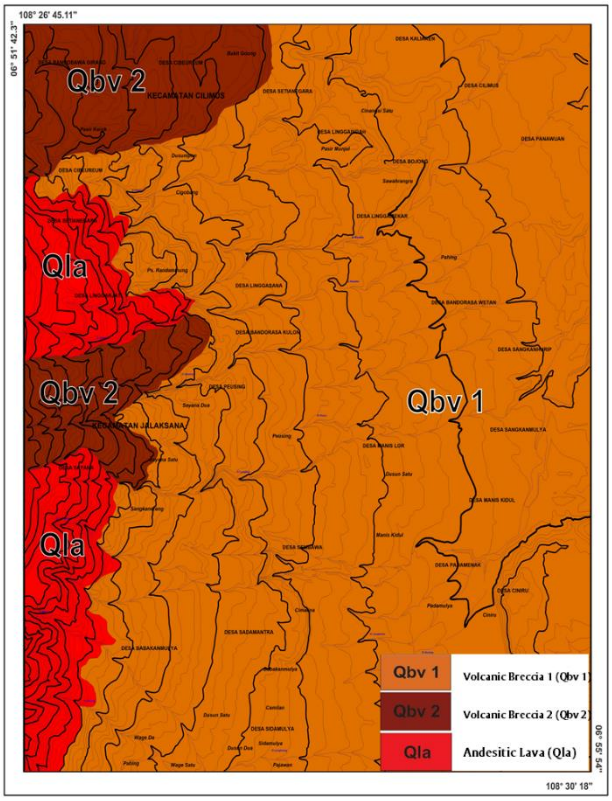

Fig 1. Geological map of research area (no scale)

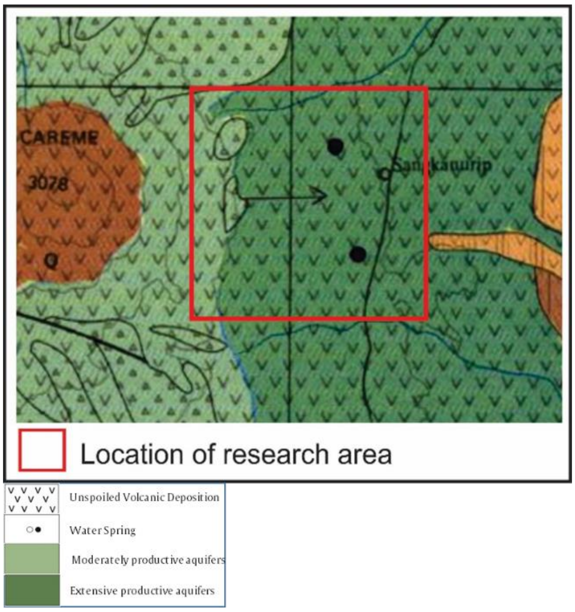

Fig 2. Hydrogeological map of research area.

4. Result and Discussion

4.1 Geological Mapping of Research Area

Based on regional geological map analysis and geological mapping, stratigraphic research area form the old to the young is divided into three stratigraphic units, among others: volcanic breccia 1 (Qbv 1), volcanic breccia 2 (Qbv 2), and andesitic lava (Qla) (Djuri, 1973).

The division of stratigraphy can be seen in the geological map of research area (Fig 1). Based on research conducted by previous researchers using geoelectric surveys, the measurement areas enter the depths of the Qbv 1 which has several lithologies: Breccia, Lava, Tuff Sand, and Lapilli from the eruption from the eruption of Mount Ciremai (Alfadli et al., 2017).

4.1.1 Volcanic Breccia 1

This unit has a visibility in the research area of varying thickness, from 0.5 meter to 4 meter. Volcanic breccia with matrix more than 50%, bad disaggregated and open pack. It has a gray andesitic igneous rock component that contains plagioclase minerals with little quartz. Matrix is tuff vitric with brownish brown color and composed of mineral glass.

4.1.2 Volcanic Breccia 2

Volcanic breccia with less than 50% matrix, bad disaggregated and closed pack. This volcanic breccia is relatively hard. It has a gray andesitic igneous rock component that contains plagioclase minerals with little quartz. Matrix is tuff vitric with brownish brown color and composed of mineral glass.

4.1.3 Andesitic Lava (Qla)

This unit has a visibility in the research area of varying thickness, from 0.5 meter to 3 meter. Andesite lava has a fresh gray color and a grayish brownies color. Has porphyritic granularity with good packing and the degree of hypo-crystalline crystallization because composed of crystals and groundmass. With a very hard hardness, with a structure that looks massive in the field.

4.2 Hydrogeology of Research Area

Based on hydrogeology map, research area can be divide into 2 hydrogeology units (Fig 2) that is moderately productive aquifers and extensive productive aquifers (Soetrisno, 1983).

4.3 Groundwater Physical Characteristics

The results of measuring the physical properties of ground water directly in the field of the spring show heterogeneous characteristics (Fig 3).

Range of EC values is 76.8 to 228 µS/Cm, TDS values from 50 to 151 mg/L, pH value from 6.4 to 7.65, water temperature 19.3 to 25.9 °C. One location of observation that is HC. 11 is hot springs having water temperature 36.1 °C, EC 832 µS/Cm, TDS value 428 mg/L and pH 6.8.

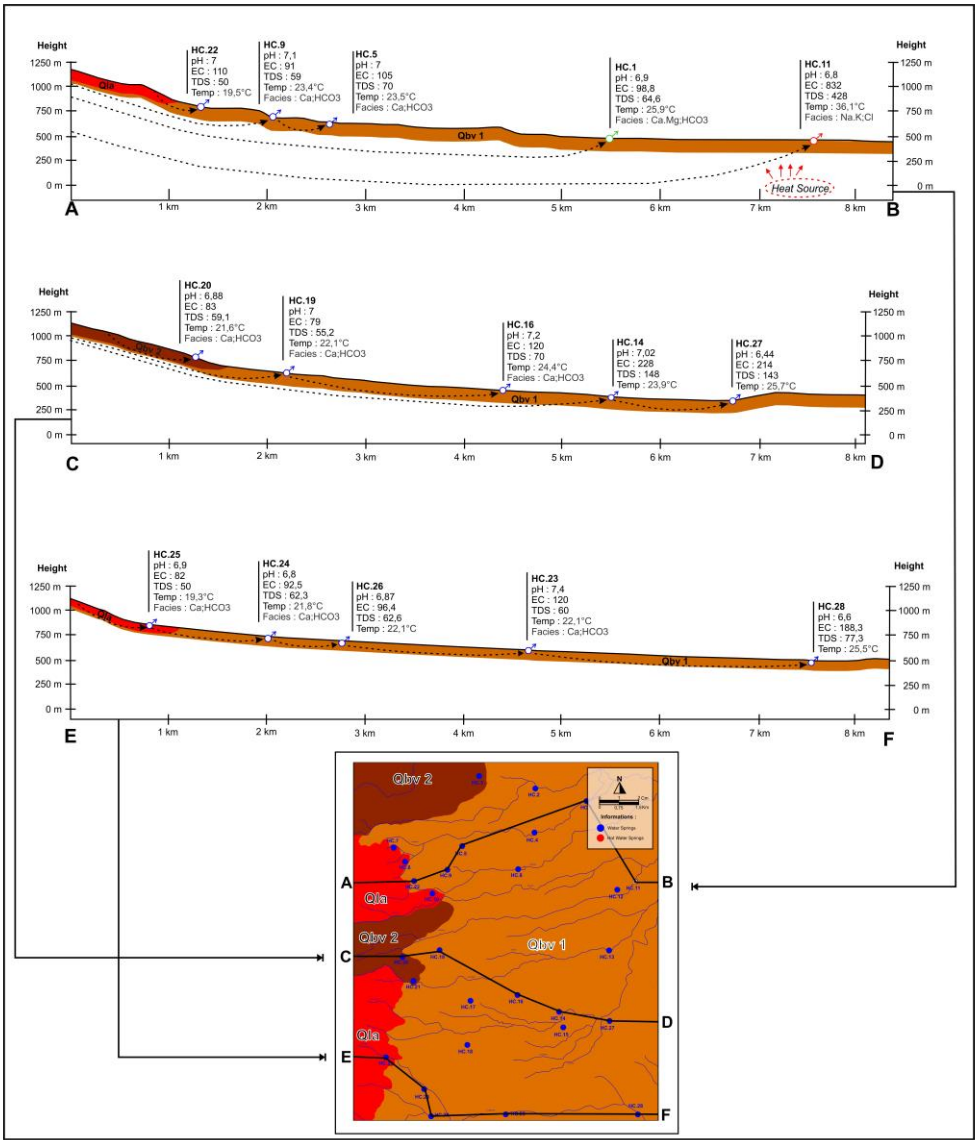

Fig 3. Section for reconstruction of groundwater physics data and groundwater chemistry

4.4 Groundwater Chemistry Characteristics

From the results of chemical analysis of groundwater in the laboratory obtained the major elements contained in groundwater (Tab 1), then converted into units of meq/L (Tab 3). The element analyzed is Na, K, Ca, Mg, HCO_3, SO_4 and Cl.

Table 1. Data of groundwater ion concentration from laboratory analysis

No	Kode Sampel	Na (ppm)	K (ppm)	Ca (ppm)	Mg (ppm)	Cl (ppm)	HCO3 (ppm)	SO4 (ppm)
1	HC.1	8.89	4.64	27.68	9.34	9.99	108.32	7.06
2	HC.5	4.23	3.02	19.29	2.41	8.26	56.60	2.95
3	HC.9	6.13	1.43	27.83	7.17	2.98	110.7	3.25
4	HC.11	469.21	74.2	124.1	31.74	913.2	171.5	2.36
5	HC.16	4.29	2.59	18.41	2.09	5.95	53.88	3.47
6	HC.19	3.93	1.94	16.69	3.26	4.85	54.42	3.47
7	HC.22	5.05	2.63	18.40	4.26	6.43	65.70	4.57
8	HC.23	10.38	4.05	29.72	11.31	14.50	107.70	17.78
9	HC.24	5.15	2.66	18.43	4.73	7.03	66.30	4.27
10	HC.25	5.58	3.01	19.39	4.85	8.97	59.55	8.37

To convert ion concentration in ppm unit into unit of meq/L used by dividing ion concentration in ppm with equivalents number of each elements (Table 2).

Table 2. Number of equivalents on the major elements

	Ion	Number Of Equivalents
Cation	Na^{+}	22,9898
	K^{+}	39,102
	Ca^{2+}	20,04
	Mg^{2+}	12,156
Anion	SO_4^{2-}	48,031
	Cl^{-}	35,453
	HCO_3^{2-}	61,017

The data of cation-anion concentration in meq/L unit then validated by ion equilibrium equation, valid data if error balance (CBE) does not exceed 10%. Percent error is calculated by equation:

$$\text{CBE }\% = \frac{\text{Number of cations} - \text{Number of anions}}{\text{Number of cations} + \text{Number of anions}} \quad (1)$$

Table 3. The data of ionized water ion concentration converted into meq/L and calculation of CBE

No	Sample Code	Na (meq/L)	K (meq/L)	Ca (meq/L)	Mg (meq/L)	Cl (meq/L)	HCO3 (meq/L)	SO4 (meq/L)	Charge Balance Error (CBE)
1	HC.1	0.39	0.12	1.38	0.93	0.28	1.78	0.15	9.28%
2	HC.5	0.18	0.08	0.96	0.20	0.23	0.93	0.06	7.57%
3	HC.9	0.27	0.04	1.39	0.59	0.08	1.81	0.07	7.44%
4	HC.11	20.41	1.90	6.19	2.61	25.76	2.81	0.05	4.17%
5	HC.16	0.19	0.07	0.92	0.17	0.17	0.88	0.07	8.95%
6	HC.19	0.17	0.05	0.83	0.27	0.14	0.89	0.07	9.11%
7	HC.22	0.22	0.07	0.92	0.35	0.18	1.08	0.10	6.85%
8	HC.23	0.45	0.10	1.48	0.93	0.41	1.76	0.37	7.69%
9	HC.24	0.23	0.07	0.92	0.39	0.20	1.10	0.10	7.04%
10	HC.25	0.24	0.08	0.97	0.40	0.25	0.98	0.17	9.16%

Based on the results of the analysis of the piper diagram (Fig 4) the study area is divided into three groundwater facies, as follows:

1) Facies Ca:HCO_3, this shows in this group the circulation of groundwater has not been too far and Ca content in the exchange of groundwater ions with rocks. The dominant Ca content in this facies is caused by the water interaction with volcanic breccia rocks.
2) Facies Ca.Mg:HCO_3, this facies found in one location that is HC.1. Groundwater in this facies has a relatively long circulation compared to facies Ca:HCO_3. Emergence of facies Ca.Mg:HCO_3 in this facies is at the location of HC.1, possibly caused by the interaction of rocks against groundwater that has been long enough because it has experienced mixing, it can be seen from the percentage of Ca and Mg ion enrichment is balanced.
3) Facies Na.K:Cl, this facies found in one location that is HC.11. The HC.11 spring is the only hot springs in the study area. Springs in this Sangkanhurip area have temperature 31.6 °C. Temperature is thought to be derived from geothermal activity beneath the surface that flows through the fracture that is indicated as a result of geological structure. Dominant Na and K content are caused by the interaction of water with the mineral constituent of rocks, while the high content of Cl may be due to the interaction with sedimentary rocks. This can be proved by the location of the springs that are located close to the Ciherang Formation and Halang Formation in the west of the research area which is a sedimentary rocks. The high Cl content indicates that the groundwater flow system is derived from a deep and predominantly regional aquifer far from the springs (Domenico, 1972).

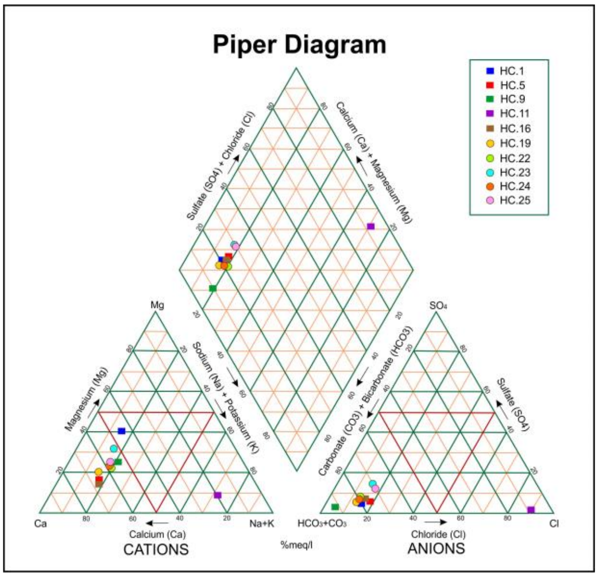

Fig 4. Piper Diagram show chemical facies of research area

5. Conclusion

Groundwater characteristics in the research area were obtained based on geological data and hydrogeological data analysis. Based on the physical characteristics of groundwater show in the research area into the fresh water category. While based on chemical analysis, groundwater characteristics in the research area is divided into three groundwater facies that is Ca: HCO_3, Ca. Mg: HCO_3 dan Na.K:Cl.

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