

## PHYSICAL AND CHEMICAL PROPERTIES OF GROUNDWATER IN BANJARARUM AREA AND ITS VICINITY, WEST PROGO

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### **Abstrak**

*Airtanah di daerah Banjararum terdapat di berbagai macam batuan yang menyusun Perbukitan Kulon Progo, di antaranya adalah Formasi Nanggulan maupun Formasi Andesit Tua. Airtanah tersebut dapat dijumpai pada sumur gali maupun mataair. Survei lapangan menunjukkan bahwa airtanah ini pada umumnya berwarna bening, tidak berasa dan tak berbau, kecuali pada sumur di Ngipikrejo. Hasil uji kimia dari empat sampel menunjukkan bahwa airtanah pada batugamping memiliki tipe Ca, Mg - HCO<sub>3</sub>, sedangkan pada batuan vulkanik bertipe Ca - HCO<sub>3</sub> dan Ca, Na - HCO<sub>3</sub>. Tipe kimia airtanah tersebut dihasilkan dari tanah, pelarutan mineral pada batuan sedimen maupun batuan beku serta atmosfer melalui air hujan. Kandungan NO<sub>3</sub> yang cukup besar di daerah Ngentak menandai adanya pencemaran dari aktivitas manusia, tumbuhan ataupun kotoran binatang. Secara umum airtanah di daerah penelitian layak digunakan sebagai air bersih atau air minum, ditandai dengan pH terukur di lapangan sebesar 6.6 – 7.2 dan TDS 54 – 155 ppm. Namun demikian, hasil uji laboratorium menunjukkan bahwa sampel airtanah merupakan air yang sadah, dengan kekerasan sebesar 135.866 - 778.048 (moderately hard – very hard), sehingga perlu dilakukan treatment khusus sebelum diminum.*

**Kata kunci:** sifat fisik, tipe kimia, airtanah, pH, kesadahan

### **Abstract**

*Groundwater in the Banjararum area is found in various rocks that build the West Progo Hills, including the Nanggulan Formation and the Old Andesite Formation. Groundwater can be found in dug wells and springs. Field surveys show that the groundwater is generally clear, tasteless and odorless, except for the well at Ngipikrejo. Chemical test results from four samples showed that groundwater in limestone has Ca, Mg - HCO<sub>3</sub> type, whereas in volcanic rocks of type Ca - HCO<sub>3</sub> and Ca, Na - HCO<sub>3</sub>. Groundwater chemistry type is generated from the soil, mineral dissolution in sedimentary rocks and igneous rocks as well as the atmosphere through rainwater. The considerable content of NO<sub>3</sub> in the Ngipikrejo area indicates pollution from human activities, plants or animal dung. In general, groundwater in the study area is suitable for use as clean water or drinking water, characterized by a measurable pH in the field of 6.6 - 7.2 and TDS 54 - 155 ppm. Nevertheless, laboratory test results show that groundwater samples are water-filled, with a hardness of 135,866 - 778,048 (moderately hard - very hard), so special treatment is required before drinking.*

**Keywords:** physical property, chemical type, groundwater, pH, hardness

### **1. Introduction**

Banjararum area is part of the developing Kulon Progo Regency. As activities in the area increase, the fulfillment of quality groundwater becomes important for the community. Therefore, a study of groundwater potential in this area needs to be developed.

The study of groundwater quality, involve its physical and chemical properties has been carried out in Banjararum area, Kalibawang District, Province of Special Region of Yogyakarta (Figure 1) [1]. The study area is included in Sendangagung Sheet, number 1408-232 according to Bakosurtanal published in 2001[2].

The study area is in Village Banjararum, District Kalibawang, West Progo Regency. This area is included in the eastern part of the West Progo Dome Physiographic zone [3]. The area usually does not considerable as groundwater basin but it still has enough water resources.

Beside its quantity, one of the important things in groundwater potential assessment is its quality. Groundwater quality can be reviewed from the chemical aspect. The quality of groundwater is

influenced by the geological conditions in an area, for example in terms of the type of rock [4]. This groundwater chemical aspect will support hydrogeological research of a region. Hydrogeological research has been developed in various regions to assist the society for their water supply. Water is a very vital and basic needs, so that it must be kept in sufficient quantity and good quality.



**Figure 1.** Research area in West Progo administration map [1].

One of the things that can be studied from groundwater chemistry is its physical and chemical properties of groundwater. The groundwater properties may vary in many regions. Furthermore, the contents of groundwater can be used to assess groundwater quality of a region. Therefore, the determination of groundwater properties becomes very important in hydrogeological work, especially in the hydrochemical field, as well as in human being needs.

The determination of the physical/chemical properties of groundwater is important in hydrogeological studies. It is also important for daily life. These physical / chemical characteristics usually assess as part of groundwater genetic understanding as well as studies of groundwater quality.

## 2. Methodology

The method of research was started by literature review, followed by field observation. The tools needed in this research are field geology tools, laboratory equipment and stationery for studio work. Field geology tools include, hammer, compass, camera, GPS, as well as stationery and sample bottles. Chemical laboratory work has been done at BBTKLP Yogyakarta. Meanwhile, studio work is done on campus using a set of computers and stationery.

Some properties of groundwater directly measured in the field from wells and springs, such as color, odor, taste and turbidity. Groundwater samples were taken from four locations in order to analyze at chemical laboratory, i.e. Ngipikrejo, Ngentak (Banjararum) and Kalisonggo (Pendoworejo).

Research materials which were equipped in the field are the geological map and topographic map scale of 1: 25.000. In addition, groundwater sampling need 1 liter bottle for each sample. Then, data analysis conducted by calculated some chemical properties in studio.

## 3. Geological of Research Area

The Banjararum region is included in the geological part of West Progo Dome [4]. This area consists of various rocks from the Nanggulan, Old Andesite, Sentolo and Jonggrangan Formations as well as Quaternary sediments of Merapi volcanic deposits of and coluvial rock from Old Andesite Formation.

The Nanggulan Formation is the oldest rocks formation exposed in eastern West Progo Dome, around Kalisonggo and Watupuru areas. The lithology is composed by sandstones with intercalation of lignite, sandstone, limonite limestone, marl and tuff sandstone containing fossils of foraminifera and mollusc [5].

The Old Andesite Formation is exposed in the center, north, west and southwest of West Progo High. It is deposited in a volcanic environment and composed of volcanic breccia, lava, lapilli breccia, lapilli tuff and volcanic sandstone. The dominant lithology consists of andesite breccia with a tuff matrix,

fragments comprising andesite pyroxene to hornblende andesite. It also revealed the intrusion of igneous rocks [4].

Jonggrangan Formation is composed by tuffaceous marl, calcareous sandstone with lignite intercalation that upwards turn into bedded limestone and reef limestone. The thickness of this formation is approximately 150 m, and unconformably lies above the Old Andesite Formation. This formation changed its facies with Sentolo Formation [5]. Sentolo Formation consists of limestone and marly limestone.

#### 4. Physical Properties of Groundwater

Groundwater quality in an area can be observed from its physical and chemical properties. The physical properties of groundwater appear in several variables such as color, odor, taste, temperature, viscosity and turbidity. This physical property should be tested to determine the feasibility of groundwater in its daily utilization.

- Color: caused by the presence of substances contained in groundwater, whether in the form of suspension or dissolved.
- Odor and taste: caused by a substance or gas that has an aroma contained in water. The taste is determined by the presence of salt or other substances whether it is suspended or dissolved.
- Viscosity: influenced by the particles contained therein.
- Turbidity: caused by substances contained but not soluble.
- Temperature: influenced by surrounding circumstances such as seasons, weather, day and night, place or location.

#### 5. Chemical Properties of Groundwater

The chemistry of groundwater can be seen from pH, Total Dissolved Solids (TDS) and the chemical composition contained in groundwater. Groundwater quality is also chemically required as a requirement for daily water classification.

- Hardness: caused by Ca and Mg contents. There are two kinds of hardness that is carbonate and non carbonate hardness.
- The amount of dissolved salt (TDS): the amount of salt concentration contained in water.
- Electrical conductivity: the conduct of electricity from water.
- Acidity: occurs because water as a solvent will dissolve all the substances present in it, both acidic, alkaline and neutral.
- The ion content of water consists of cations, anions, and metal ions. Important ions include  $\text{Na}^+$ ,  $\text{K}^+$ ,  $\text{Ca}^{2+}$ ,  $\text{Mg}^{2+}$ ,  $\text{Al}^{3+}$ ,  $\text{Fe}^{2+}$ ,  $\text{Fe}^{3+}$ ,  $\text{Mn}^{2+}$ ,  $\text{Cu}^{2+}$ ,  $\text{Zn}^{2+}$ ,  $\text{SO}_4^{2-}$ ,  $\text{H}_2\text{S}$ ,  $\text{F}^-$ ,  $\text{NH}_4^+$ ,  $\text{NO}_3^-$ ,  $\text{NO}_2^-$ ,  $\text{KMnO}_4$ ,  $\text{SiO}_2$ .

Some organic and inorganic solids, organic liquids and gases are found in groundwater [6]. The diversity of solutes in groundwater is common. The dissolved inorganic content is classified as a major component with a concentration  $> 5$  mg/l, a minor content with a concentration of  $< 0.01$  mg/l [7]. Groundwater analysis is generally conducted to determine major and minor components. Analysis of major components is useful for determining the type of groundwater chemistry.

Groundwater quality is an important consideration in the needs of everyday life. The need for clean water, especially for drinking water is an important thing fulfilled by water quality as required.

## 6. Result and Analysis

### 6.1. Field Data

Field observation showed physical properties of groundwater as clear / colorless, tasteless and odorless, with low turbidity one. Ten locations has been sampled and only groundwater in Ngipikrejo that showed less transparent, slightly smelly and slight turbid (Table 1; Figure 2).



**Figure 2.** Well in Ngipikrejo, Banjararum has less quality of groundwater.

**Table 1.** Field data of groundwater observation.

No.	Longitude	Latitude	Location	Gw. Occurrence	pH	TDS
1	110° 12' 51.3"	07° 42' 42.5"	Ngipikrejo / Banjararum	Well	7.2	73
2	110° 12' 41.8"	07° 43' 00.5"	Ngentak / Banjararum	Well	7	155
3	110° 12' 34.1"	07° 43' 22.7"	Ngentak / Banjararum	Spring	6.6	108
4	110° 12' 13.8"	07° 43' 25.5"	Sentul / Banjararum	Spring	6.7	132
5	110° 11' 43.8"	07° 43' 33.5"	Mejing / Banjararum	Spring	6.7	115
6	110° 12' 00.5"	07° 44' 15.2"	Degan 2 / Banjararum	Spring	6.8	73
7	110° 12' 38.5"	07° 44' 00.3"	Degan Banjararum	Spring	6.8	55
8	110° 12' 48.7"	07° 44' 02.2"	Kemesu / Banjararum	Well	6.9	68
9	110° 12' 52.8"	07° 44' 04.2"	Kemesu / Banjararum	Well	7	54
10	110° 11' 52.2"	07° 44' 22.5"	Kalisongo / Pendoworejo	Spring	6.8	85

## 6.2. Laboratory Data

Groundwater samples used for chemical laboratory analysis were taken in one well and three springs (Figure 3). The physical/chemical properties can be read in Table 2.



**Figure 3.** A well in Ngentak, Banjararum that has been sampled for chemical laboratory work.

## 7. Discussion

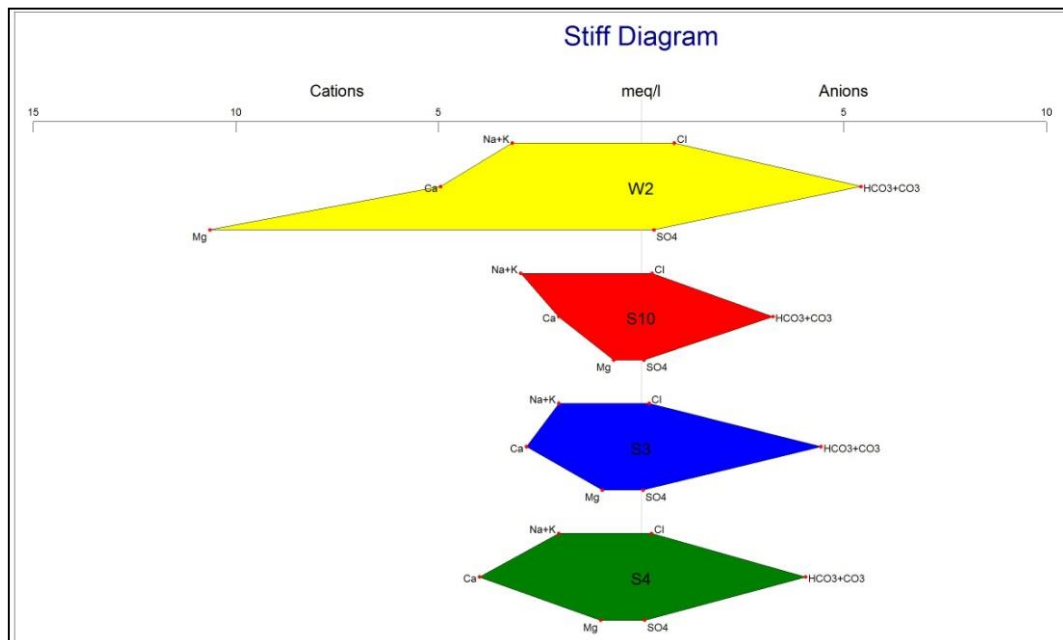
The West Progo area, although poor in water, has old rock formations such as OAF that can still function as aquifers even though their potential is small [8]. The higher potential should be gained because of more cracks or joints [9]. Field survey showed that the groundwater is generally colorless, tasteless, odorless, and not turbid. Anomaly occurs in the groundwater of the well at Ngipikrejo which showed the color that was less clear, tasteless, smelly and slightly turbid. The groundwater conditions are clear, tasteless and odorless and not turbid is a natural condition groundwater that has not experienced by contamination.

Chemical test results from four groundwater samples showed that groundwater from well W2, S3, S4 and S10 springs showed colorless, tasteless, odorless and non-turbid properties (turbidity  $\leq 3$  NTU), with normal temperature (25.2 °C). Nevertheless, laboratory test results showed that groundwater samples are hard water, with hardness of 135.866 - 778.048 (moderately hard - very hard) (Sawyer & McCarty, 1967 in [10]). A maximum TDS score of 379 ppm indicates that groundwater in the study area is in fresh water class (Carroll, 1962 in [10]).

W2 well with limestone aquifer have Ca, Mg - HCO<sub>3</sub> type of groundwater, whereas in S3, S4 and S10 springs with volcanic aquifer have type Ca - HCO<sub>3</sub> and Ca, Na - HCO<sub>3</sub> ones. The major ion content that supports the chemical type is shown in the Stiff diagram of Figure 4. The groundwater chemical type is produced from soil, mineral dissolution in sedimentary rocks as well as igneous rocks and the atmosphere through rainwater. The considerable content of NO<sub>3</sub> in Ngentak (W2 well) can occurred due to pollution from human activities, plant or animal dung. In general, groundwater in the study area is suitable for use as clean water or drinking water, characterized by a measurable pH in the field of 6.6 - 7.2 and TDS 54 - 155 ppm. But, a high degree of hardness in groundwater observed results in groundwater were not feasible for immediate drinking, but requires special treatment beforehand.

**Table 2.** Physical/chemical properties of groundwater samples.

No	Parameter	W2	S3	S4	S10
<b>PHYSICAL</b>					
1	Color	Colorless	Colorless	Colorless	Colorless
2	Odor	no	no	no	no
3	Taste	no	no	no	no
4	Turbidity (NTU)	3.00	1.00	1.00	1.00
5	Suhu (°C)	25.20	25.20	25.20	25.20
<b>CHEMICAL</b>					
1	Hardness	778.05	189.81	249.82	135.87
2	TDS (mg/l)	379.00	197.00	250.00	164.00
3	pH	6.60	5.80	6.30	6.00
4	Ion content (mg/l)				
	<b>Cation</b>				
	a Ca	99.20	56.80	80.00	40.80
	b Na	72.00	45.00	45.00	66.00
	c K	2.00	3.00	3.00	4.00
	d Mg	129.28	11.66	12.15	8.26
	e Fe	0.02	0.02	0.02	0.08
	f Mn	0.01	0.01	0.01	0.01
	g Zn	0.05	0.01	0.01	0.01
	<b>Anion</b>				
	a NO <sub>3</sub>	15.50	1.44	1.80	1.64
	b HCO <sub>3</sub>	330.50	270.40	247.40	198.30
	c SO <sub>4</sub>	15.00	2.00	4.00	3.00
	d Cl	28.80	6.90	8.90	9.40
	e SiO <sub>2</sub>	12.93	14.84	18.16	19.84
	<b>Chemical Type</b>	Ca, Mg - HCO <sub>3</sub>	Ca - HCO <sub>3</sub>	Ca - HCO <sub>3</sub>	Ca, Na - HCO <sub>3</sub>



**Figure 4.** Stiff diagram of groundwater samples in Banjararum area.

## 8. Conclusion

A study of the physical and chemical properties of groundwater in Banjararum has been conducted through field observations and water chemistry tests. The results of field survey and chemical analysis indicate that groundwater from both dug wells and springs is generally of good quality, characterized by transparent color, tasteless, odorless, not turbid in many places except at wells in Ngipikrejo and Ngentak. The type of groundwater chemistry developed as bicarbonate water with variation of cations (Ca-HCO<sub>3</sub>; Ca, Na-HCO<sub>3</sub> and Ca, Mg-HCO<sub>3</sub>). Groundwater chemistry properties in the form of pH and TDS showed good quality, but groundwater is generally hard. For that, special treatment is needed to reduce the hardness before the water is used as drinking water.

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