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Hydrogeology Potential of Hargorejo Area Kokap Subdistrict West Progo Regency

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ABSTRACT

This research is a hydrogeological survey activity with the aim to determine the geological characteristics of groundwater in the Hargorejo area, Kokap Sub-district, West Progo. The study wants to know about the pattern of groundwater flow and water quality in the area. The northern part of the research area is included in the non-groundwater basin region of the West Progo Dome, while the southern part is included in Wates Groundwater Basin. Method of research is a field hydrogeological survey, to obtain geological and groundwater data. Groundwater flow pattern and quality analyses are based on groundwater data and pH, TDS and EC values. Groundwater can be obtained from springs or dug wells, with relatively shallow groundwater tables. The pattern of groundwater flow is generally to the south, with the H4 / H5 basin boundary type. Groundwater quality is quite good, with a pH value of 6.2 -7; TDS 191 - 558 ppm, and EC ranges from 279-783 µS / cm.
Keywords : water resource, groundwater flow, groundwater quality.

ABSTRAK

Penelitian ini merupakan kegiatan survei hidrogeologi dengan tujuan untuk mengetahui karakteristik geologi airtanah daerah Hargorejo, Kecamatan Kokap, Kulon Progo, tentang pola aliran airtanah maupun kualitas air di daerah tersebut. Daerah penelitian bagian utara termasuk dalam wilayah non CAT Kubah Kubah Progo, sedangkan bagian selatan termasuk dalam CAT Wates. Metode penelitian berupa survei hidrogeologi lapangan, untuk memperoleh data geologi maupun airtanah. Analisis pola aliran dan kualitas airtanah dilakukan berdasarkan data muka airtanah dan nilai pH, TDS serta EC. Airtanah dapat diperoleh dari mataair maupun sumur gali, dengan muka airtanah yang relatif dangkal. Pola aliran airtanah pada umumnya ke selatan, dengan batas cekungan bertipe H4/H5. Kualitas airtanah cukup baik, dengan nilai pH 6,2 -7; TDS 191 – 558 ppm, dan EC berkisar 279-783 µS/cm.
Kata kunci: sumber daya air, pola aliran, kualitas, airtanah

1. INTRODUCTION

This hydrogeological study was conducted in Hargorejo and its vicinity, West Progo District, Yogyakarta (Figure 1). The study area is astronomically located at the coordinates 07^{0} 50' 15" - 07^{0} 53' 00" S and 110^{0} 5' 15 " - 110^{0} 7' 45" E. This is included in Bagelen, Wates, Temon dan Brosot Sheets, according to topographic map of Bakosurtanal published in 2001. This area includes some hamlets in Hargorejo Village and surrounding area near the village.

Most of the research areas occupy the West Progo Hills area. This hilly area is known as an area that has a landscape with quite steep to very steep reliefs, strongly dissected with relatively hard and compact rocks [1, 2]. The varied geomorphology of West Progo Hills can also be identified from remote sensing images [3]. Meanwhile, the rocks which consist these hills are dominated by Tertiary sedimentary rocks and igneous intrusions. Andesite intrusion can be found in various places, where its presence can also be detected from geophysics [4]. In addition, the geological structure in West Progo Hills is very intensive. In fact, hilly morphology may also be offset due to this geological structure [5]. Such complex geological conditions greatly determine the potential of water resources, especially groundwater.

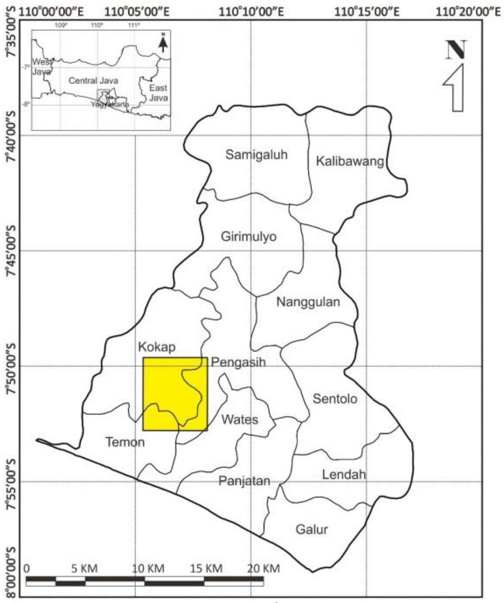


Figure 1. Location of research area.

The central to northern parts of the study area are part of the non-groundwater basin area [6]. Meanwhile, the southern part of the research area is included in the Wates Groundwater Basin. The study of water resources in the research area which is part of a different groundwater basin zone is interesting to be learned. The non-groundwater basin is difficult water area, so the water potential should be studied to understand the groundwater potential. Meanwhile, areas in the Wates Groundwater Basin generally have better potential, and allow receiving groundwater flow from the north area [7].

The purpose of this research is a field hydrogeological survey, with the aim of revealing the hydrogeological potential of the research area. This hydrogeological potential can be viewed from the flow pattern and groundwater quality. This information on hydrogeological conditions may be useful for the community in understanding of water resources in the local area.

2. METHOD

The research began with a study of libraries of the geological conditions of West Progo Dome and Central Depression Zone [1]. Furthermore, by knowing its regional physiography, the hydrogeological survey was held directly in the research area. Standard geological equipment (compass, hammer, loupe, GPS) were used and completed by topographic map of Bagelen, Wates, Temon dan Brosot sheets.

The hydrogeological observation has been carried out at 18 locations for knowing aquifers and groundwater conditions. The hydrogeological description in the field is focused on measuring of groundwater level and its quality data such as pH, total dissolved solid (TDS) and electrical conductivity (EC). The equipment used is the Hana brand which includes a pH-meter, TDS-meter and EC-meter.

Data analysis was started by generating groundwater table map. Description of natural resources was also collected as additional data. The hydrochemical map was generated by Arc GIS 10.3 software. These maps then become a consideration for determining the hydrogeological potential in the study area.

3. RESULT AND DISCUSSION

3.1 Geology of Hargorejo Area

3.1.1 Geomorphology

The research area generally occupies in the physiography of the West Progo Dome and Central Depression Zone of Java [1]. The morphology of Hargorejo and its vicinity area can be divided into 4 units based on Van Zuidam – Cancelado (1979) and Van Zuidam (1983), as described below (Figure 2) [8, 9].

a. Denudational hilly unit
b. Denudational rolling unit
c. Denudational undulating unit
d. Fluvial flat unit

One of morphological features can be shown in Figure 2.

Figure 2. Landform of fluvial flat unit at southern part of research area, east of Kedundang.

3.1.2 Stratigraphy

The study area is included in two Tertiary formations and Quaternary sediments [6]. The Tertiary formations include Old Andesite Formation (OAF) and Sentolo Formation (Figure 3). Old Andesite Formation composed by andesite breccias, lapilli tuff, tuff, lava flows and volcanic sandstone, Oligocene-Miocene age. Sentolo Formation is laid unconformably to the Old Andesite Formation. Its lithology composed of tuffaceous marl, limestone and calcareous sandstone.

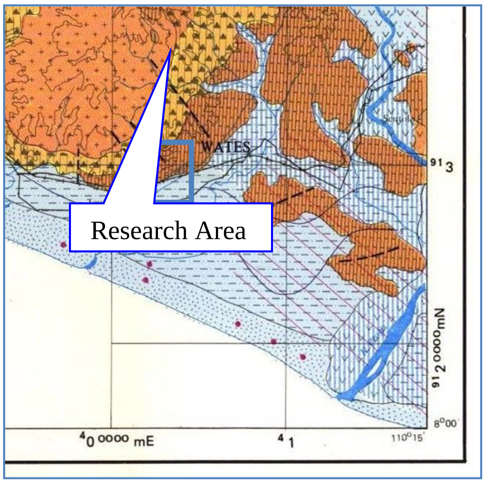
Stratigraphy of the research area can be divided into four units namely andesite breccia unit, andesite intrusion unit, calcareous claystone and sand-clay sediment units. Andesite breccia unit has the most widespread distribution and are found in central to north part of study area. Andesite intrusion unit is located in northwest end of study area. Calcareous claystone unit is scattered in the south part of study area. All of lithology units usually have poor – moderate quality of aquifer, except in alluvial/fluvial sediment.

3.1.3 Geological Structure

Geological structures of research area were strongly influenced by the dynamic processes in Oligocene - Miocene. The existing structures are joints and estimated fault. The fault is estimated as normal fault with relatively northwest-southeast direction. These geological structures strongly influence the aquifer characteristics especially in hilly physiographic zone.

3.1.4 Hydrogeology

The study area includes in two hydrogeological zone, there are non-basin area of the West Progo Hills and Wates groundwater basin [7]. The hydrogeological map is shown in Figure 4. This figure shows three aquifer zones in research area, namely extensive, moderately productive aquifers; poorly productive aquifers to local importance and regions without exploitable groundwater zones. Low productivity aquifers in north part area generally have groundwater potentials that are only beneficial to local residents near springs. The springs generally have small to medium discharge of water.



Legend:

	Aquifers in which flow is intergranular	Extensive, moderately productive aquifers	Low to moderate transmissivity aquifers. Groundwater table from near land surface to > 5 m depth; wells yield usually < 5 l/s.
	Aquifers (fissured or porous) of poor productivity	Poorly productive aquifers to local importance	Low to very low transmissivity aquifers. Locally small quantities of groundwater in valleys and weaathered zones.
		Regions without exploitable groundwater	

Figure 4. Research area in hydrogeological map [11].

The intergranular porosity of aquifer comes from Quaternary sediments of alluvial/fluvial deposits. These aquifers usually have moderately productivity, built by alluvial plain and river deposits, mainly composed of sands, gravels, silts and clays.

Soil in this area is quite fertile, while the water can be obtained from surface water or groundwater contained locally as a spring [12]. Springs can be appeared through soil or weathered zone of rocks. Colluvium deposit and weathered – medium weathered rock is commonly found as a good aquifer in West Progo Area [13].

3.2 Groundwater Resource

3.2.1 Groundwater Flow

Although West Progo Hills is a hard water region, groundwater may be found in shallow dug well or spring [14]. As shallow groundwater, the groundwater table is almost follows topographic relief [15]. It seems that landform or geomorphological aspects control groundwater condition in West Progo area [16].

Groundwater table has been measured from 18 dug wells (Table 1; Figure 5). The depth of groundwater in wells ranges from 0.62 to 12.68 m from the local land surface, meaning that it still includes shallow groundwater. Groundwater levels in the study area are at elevations of 13.4 - 276.2 above sea level (Figure 6).

Table 1. Groundwater table and hydrochemical data of dug well.

No	Location	Longitude	Latitude	Water table (m)	pH	TDS (mg/l)	EC (μS/cm)
1	Kaligayam, Kulur	7° 52' 57,31"	110° 06' 38,15"	28,74	6,2	558	783
2	Kaligayam, Kulur	7° 52' 12,99"	110° 06' 37,43"	26,17	6,2	426	642
3	Krengseng , Hargorejo	7° 52' 01,17"	110° 06' 48,43"	41,32	6,4	463	646
4	Krengseng, Hargorejo	7° 51' 44,84"	110° 07' 13,25"	55,53	6,7	326	448
5	Penggung, Hargorejo	7° 51' 14,78"	110° 07' 31,43"	103,7	6,4	432	612
6	Pandu, Hargorejo	7° 50' 39,94"	110° 07' 11,46"	144	6,3	328	455
7	Pandu, Hargorejo	7° 50' 31,50"	110° 06' 49,57"	191,38	6,5	367	513
8	Sambeng, Hargorejo	7° 50' 28,28"	110° 06' 22,77"	151,82	6,6	362	504
9	Sambeng, Hargorejo	7° 50' 27,98"	110° 06' 04,29"	101,63	6,5	270	450
10	Kukusan, Hargorejo	7° 50' 15,12"	110° 05' 17,13"	276,2	6,4	261	357
11	Ngaseman, Hargorejo	7° 50' 17,31"	110° 05' 54,45"	145,48	6,5	314	435
12	Sangkrek, Hargorejo	7° 50' 57,80"	110° 06' 0,24"	193,77	6,2	320	461
13	Tangkisan, Hargomulyo	7° 51' 07,45"	110° 05' 21,26"	97,43	6,5	276	382
14	Kliripan, Hargorejo	7° 51' 30,77"	110° 06' 56,53"	13,4	6,5	334	459
15	Selotimur, Hargorejo	7° 51' 40,19"	110° 06' 27,58"	41,48	6,6	311	427
16	Selobarat, Hargorejo	7° 51' 54,96"	110° 06' 10,56"	42,29	6,3	352	488
17	Setro, Kulur	7° 52' 12,33"	110° 06' 1,71"	37,19	6,5	313	369
18	Setro, Kulur	7° 52' 02,46"	110° 07' 32,64"	33,66	6,7	412	585

Figure 5. Dug well at Kukusan taps water from soil of andesite intrusion (left); dug well at Setro takes water from alluvial sediments (right).

Groundwater flow patterns in non groundwater area appears to develop in various directions, sometimes erratic, may scatter or converge. On the other hand, groundwater in Wates Basin usually flows to the south almost uniformly (Figure 6; Table 2).

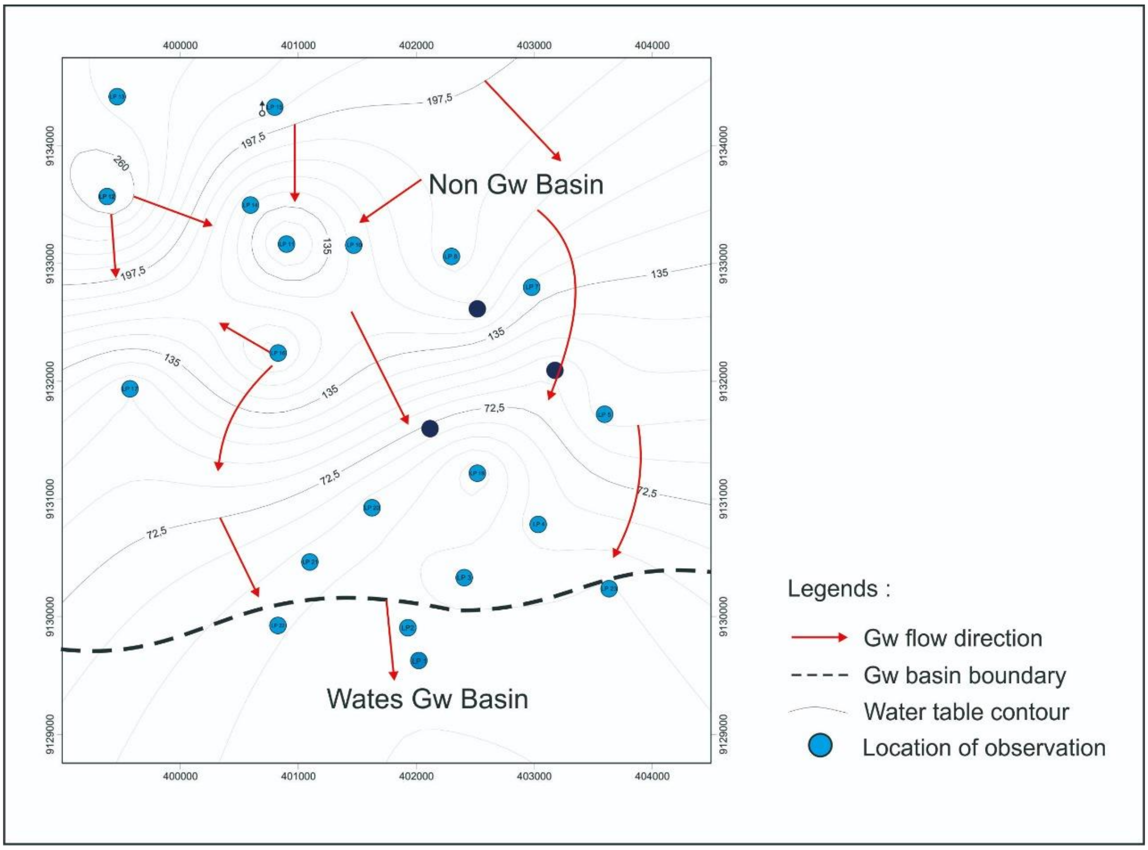


Figure 6. Groundwater table map of research area.

Table 2. Groundwater flow conditions of research area.

Research Area	Groundwater Basin	Groundwater Flow	
		Direction	Pattern
Midle –northern part	Non-basin	Developing in various directions; sometimes radially	Varies locally, spot by spot, usually controlled by the hill – valley morphology
Southern part	Wates Basin	Down the hilly slope to the south; towards a flatter morphology	Almost parallel, in line with the morphological slope which ramps down flat to the south

Groundwater flows in colluvial aquifer in non basin area [8], but it may be occur in almost weathered bed rocks through cracks porosity [14, 15]. The study area has a horizontal boundary type H4 (inflow boundary) and H5 (outflow boundary) (Figure 7). The H4 limit is the boundary of the groundwater basin with the direction of groundwater flow into the Wates groundwater basin. Meanwhile, the H5 limit is the boundary of the groundwater basin with the direction of groundwater flow out of the basin [8]. The groundwater flow is also supported by joints networks [17]. Cracks/fractures in rocks usually support groundwater flow by crack porosities, especially at the top of bed rocks.

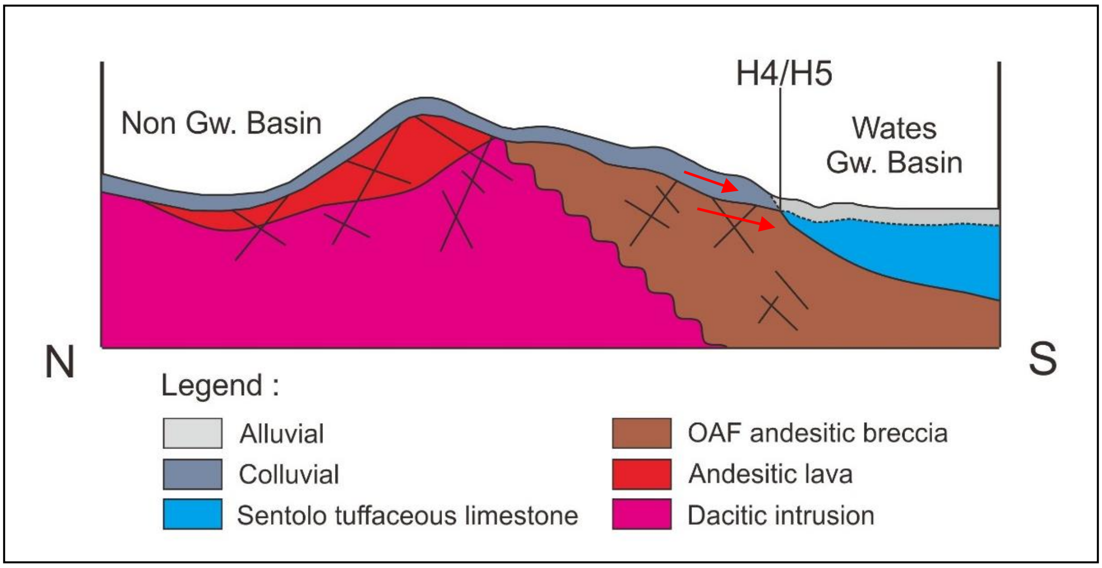


Figure 7. Horizontal boundary condition of groundwater in research area [8, 17].

3.2.2 Quality of Groundwater

Small quantity of surface water comes from tributaries of Serang River, flows from north to south of research area. The groundwater in Wates Basin is primarily provided by Quaternary sediments aquifers, sometimes depends on river water. The water usually moderate to good quality, even though it looks a little turbid which is caused by carbonate precipitation.

On the other hand, West Progo hills usually act as poor or moderate aquifers. Although there are small quantity of groundwater, in the field it is generally of good quality, showing a clear / colorless, tasteless and odorless, and clear.

3.2.2.1 Acidity or pH

The pH is a measure of the intensity of the water's acidity. All chemical and biological reactions in water are very pH dependent. The PH value of water determines the various types of geochemical equilibrium in water, for example in terms of the solubility of an element (Hem, 1985 in [18]).

The pH value of groundwater and surface water in the study area ranges from 6.2-7, meaning that the acidity of the water is relatively normal or slightly acidic. However, because of the pH <6.5, there are several wells, river and spring that have water that does not qualify the requirement of drinking water quality standard. Furthermore, the pH iso map is given in Figure 8.

The weakly acidic to neutral groundwater shows that dissolved carbonate mostly in the form of HCO_3 (Adams *et al*, 2001 in [19]). Precipitaton usually strongly support this quality of groundwater.

Groundwater with fairly low acidity (<6.5) is apparently spread in various types of aquifers. This indicates that all types of aquifer rocks potentially produce relatively acidic groundwater, or the acidity aspect is supported by local rainfall.

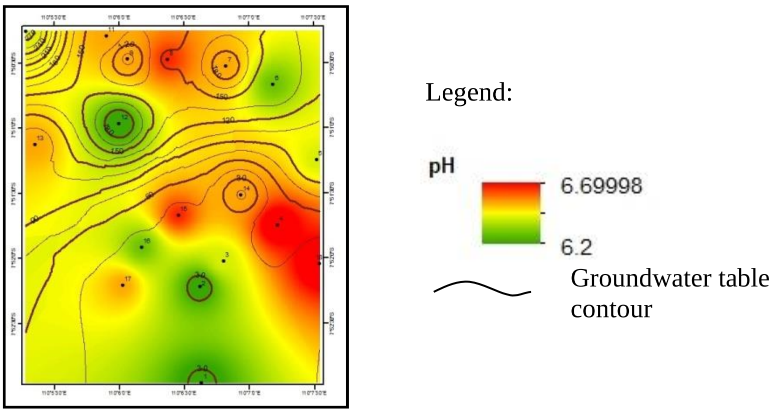


Figure 8. Iso-pH map of groundwater in research area.

3.2.2.2 Total Dissolved Solids (TDS)

The TDS value shows the amount of solid dissolved in water. This amount of solids can be used as a consideration for the suitability of drinking water. Davis & De Wiest (1966, in [18]) stated that TDS <500 mg/L indicates desirable for drinking water type. Water with TDS 500 - 100 mg/L is permissible for drinking water type.

The TDS values of water of research area ranged from 191 - 558 ppm. All water samples meet the requirements as drinking water according to standards [20], except one well in Kaligayam. However, all the water is still fresh water (Carrol, 1962, in [21]). The iso -TDS map is given in Figure 9.

3.2.2.3 Electrical Conductivity (EC)

Electrical conductivity is a measure of water capacity in terms of carrying electric current. A high ec value can occur because of the high salt composition in groundwater. Water with low salt content usually has a value of EC <1500 µS/cm.

All groundwater samples show low salt water type. The EC water value shows a range of 279-783 µS / cm. The EC value is usually positively correlated with the TDS value, so that if the water has a TDS that qualifies the requirements of drinking water, the EC value will be in accordance with the standard. The iso-EC map of groundwater is given in Figure 10.

Fairly high TDS and EC values were found in the western and southeastern parts of the study area, especially in Kaligayam, Kulur Village. This may be related to the flow direction that is getting longer and closer to the Wates basin area. It also perhaps due to contaminant supply from the Serang tributary or the effect of household disposal.

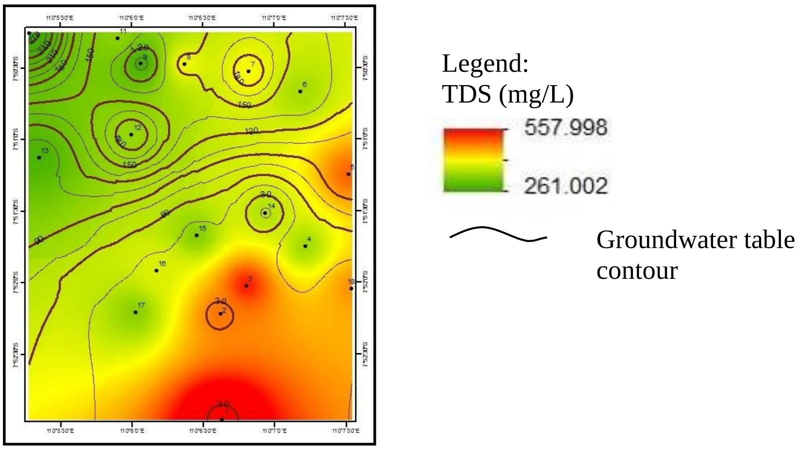


Figure 9. Iso-TDS map of groundwater in research area.

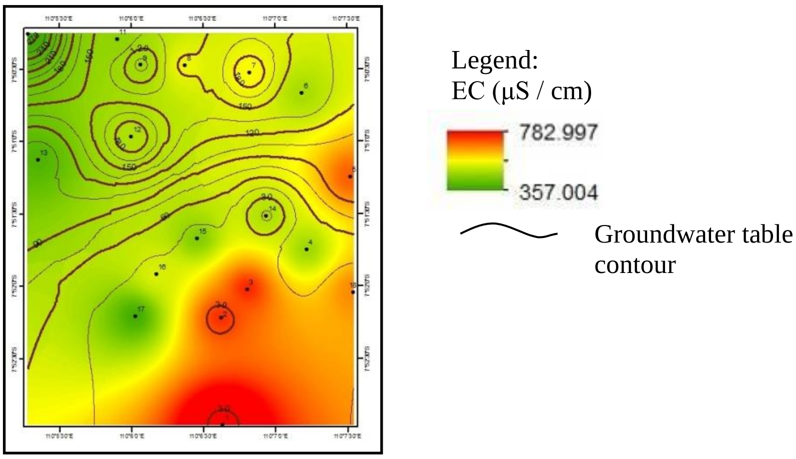


Figure 10. Iso-EC map of groundwater in research area.

4. CONCLUSION

The middle to north part is a part of the physiography of the West Progo Dome, where this area is a non groundwater area. The southern region is part of the physiographic zone of central depression or graben Yogyakarta. The diversity of physiography provides a variety of hydrogeological conditions in the study area. Water resources are obtained from rivers, springs or dug wells that are scattered in many places. Groundwater aquifers are formed by rocks from the Old Andesite Formation, Sentolo Formation and alluvial deposits.

Groundwater potential is not good in the northern part of the study area, but is quite good in the southern part, especially in alluvial deposits. Groundwater generally flows southward, from hilly areas to Wates Groundwater Basin, with horizontal boundary conditions H4/H5. The quality of groundwater is relatively good, some locations show groundwater that can be used as drinking water, although the pH in some locations is slightly more acidic. The pH value of water in the study area ranged from 6.2 to 7; TDS 191 - 558 ppm, EC ranges from 279-783 μS / cm.

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