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Research Article

Aquifer characteristics and groundwater potential for domestic requirements in Kediri Regency, Indonesia

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Abstract

Like other natural resources, groundwater is also being exploited at an increasing rate, especially for domestic requirements. Groundwater is preferred as a domestic water source because of its continuous availability and relatively good quality. Unfortunately, not all places have sufficient groundwater availability of good quality. The purpose of this study was to analyze the characteristics of the aquifer in the study area and evaluate its groundwater potential for domestic needs. Aquifer characteristics were determined based on geological and geomorphological conditions, while groundwater potential was calculated using a static approach. The results showed that the characteristics of the aquifers in Kediri Regency are various. In the eastern and central parts of the study area, the characteristics of the aquifer can be in the form of unconfined aquifers with high productivity. In the western part, most of them have non-aquifer material, so it is difficult to find groundwater. Groundwater generally fills joints and diaclase formed in andesitic lava with low discharge. Although the conditions of the aquifer are various, in general, the potential for groundwater in Kediri Regency can still support its requirements because the potential for groundwater in Kediri Regency is 71,121,313,394 m^3, while domestic requirement is 52,348,490 m^3/year.

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Introduction

Water is one of the most important natural resources for humans and other living things. Without water, there is no life on this earth. Unfortunately, not all places have sufficient water availability in terms of quantity, quality and distribution (Purnama, 2020; Salamah et al., 2020; Isa and Purnama, 2021; Nugrahaeni et al., 2021). Of all types of water, groundwater is still a source of water for domestic requirements (Berg et al., 2007; Kura et al., 2013; Islam et al., 2017; Vijakanth et al., 2017; Khan and Qureshi, 2018; Belkhiri et al., 2020; Thyagarajan et al., 2021). One of the reasons is that groundwater is more dispersed than other types of freshwater (Patra et al., 2018; Purnama, 2020; Wandari et al., 2020). At present, groundwater contributes around 34% of the total annual water supply and is an important freshwater resource in the world (Genet, 2017). Besides domestic use, groundwater is also a source of water for agricultural and industrial requirements. In general, 38% of irrigation requirements depend on groundwater (Siebert et al., 2010). In fact, a quarter of irrigation water requirements are sourced from groundwater, of which 75% is in Asia (Shah et al., 2007).

It can be said that groundwater is the main source of water for human activities taken from the earth (Purnama et al., 2021). As a result, from time to time, groundwater exploitation increases along with the progress of civilization (Senanayake et al., 2016; Purnama, 2019). If there is no balance between extraction and recharge, various problems can occur, such as a decrease in the groundwater level (Zhou and Li, 2011; Konikow, 2015; Abdullahi et al., 2016; Kalhor et al., 2019; Kadam, 2020).

Based on its geomorphology, Kediri Regency is formed from volcanic and fluvial processes. The western part is formed by the volcanic process of Wilis Volcano, while the eastern part is formed by the volcanic process of Kelud Volcano and Anjasmara Volcano. The middle region is the result of fluvial processes from the Brantas River. Geologically, the characteristics of Kediri Regency area can be classified into three parts, i.e., the western part of the Brantas River, which is the hilly slopes of Wilis Volcano and Klotok Hill, the middle part, which is a very fertile lowland that is passed by the Brantas River which stretches from south to north of the region. Kediri Regency and the eastern part of the Brantas River are infertile hills that stretch from Mount Argowayang in the north and Kelud Volcano in the south. Based on its area, the alluvium formation or river sediment in the center of the study area is the dominant formation because the study area is crossed by several rivers, both large rivers such as the Brantas River and other small rivers. The alluvium formation is a Holocene age formation. This formation consists of river and swamp deposits, gravel, silt, and clay. With varying geomorphological and geological conditions, it is possible that variations in groundwater conditions will occur, so this study aimed to analyze the characteristics of the aquifer in the study area and evaluate the groundwater potential for domestic needs.

Materials and Methods

Study area

The study location covers the entire area of Kediri Regency, East Java Province. Overall, the study sites consist of 26 sub-districts which are divided into 344 villages. The area of Kediri Regency is 1,386.05 km². The total population of Kediri Regency is 1,635,294 inhabitants. Physiographically, it occupies the slopes of the Wilis Volcano in the western part, the Kelud and Anjasmara volcanoes in the eastern part and the alluvial plain formed by the fluvial process of the Brantas River in the middle part of Kediri Regency.

Determination of groundwater characteristics and potential

The depth of the groundwater table was known through direct measurements of dug wells scattered in the study area. Measurements of water table depth were carried out at 56 sample wells (Figure 1).

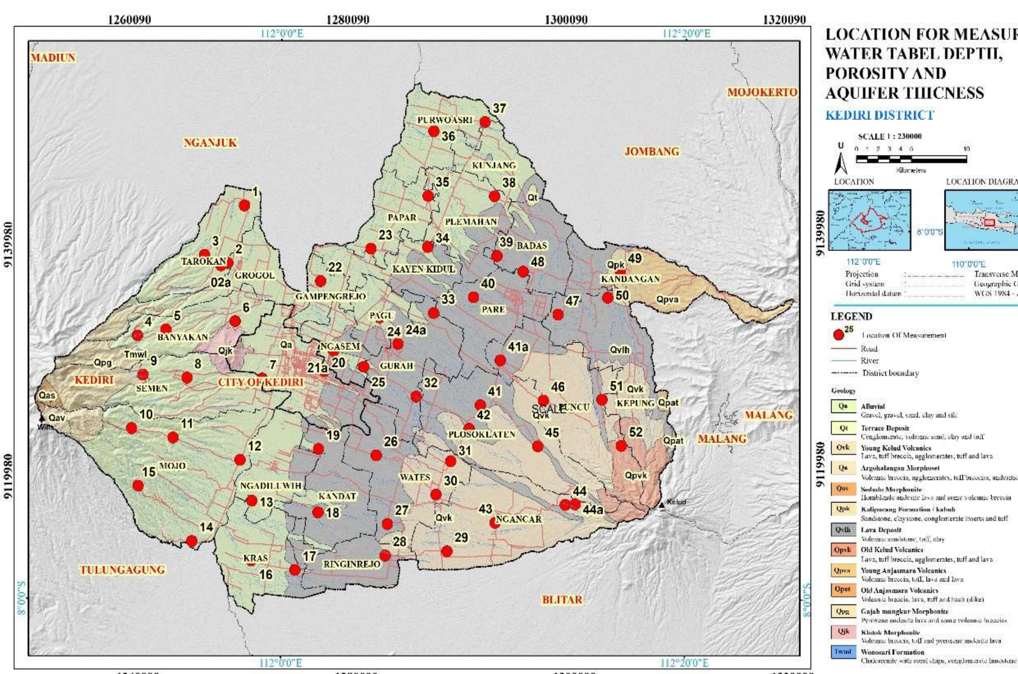

Figure 1. Locations for measuring water table depth and geosonar (porosity and aquifer thickness).

The determination of the porosity value was carried out by geosonar measurements at the same point as the measurement of the depth of the groundwater table (56 points). Geosonar is an active geophysical method that uses sonar to detect rock material and water in the earth. The determination of geosonar porosity is based on the ability of the material to propagate sonar waves. Geosonar scans so that the boundaries between layers are recorded in sufficient detail and can be read directly with the depth and porosity values. Rock type analysis was based on rock porosity values based on the results of studies conducted by Petrov et al. (2005), Giberti et al. (2006), Hemmings et al. (2015) and Jasim et al. (2019). An example of geosonar measurement results and their interpretation are presented in Figure 2.

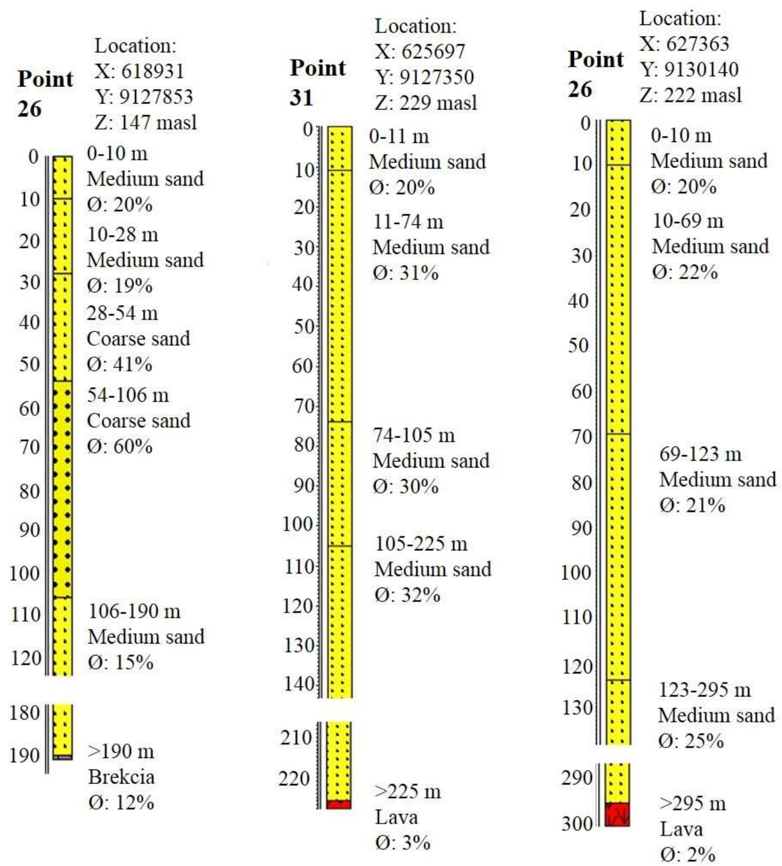

Figure 2. An example of geosonar measurement results and their interpretation in this study.

Aquifer characteristics were also determined based on geological and geomorphological conditions through analysis of Geological Maps, Hydrogeological Maps and Sounding Data. Groundwater potential is calculated using a static approach using equation 1.

Vat = Sy x Vak …………………(1)

where: Vat is the volume of groundwater that can be abstracted from the aquifer, Sy is the specific yield or percentage of water that can be released from the aquifer, and Vak is the volume of the aquifer (Todd and Mays, 2005; Fetter, 2018; Davie and Quinn, 2019).

Determination of domestic water requirements

Domestic water requirements in Kediri Regency were calculated based on the population, which was the result of multiplying the number of rural/urban residents with the standard of water requirements in rural/urban areas. The standard water requirement used is 60 liters/person/day for rural areas and 120 liters/person/day for urban areas. The criteria for rural and urban areas were determined based on published data from the Central Bureau of Statistics Kediri Regency.

Results and Discussion

Rainfall as a source of groundwater

The main source of groundwater is rainfall; therefore, an analysis of regional rainfall is important. Regional rainfall analysis was carried out using the Isohyet Method at eight climatological stations in the Kediri Regency (Figure 3).

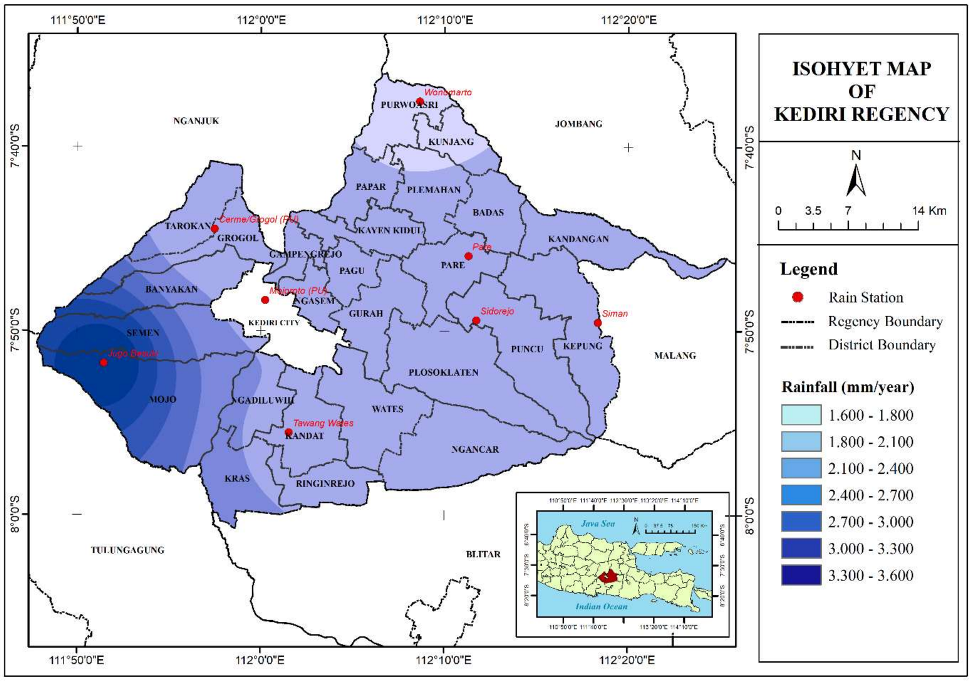

Figure 3. Isohyet map of the research area.

The results of the analysis show that areas with rainfall intervals of 1,800-2,100 mm/year are evenly distributed in Kediri Regency with a coverage area of 72.15% (Figure 3). The area with the highest rainfall, between 3,300-3,600 mm/year, only covers 3.19% of the total area of Kediri Regency, and the rain area is only on the slopes of Wilis Volcano. Taking into account the distribution of rain, the Wilis Volcano area should have a high groundwater potential.

Aquifer characteristics

Observing the Geological Map Sheet Kediri Scale 1: 100,000 published by the Center for Geological Research and Development (Santosa and Atmawinata, 1992), most materials make up the area of Kediri Regency are quaternary-aged materials derived from volcanic eruption materials and fluvial process materials. In addition, in some areas, carbonate rock outcrops of the Wonosari Formation were also found with a narrow area.

Observing the distribution of the area, the eastern part is composed of geological formations formed from the activity of the Kelud Volcano and the Anjasmara Volcano. These formations are the result of eruptions with properties that are not always the same, so they have different aquifer characteristics. Lava, andesite lava, tuff breccia, tuff, volcanic breccia, agglomerates, clays, and dikes are massive rocks that cannot function as aquifers, while volcanic lava, sand, gravel, and boulder are materials that would be good aquifers. The sound results show that the thickness of the aquifer in this area in some places can reach more than 200 meters. Taking into account the constituent materials, the aquifer that may be formed is an unconfined aquifer with bedrock that limits it at the bottom in the form of lava from a volcano.

The entire formation is the result of an eruption with various characteristics, each of which causes it to have different characteristics as groundwater aquifers. Materials such as lava, andesite lava, tuff breccia, tuff, volcanic breccia, agglomerates, clays and dikes are not aquifers, while materials such as laharic sediment and volcanic sand gravel are materials that will become good aquifers. Although known as eruptions that tend to be explosive, it turns out that Kelud Volcano often erupts effusively, so several rocks that characterize effusive eruptions are found, such as lava and andesite lava. However, in the last thousand years, it is estimated that Kelud Volcano produced explosive eruption materials (Brotopuspito and Wahyudi, 2007). This can be seen from the research results produced by previous studies that characterize explosive eruptions such as tuff, pyroclastic falls such as lapilli and lava deposits (Zaennudin et al., 2013).

The middle part is composed of material produced by river processes. The material is alluvial, consisting of gravel, boulder, sand, clay, and silt as well as terrace deposits composed of conglomerate, volcanic sand, clay, and tuff. Alluvial is a good aquifer constituent, while terrace sediment is not good because it is semi-impermeable or even impermeable. Sounding results show that the groundwater storage aquifer in the central part of Kediri Regency has a depth of almost 200 meters. The aquifer formed from the alluvial process shows several layers that cause differences in porosity and groundwater flow discharge. This material difference occurs because the material comes not only from the Brantas River but also from the tributaries of the rivers flowing past the location of each point. There is no material contained in this location that has the potential to become an impermeable layer, so it is most likely to produce a free aquifer.

In the west, the geological formations that make up this area are not good aquifer constituents. So although the rainfall in this area is relatively high, most of it will be a runoff. This condition will cause groundwater scarcity in several places in this region. This phenomenon occurs because not all formations are produced by Volcano Wilis. Klotok Morphonite is a separate unit formed by magma intrusion, which then comes out to form its own morphology. As a magma intrusion formation, the nature of the resulting rock is dominated by andesite lava and has non-aquifer properties. Figure 4 shows a geological cross-section in the western part of Kediri Regency contained in the Madiun Geological Map sheet with a scale of 1:100,000. The sounding results show that almost all points measured in the western part have non-aquifer material characteristics. The depth of the non-aquifer layers is very deep, making groundwater difficult to find. Even if groundwater is present, it generally fills the joint and diaclase formed in andesite lava with low discharge.

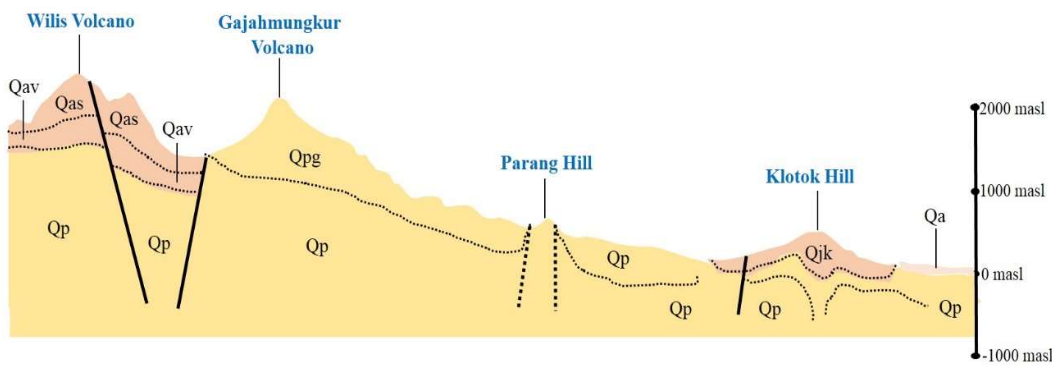

Figure 4. The geological cross-section in the western part shows the dominance of geological formations that do not have the potential to become groundwater aquifers. Qas is the Sedudo Morphonite (andesite lava, hornblende and a few volcanic breccias), Qjk is the Klotok Morphonite (volcanic breccia, tuff and andesite lava), Qa is quarter (holocene) alluvium (alluvial deposits from Brantas River), Qav is Argokalangan Morphocet (andesitic volcanic breccia, agglomerate, tuff, aglomeratic volcanic breccia, and lava) and Qp is Wilis Volcano morphonite (andesite lava and a few volcanic breccias). (Source: Geological Map Sheet Madiun).

Water table depth, porosity and aquifer thickness

The results showed that, in general, the depth of the water table in Kediri Regency could be divided into two parts: shallow in the middle and deep in the west and east. This phenomenon is caused by conditions in the west and the east, which have a mountain topography, while the middle has a lowland topography. In the lowland area around the Brantas River, the water table is also controlled by the elevation of the river surface. Even the very porous media in the eastern part of the study area creates a rather extreme groundwater level reaching 185 meters (Table 1). Most of the aquifers in the study area have a thickness of more than 40 meters or are classified as thick with varying porosity. However, some aquifers in the study area are in the form of fissures in lava or intrusive rocks that are cracked and weathered, so their productivity is not too high, and they have relatively low productivity. Besides that, many aquifers are in the form of fine sand material which has relatively low productivity. The thickness of the aquifer in Kelud Volcano ranges from 99-323 meters with material lavaric sediment and volcanic sand gravel, which is classified as an unconfined aquifer. The aquifer is classified as very thick, but at Kelud Volcano, there is no artesian aquifer layer because there is no impermeable layer. The results of aquifer thickness in other volcanoes in Java Island are quite different from the study location because they have impermeable layers and artesian aquifers. The conditions in Kelud Volcano are very different from other stratovolcanoes in Indonesia, which generally have an impermeable layer that forms a confined aquifer. The southeastern part of Merapi Volcano has an aquifer thickness ranging from 40-50 meters and has a depressed aquifer layer found at a depth of 65-75 meters (Selles, 2014; 2015), while in the southern part of the aquifer of Merapi Volcano there is no extensive impermeable layer but was found in several locations, which gave rise to artesian springs. This southern part of the Merapi Volcano aquifer has a thickness ranging from 80-150 meters (Hendrayana et al., 2020). The thickness of aquifers in other stratovolcanoes in Indonesia, for example, at Mount Bromo-Tengger ranges from 0-60 meters which is an unconfined aquifer and at a depth of more than 100 meters is a depressed aquifer (Hendrayana et al., 2021a).

Table 1. Water table depth, porosity and aquifer thickness.

Samples Number	Water Table Depth (m)	Porosity (%)	Aquifer Thickness (m)
1	2	46	109
2	7	18	128
3	10	17	63
4	12	4	112 (Crevice Aquifer)
5	10	30	26 (Crevice Aquifer)
6	10	41	271 (Crevice Aquifer)
7	7	0.13	Non Aquifer
8	5	45	149
9	10	10	71
10	5	2	110 (Crevice Aquifer)
11	31	0.6	120 (Crevice Aquifer)
12	12	0.8	159 (Crevice Aquifer)
13	12	12	127
14	3	45	135
15	7	20	116
16	15	42	250
17	10	17	170
18	10	11	181
19	7	10	139
20	7	10	185
21	8	36	143
22	3	3	110
23	5	18	176
24	3	45	193
25	7	19	166
26	7	8	128
27	7	49	140
28	10	19	180
29	8	31	233
30	10	0.10	210
31	10	70	131
32	10	39	211
33	11	31	214
34	10	79	280
35	11	20	135
36	9	1	265
37	3	19	199
38	10	28	215
39	5	20	176
40	2	40	217
41	8	11	118
42	5	1	186
43	2	10	221
44	7	7	186
45	10	22	285
46	27	20	193
47	73	48	71
48	185	43	384
49	37	32	353
50	25	37	293
51	8	20	165
52	5	10	235
53	10	9	106
54	7	1	139
55	23	47	168
56	10	42	177

Sources: Interpretation of Geosonar Data (2022), Petrov et al. (2005), Giberti et al. (2006), Hemmings et al. (2015) and Jasim et al. (2019).

The aquifer at Mount Bromo-Tenggerr is impermeable and contains at least 11 artesian springs and 461 artesian wells (Toulier, 2019ab). An impermeable layer is also found in aquifers in the Arjuno-Welirang Volcano. The thickness of the aquifer in Arjuno-Welirang Volcano has variations in the thickness of shallow aquifers ranging from 30-50 meters (Kusumayudha et al., 2021), and has an impermeable layer, which can be seen from the appearance of several artesian wells and artesian springs, as well as the number of deep wells that used for industries that penetrate the impermeable layer (Baud et al., 2021). Other analysis results, for example, the depth of the aquifer in Salak Volcano, obtained a depth ranging from 30-80 meters with an impermeable layer and artesian springs (Dumont et al., 2021).

The average depth of the groundwater table on the middle to the lower slopes of Kelud Volcano is 2-31 meters which is classified as shallow and moderate. However, on the upper slopes, the depth of the groundwater table can be up to 100 meters. This pattern is similar to the results of hydrogeological mapping in Karang Volcano, Banten, which shows groundwater levels that are generally shallow to moderate on the middle to lower slopes and deep groundwater levels on the upper slopes (Cahyadi et al., 2019). Other groundwater depths in strato volcanoes in Indonesia also have a similar pattern of distribution of depth values. The southeastern part of Merapi Volcano has a groundwater level ranging from 5-43 meters (Selles, 2014), while the southern part of Merapi Volcano has a lower groundwater level ranging from 1-15 meters (Hendrayana et al., 2021b). The same depth of groundwater level is also found in the Arjuno-Welirang Volcano, with a depth ranging from 1-36 meters (Baud et al., 2021; Kusumayudha et al., 2021). The same pattern of groundwater table depth is also found in Mount Bromo Tengger, ranging from 2-40 meters (Toulier et al., 2019a). The results of measurements of the same groundwater level were also obtained at Volcano Salak in the range of 2-30 meters (Dumont et al., 2021).

The porosity results at the Kelud Volkano ranged from 10-40%. The same pattern is also found in other volcanoes on the island of Java. The same porosity results are also found in the southeast of Merapi Volcano, ranging from 20-40% (Selles, 2014) with materials in the form of lava, pyroclastic deposits (surge, flow, block, and ash flow), and tephra. The same porosity results were also obtained at the Bromo-Tengger Volcano of 30% (Toulier, 2019b) with materials in the form of lava, lavaric material, and tuff. The same porosity results were also obtained at Mount Salak of 35% (Wibowo et al., 2019) with materials in the form of tuff, lava, lavaric material, volcanic breccia, and lapilli. The same porosity results were also obtained at Arjuno Welirang Volcano of 7-50%. The results were approached from the equation (Rouwet et al., 2019) of tuff and lava materials. The porosity of the study site has the same characteristics as other volcanoes on the island of Java. This result is also strengthened by the porosity in tropical areas, which have the same values as Hawaii (30-60%), Fefe Guadeloupe (30-59%), Merapi Volcano (33-45%) (Toulier, 2019). The specific yield at Kelud Volcano is around 17-26%. The same pattern is also found in other volcanoes on the island of Java. The specific yield in the southeast of Merapi Volcano is around 20% (Putra et al., 2015). The same specific yield results were also obtained at the Bromo-Tengger Volcano of 25-48% (Toulier, 2019b). These results were approached from the equation (Rouwet et al., 2019) of tuff and lava materials. The same specific yield results were also obtained in the Volcano Salak by 20% (Wibowo et al., 2019). These results show that the study area has the same specific yield pattern on volcanoes on Java Island.

The results of the comparison of groundwater potential with water needs in the study location are still being met. This is because the potential for groundwater is greater than the need for water. The same results were also obtained in Merapi Volcano where the potential value for groundwater is greater than the water demand (Hendrayana et al., 2020). Similar results are also found in the Bromo-Tengger Volcano, which has a higher groundwater potential in shallow and depressed aquifers compared to water requirements (Hendrayana et al., 2021a). The same results were also obtained in Arjuno Welirang Volcano, which has a large groundwater potential compared to utilization by domestic and industrial needs (Subekti, 2012; Baud et al., 2021). The same results were also obtained in Salak Volcano for the potential for groundwater to be greater than the water demand (Waspodo, 2015; Wibowo et al., 2019).

Aquifer productivity

The materials that constitute the aquifer with high productivity in Kediri Regency are gravel, boulder, coarse-grained sand and medium-grained sand, while the aquifer-forming material with medium potential is fine-grained sand. This is in accordance with previous research, which states that groundwater occurs in different geological formations and topography; the factors mostly control its distribution (Rushton, 2004; Genet, 2017; Purnama et al., 2021). Aquifers with low productivity are lava material or breakthrough rock that has undergone weathering and cracking so an aquifer is formed through rock crevices, which is referred to as a crevice aquifer. East Wilis, Morphonite Sedudo, Klotok Hill and intrusive rocks of Parang Hill.

Referring to the Hydrogeological Map of Kediri Regency, Scale 1: 230,000, the aquifer productivity in Kediri Regency is divided into 7 types, namely (1) crevice aquifers, groundwater scarcity, (2) productive local aquifers with crevice and inter-grain space, (3) medium productivity aquifers, wide distribution with crevice and inter-grain space, (4) medium productivity aquifers with wide distribution with inter-grain space,

(5) productive aquifers with wide distribution with inter-grain space, (6) high productivity aquifers with wide distribution with crevice and inter-grain spaces and (7) aquifers high productivity wide distribution with inter-grain spaces (Table 2). High productivity aquifers, are widely distributed, with inter-grain space occupying the largest area, reaching 28.95%, followed by medium productivity aquifers, with wide distribution with crevice and inter-grain spaces with an area of 25.54%. High productivity aquifers, wide distribution with crevices, and inter-grain spaces occupy an area of 20.03%.

Groundwater potential

The calculation results show that the static groundwater potential in Kediri Regency is 71,121,313,394 m^3 (Table 3). The amount of groundwater potential in Table 3 is a static potential that is considered to be taken in one year. Plosoklaten District has the highest groundwater potential of 8,106,250,202 m^3, while Banyakan District has the lowest groundwater potential of 6,213 m^3. In general, the area does have a major influence on groundwater potential, but not always areas with large areas have high groundwater potentials, such as in the Banyakan and Mojo Districts. The influence of aquifer-composing materials on groundwater potential in the study area appears to be very high. Areas with relatively impermeable aquifer materials have low groundwater potential, such as in Banyakan District. Banyakan District has aquifer-forming materials in the form of a crevice in andesite rocks produced by Klotok Hill and the intrusion of Parang Hill. This causes the potential of groundwater in the district to be very low.

Domestic water requirements

The calculation of domestic water requirements is distinguished based on the place of residence of the population, namely rural and urban. Actually, the number of rural and urban residents in Kediri Regency is not so different, i.e., 880,246 people in rural areas and 755,048 people in urban areas or only a difference of 125,198 people, but the water requirements in urban areas is much larger, with a difference of almost double the requirements rural water. The calculation results show that the water requirements for rural domestic requirements is 19,277,387 m^3/year, while the water requirements for urban domestic needs is 33,071,102 m^3/year (Table 4). This is due to the requirements for water per individual community in urban areas being higher than in rural areas. Furthermore, by looking again at Table 4, it can be seen that the total water requirements for domestic requirements in Kediri Regency is 52,348,490 m^3/year, with the highest water requirements in Pare District at 4,235,263 m^3/year and the lowest in Ngancar District at 1,104,045 m^3/year. If the data on domestic water requirements are linked to its potential, then the potential for groundwater in Kediri Regency can still support its requirements. It is known that the potential for groundwater in Kediri Regency is 71,121,313,394 m^3, while the domestic requirement is 52,348,490 m^3/year.

Table 2. Distribution of aquifer productivity, transmissibility and discharge in Kediri Regency.

No	Aquifer Productivity	Transmissibility	Discharge	Spatial Distribution
1	Crevice aquifers, groundwater scarcity	Low	Scarce	Top until the upper slopes of Kelud Volcano in the west and the slopes of Wilis Volcano in the east
2	Productive local aquifers with crevice and inter-grain space	Low-medium	Very low	Upper slope of Kelud and Wilis Volcanoes
3	Medium productivity aquifers, wide distribution with crevice and inter-grain space	Low-Medium	<5 liter/sec	Lower slopes of Kelud and Wilis Volcanoes
4	Medium productivity aquifers with wide distribution with inter-grain space	Medium	<5 liter/sec	Lower slope of the Southern Volcano of Wilis
5	Productive aquifers with wide distribution with inter-grain space	Medium	5-10 liter/sec	Alluvial plain of Wilis
6	High productivity aquifers with wide distribution with crevice and inter-grain space	Low-high	5-10 liter/sec	Lower slope of Kelud Volcano
7	High productivity aquifers wide distribution with inter-grain space	Medium-high	>10 liter/sec	Alluvial plain along the Brantas River

Sources: Hydrogeological Map and results of analysis and re-delineation.

Table 3. Groundwater potential in District in Kediri Regency.

No	District	Area (m^2)	Aquifer Thickness (m)	Specific Yield (%)	Groundwater Potential (m^3)
1	Kandangan	64,457,386.14	323.00	26.85	5,590,851,584
2	Kepung	90,095,599.46	228.50	26.93	5,543,021,182
3	Puncu	94,907,064.81	212.67	26.96	5,442,445,451
4	Ngancar	101,074,086.46	194.75	26.89	5,292,545,204
5	Kayen Kidul	41,283,230.30	229.00	25.88	2,446,590,837
6	Plemahan	50,881,468.26	199.75	26.52	2,694,984,879
7	Pare	49,676,701.36	168.50	26.86	2,248,171,880
8	Badas	42,621,652.82	190.00	26.98	2,185,162,504
9	Gurah	54,012,621.25	170.75	25.77	2,376,528,247
10	Plosoklaten	108,172,650.34	284.75	26.32	8,106,250,202
11	Wates	73,479,813.75	209.50	26.56	4,089,069,321
12	Kras	53,445,242.55	162.00	26.87	2,326,203,887
13	Grogol	47,079,961.80	122.33	24.33	1,401,326,567
14	Gampengrejo	18,344,119.58	153.50	26.69	751,642,589
15	Pagu	26,238,167.39	208.00	25.92	1,414,567,867
16	Ngasem	23,317,730.27	131.00	26.26	802,084,336
17	Semen	88,087,036.98	110.00	17.99	1,742,761,833
18	Ngadiluwih	43,007,997.28	149.00	23.64	1,514,755,210
19	Kandat	53,928,712.40	178.75	26.07	2,513,393,495
20	Tarokan	47,870,583.21	103.00	18.25	899,759,096
21	Banyakan	62758,490.03	99.00	0.01	6,213
22	Mojo	141.516,445.00	154.40	17.44	3,811,409,920
23	Ringinrejo	38,036,084.95	180.50	26.55	1,822,774,825
24	Purwoasri	45,293,393.79	195.50	26.73	2,367,256,592
25	Kunjang	31,679,107.65	196.50	26.76	1,665,789,751
26	Papar	36,196,271.28	219.00	26.14	2,071,959,924
Total of Groundwater Potential of Kediri Regency (m^3)					71,121,313,394

Table 4. Domestic water requirements in each district in Kediri Regency.

District	Population Number			Water Requirements (m^3/year)		
	Rural	Urban	Total	Rural	Urban	Total
Mojo	56,584	23,033	79,617	1,239,189.6	1,008,845.4	2,248,035
Semen	29,633	25,109	54,742	648,962.7	1,099,774.2	1,748,737
Ngadiluwih	7,737	72,287	80,024	169,440.3	3,166,170.6	3,335,611
Kras	43,739	18,877	62,616	957,884.1	826,812.6	1,784,697
Ringinrejo	43,290	13,616	56,906	94,805.1	596,380.8	1,544,432
Kandat	39,574	22,707	62,281	866,670.6	994,566.6	1,861,237
Wates	60,678	30,094	90,772	1,328,848.2	1,318,117.2	2,646,965
Ngancar	50,413	0	50,413	1,104,044.7	0	1,104,045
Plosoklaten	55,907	18,377	74,284	1,224,363.3	804,912.6	2,029,276
Gurah	41,391	41,182	82,573	906,462.9	1,803,771.6	2,710,234
Puncu	55,794	7,865	63,659	1,221,888.6	344,487.0	1,566,376
Kepung	44,815	40,625	85,440	981,448.5	1,779,375.0	2,760,823
Kandangan	22,285	29,398	51,683	488,041.5	1,287,632.4	1,775,674
Pare	18,623	87,384	106,007	407,843.7	3,827,419.2	4,235,263
Badas	17,351	49,935	67,286	379,986.9	2,187,153.0	2,567,140
Kunjang	22,887	13,878	36,765	501,225.3	607,856.4	1,109,082
Plemahan	53,774	6,881	60,655	1,177,650.6	301,387.8	1,479,039
Purwoasri	48,704	10,261	58,965	1,066,617.6	449,431.8	1,516,049
Papar	0	52,400	52,400	0	2,295,120.0	2,295,120
Pagu	24,292	15,886	40,178	531,994.8	695,806.8	1,227,802
Kayen Kidul	35,363	11,787	47,150	774,449.7	516,270.6	1,290,720
Gampengrejo	16,061	19,467	35,528	351,735.9	852,654.6	1,204,390
Ngasem	4,499	62,475	66,974	98,528.1	2,736,405.0	2,834,933
Banyakan	38,183	20,342	58,525	836,207.7	890,979.6	1,727,187
Grogol	9,041	38,487	47,528	197,997.9	1,685,730.6	1,883,728
Tarokan	39,628	22,695	62,323	867,853.2	994,041.0	1,861,894
Total	880,246	755,048	1,635,294	19,277,387.4	33,071,102.4	52,348,490

Conclusion

Landform Genesis in Kediri Regency is very influential on groundwater potential. The eastern part is dominated by explosive eruptions, which produce very good and thick aquifer-forming materials with high groundwater potential. The middle part is composed of material produced by river processes in the form of alluvial, which is composed of gravel, boulder, sand, clay and mud, and terrace deposits are composed of conglomerate, volcanic sand, clay and tuff. The depth is almost 200 meters, and there is no material found at this location that has the potential to become an impermeable layer, so it is likely to produce unconfined aquifers. The western part is dominated by effusive volcanic eruptions with non-aquifer material characteristics. Groundwater generally fills the crevice formed in andesitic lava and boulders with low discharge. Groundwater potential in Kediri Regency is 71,121,313,394 m^3. Based on its requirements, the total water requirements for domestic requirements in Kediri Regency is 52,348,490 m^3/year. Based on this calculation, the groundwater potential in Kediri Regency can still support its requirements.

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