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The Potential of Recharge Area Based on the Permilabilty and Infiltration Rock Test in the Southern Flank of Mount Merapi, Yogyakarta Indonesia

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Abstract: Groundwater basin-Yogyakarta, Sleman as part of Sleman, Yogyakarta and Bantul in geomorphology located at Fluvio volcanics plain units, beach plain units and Sand Dune unit consist of with material alluvial deposits. This area has a relatively varied lithology and has a groundwater aquifer characteristics. For instance, lithology has a changing groundwater potential preservation system if there is the excessive extraction of groundwater in the research area it can be characterised by wide fluctuations in water level and changing in groundwater quality. The main objective of this research was to determine the recharge area potential in relation to the preservation of groundwater. The field observation method and description of rock including, the measurement of strike-dip layer of rock, the measurement of geological structure, the condition observation of morphology, the sampling of soil/rock to be tested in laboratory related with the mineralogy content, texture and structure. The physical properties were processed by field tests infiltration and permeability. Based on the researcher it can be seen that the research area of Pakem and Ngemplak as recharge area were good with the infiltration rate of 19-28 mm/h and the permeability of 12×10^{-2} cm/sec.

Key words: Ground water, aquifers, recharge, infiltration, permeability, geological structure

INTRODUCTION

Groundwater in the Groundwater Basin (CAT) Yogyakarta, Sleman is the part of Sleman Regency, Yogyakarta and Bantul Regency. This groundwater basin is very specific because the position of a volcano spreads with trending South to the coastal area. According to the geomorphology literature it is located Fluvio volcanic plains unit, coastal plains unit and sand dunes unit consists of alluvial material interbreed with sand, gravel, silt, clay and lava sediment. Relatively, the morphological condition in the groundwater basin, Yogyakarta, Sleman not only flat and has the lithology varieties but also it has a groundwater in the aquifer which has a variety characteristics. Those lithologies have a potential changing in the groundwater preservation systems (Arifin and Sukrisna, 2002; Galeandro *et al*., 2013). If the groundwater was taken more than capacity, thus it will affect to the fluctuation of groundwater levels. The fluctuation groundwater condition depends on rainfall and the potential recharge area on the southern flank of Mount Merapi. As the matter of fact, knowing the potential recharge area is paramount of important to know (Mu *et al*., 2015).

MATERIALS AND METHODS

Location and allocation research time: The research about the potential recharge area based on permeability and infiltration rock test on the Southern Mount Merapi is processed in the surrounding area of the groundwater basin system Yogyakarta, Sleman. In particular Northern includes Ngaglik and Pakem Regency. This research conducted for 3 months in between April-July 2016 in the dry season (Fig. 1).

Materials and research tools: The lithology that constituents locations recharge areas will be examined on their physical properties in order to know about the relationship in between aquifer the groundwater condition in the surrounding area, the materials and tools are required, hammer and geological compass, instruments sampling for undisturbed soil, measuring tape, stopwatch, Geo-electricity, laboratory equipment for soil analysis and water analysis. Secondary data for instance, well drilling logs in the research area used to analyse the characteristics of the aquifer.

This research is an experimental field and laboratory experiments to detect lithology in the Northern part of the CAT-Sleman, Yogyakarta. Essentially, the first phase of this research conducted to identify the configuration-CAT Yogyakarta, Sleman and the basement rock to be more precise in analysing the characteristics of the aquifer. Subsequently, the next step of this research is processed on these thought the layer position of rock, lithological types and the geological structure observation (fault and fracture). There is an analysis of the quality of groundwater in the basin.

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Fig. 1: The research location map

The field observation: At this observation stage was conducted the general observation related to the conditions on the field either in the form of physical condition or water conditions. The general observations can be generated into specific things:

- Field orientation to make a work planning field
- Geological conditions observation, the general observation that includes the condition geomorphology, stratigraphy and geological structure
- Geological and tectonic structure observation include the presence of rock layering, fractures, faults and folds
- Observations for groundwater mapping spread in the Northern part of Yogyakarta

The analysis: At this stage, the analytical method which was used for the development zone is based on analysis of data from maps through the overlapping/overlapping and weighting (scoring). The maps were processed with the overlay method including the geological map, hydrogeological map, groundwater basin map, electrical conductivity analysis, electrical conductivity map and the soil genesis of salty groundwater. Having analysed, thus it could be classified the groundwater recharge zone. The results of development zone divided into 3 parts, namely high, medium and low zone (Mu *et al*., 2015; Purwanto *et al*., 2015; Song *et al*., 2013).

RESULTS AND DISCUSSION

Geological research areas geomorphology: Generally, the physiography of Central Java for Southeastern part which covered the region of Mount Merapi, Yogyakarta, Surakarta and the Southern Mountain can be divided into two zones, namely: Solo zone and Southern Mountains, Solo zone is the part of Central Depression Zone Java. This zone is occupied by a cone of Mount Merapi (±2.968 m). The South-East flank is a plateau of volcanic Yogyakarta, Surakarta (±100-150 m) which is composed of alluvium sediment from Mount Merapi.

In the West of the Southern Mountains Zone, Yogyakarta plateau towards to the South coast of Java, lengthways from P. Parangtritis to K. Progo. The main river in the Western part is K. and K. Opak Progo, meanwhile in the East is K. Dengkeng which is a sub tributary of the Bengawan Solo (Arifin and Sukrisna, 2002; Kurniasih, 2016). The hill units located in the Southern of Klaten, namely Hills Jiwo. These hills have the slope around 40-150 and the height difference of 125-264 m. Some of the highest peaks in the Hills Jiwo are G. Jabalkat (±264 m) on the Western part and G. Jiwo Konang (circa. 257 m) in the H Eastern Jiwo. Both hills are separated by K. Dengkeng River, Jiwo hills composed with the pre-tertiary-tertiary rocks.

According to Arifin and Sukrisna (2002) in the Southern mountain zone was bounded by the Yogyakarta, Surakarta plains to the West and North on the East part by Waduk Gajahmungkur, Wonogiri and on the South by the Indian Ocean. In the West between the Southern Alps and the Plain of Yogyakarta was bounded by River K. Opak while in the Northern part is Baturagung. The shape of the Southern Alps is almost longitudinal East-West along 1 k. About 50 km and to the North-South direction has a width 1 k 40 km.

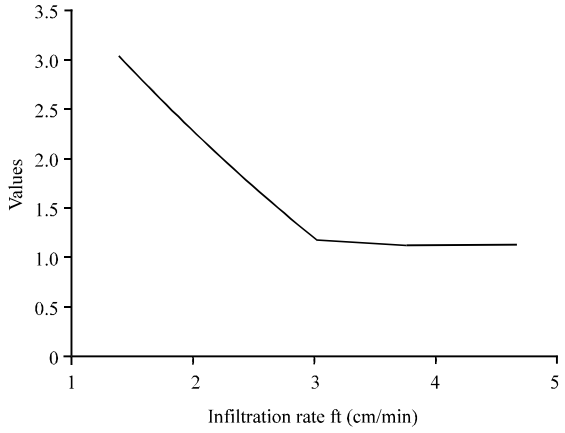

Fig. 2: Infiltration rate in Ngaglik distance

Table 1: Infiltration table in the Ngaglik

Time (min)	Infiltration rate ft (cm/min)
0	3.0
2	2.0
4	1.2
6	1.1
8	1.1
10	1.1

The incoming water volume; V = 0.2 m^3/h; thus, the infiltration rate = 20 mm/h

Stratigraphy: Yogyakarta was formed by compression of the Southern Mountain and Kulon Progo Mountains at early Pleistocene (0.01-0.7 million years old). Tectonic processes are believed to be the quaternary age limit in the region. After removal of the Southern Mountains, waterlogging (lake) along the foothills to Gantiwarno and Baturetno.

This is related to the closing of the surface water flowing along the flank of the mountains that deposited in the lower basin. Volcano Merapi formed around 42,000 years ago but the age data K/Ar andesite lava on Mount Aunt, Berthomier in 1990 determined the volcanic activity has been formed since last year's 0.67 million (Fig. 2).

The physical properties of lithology in the recharge area: The physical properties of lithology in the recharge area were observed based on the ability of infiltration and permeability of rocks in the Ngaglik and Pakem sub-districts (Mu *et al*., 2015) infiltration process is the event of water ilnfill to the ground through the surface of the ground as vertically. Furthermore, the amount of water that fills through the surface each time is known as an infiltration. The value infiltration rate is highly dependent on the capacity of infiltration, the soil's ability to pass water from the surface vertically. According to Purwanto *et al*. (2015), Vavro and Soucek (2013) the value of infiltrations in the region are as in Table 1; Fig. 3 and 4 which was shown similar to the rate of infiltration quite large around 20 mm/h.

Fig. 3: The sample image for infiltration data, take in Pakem

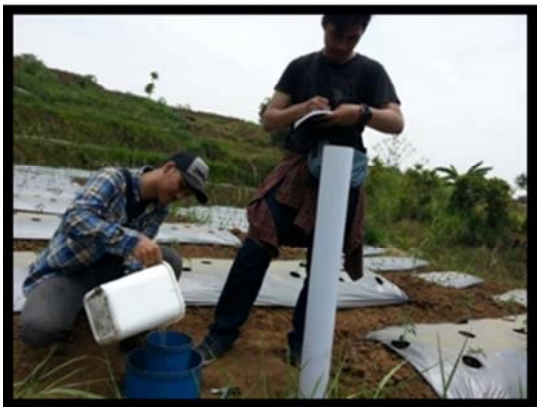

Fig. 4: The sample image for permeability data, take in Pakem

Based on measurements of infiltration rate in the research area was acquired result in the average ranges between 20-33 mm/h which spread in the Ngaglik Region, and 19-28 mm/h spread Pakem Region. Thus, it can be seen that the study area has a large size of infiltration rate according to the classification above. Besides of the permeability calculation of Ngaglik District area was shown in Table 2 and 3. It had shown the amount of permeability is large enough of 12×10^{-2} cm/sec (Table 4).

Based on morphological observation for recharge areas around Pakem and Ngaglik slpoe sloping Pakem-ramps with lithology consist of not compacted sand and gravel (Sally *et al*., 2010). The value of infiltration rate is 19-33 mm/h classified as a good infiltration. If the terms of the permeability of rock it has a sufficiently large value around 12×10^{-2} cm/sec. Thus, based on the geological observation, geomorphology, rock permeability and infiltration of the study area is an areas that is quite good as a recharge area for the groundwater aquifer basins of Sleman, Yogyakarta.

Table 2: The infiltration capacity from several type of soil was aquired in measurement, according to Suripin in 2004

Type of soil	Infiltration capaxity (mm/h)
Loamy sand	25-50
Loam	12.5-25
Loamy loam	7.5-15
Clay loam	0.5-2.5
Clay	<0.5

Table 3: The permebility measurement in Ngaglik Region

t (sec)	V (cm^3)	Q (cm^3/sec)	Log (L/r)	K (cm/sec)
9	2512	279.11	0.3979	0.0353
13	2512	193.23	0.3979	0.0244
13	2512	193.23	0.3979	0.0244
14	2512	179.42	0.3979	0.0227
20	2512	125.60	0.3979	0.0159
20	2512	125.60	0.3979	0.0159
25	2512	100.48	0.3979	0.0127
33	2512	76.12	0.3979	0.0096
44	2512	57.09	0.3979	0.0072
54	2512	46.51	0.3979	0.0058
70	2512	35.88	0.3979	0.0045
84	2512	29.90	0.3979	0.0037
84	2512	29.90	0.3979	0.0037
87	2512	28.87	0.3979	0.0036
87	2512	28.87	0.3979	0.0036

K = 0.0129

Table 4: The permeability of rock

Researchers	Characteristic	K value (cm/sec)
Bowles	Silty shale	10^{-4}-10^{-9}
Das	Medium to coarse gravel	>10^{-1}
	Fine to coarse sand	10^{-1}-10^{-3}
	Fine sand to silty sand	10^{-3}-10^{-5}
	Silt, argellaceous, silt, clay	10^{-4}-10^{-6}
	Clay loam	<10^{-7}

CONCLUSION

Based on the permeability data test in the field it can be known that soil types from the material flank are fine to coarse sand which have a good permeability values. The subsurface flow patterns can be determined by looking not only at the pattern of surface runoff but also the structure of the research area. The runoff surface water pattern on the slope leads to the South. The runoff surface water pattern from the research area towards to the Southern part and fills the groundwater basin in Yogyakarta, Sleman. The runoff pattern depends on the morphological shape and the geological structure. This matter should be accounted during making conservation zone for recharge area.

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