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**Research Paper**

# Application of the HVSR Microtremor Method for Groundwater Aquifer Identification: Case study in Pencitrejo, Terong Village, Dlingo, Bantul, Yogyakarta, Indonesia

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***ABSTRACT:*** *Research to identify the location of groundwater aquifers in areas that are difficult to obtain water was carried out using the HVSR method in the Pencitrejo area, Terong Village, Dlingo, Bantul, Yogyakarta, Indonesia. Geologically, the research area is predominantly in the form of breccia rocks of the Nglanggran Formation which are relatively hard with low porosity. With the approach that the shear wave cannot pass through the fluid, the location below the surface indicated to have a low $V_s$ value and high $V_p/V_s$ can be suspected to be the location of the aquifer's existence. With an area of 290 x 210 $m^2$, data acquisition is carried out at 29 points with a measurement time duration at each point of 20 minutes. Based on the 3D model the $V_s$ value is obtained a relatively large $V_s$ value which is lithologically in the form of soft to hard rocks with a layer of sediment on a relatively thin surface. There is no layer with a low $V_s$ value below the surface. Based on a 3D model of $V_p/V_s$ obtained 4 locations indicating the presence of a high value closure with a maximum value of 3.53 located near springs and dug wells near rice fields and near rivers. The acquired aquifer is a shallow unconfined aquifer located at a depth of about 20 m.*

***KEYWORDS:*** *HVSR, ground water, aquifer, Nglanggeran, breccia*

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## I. INTRODUCTION

Pencitrejo Hamlet in Terong Village, Dlingo District, Bantul DIY Regency is included in the hilly structural landscape unit which has an average slope percentage of 30 percent with a height of 350 m above sea level. Morphological conditions of this region have relatively steep and hilly land conditions with the dominant process is structurally influenced by endogenous factors in the form of tectonics. Based on the regional geological map of Yogyakarta sheet [1], the rocks in this location are mainly composed of Breccia rocks from the Nglanggran Formation which is above the Semilir Formation that relatively hard. The morphology this area is the result of weathering from the Breccia Nglanggran Formation which is produced from the eruption of the ancient Nglanggran Volcano. This formation is reflected almost on most of the surface in Dlingo Subdistrict. Because it has a small porosity, the rock will be difficult to store water. With these conditions, the Pencitrejo Hamlet area has difficulty groundwater for households in the dry season.

The characteristics of the soil and rock layers below the surface can be identified using the values the velocity of P wave ($V_p$) and the values the velocity of P wave ($V_s$). According to Telford [2] the ratio of the velocity of P waves and S waves propagating on a medium depends on the characteristics of the medium. One method of knowing the condition and physical properties of soil with a geophysical approach is the microtremor HVSR method. The Horizontal to Vertical Spectral Ratio (HVSR) method is a method that calculates the comparison of horizontal component seismic record data against its vertical components. The HVSR method was introduced by Nakamura [3] to estimate the resonance frequency and amplification factors of rock from microseismic data. The HVSR method is commonly used in the three-component passive seismic (microtremor). Important parameters resulting from the HVSR method are natural frequency and amplification. Natural frequency and amplification are related to subsurface physical parameters [4]. The result of data inversion are profiles of the value of $V_p$ and $V_s$, and the density of rock layering toward depth [3][5][6]. From the characteristics of the $V_s$ and $V_p/V_s$ profiles, it is expected to be used to estimate a condition of the rock that

contains groundwater or not. Shear waves cannot pass through the fluid so the presence of fluid below the surface can be estimated from a low $V_s$ value and a high $V_p/V_s$ value. Porosity and cracking may be the leading factors which control the variation of $V_p/V_s$ at depth [7]. Microtremor can also be used to analyze of the correlation with local geology and damage [8].

The microtremor method has a pretty good data correlation to the measurement data by the geoelectric resistivity method [9]. In addition, there are also several studies on the use of microtremor to identify the presence of aquifers and fluid flow, including the correlation of $V_p/V_s$ ratio against the resistivity value to determine the aquifers presence estimation in Jetak, Getasan Sub-District, Semarang Regency [10], integrated survey to identify potential groundwater aquifers in Jabungan Semarang using geoelectric and microtremor methods [11], and determining the hydrothermal flow media using seismicity properties in Kaliulo geothermal field, Semarang, Central Java [12]. Based on these studies, the use of the microtremor method to identify the potential for groundwater is very efficient, data acquisition can be made quickly and easily, and the results can be compared with the resistivity method.

## II. METHODS

Data acquisition is carried out by acquiring HVSR data by first conducting geological surveys to determine the appropriate measurement points. At the location of this study, data acquisition was carried out at 29 points as shown in Figure 1. Data acquisition at each measurement site is carried out with a duration of 20 minutes. In the processing of the HVSR curve, antitriggering were carried out to eliminate transient signals and HV curves smoothing were carried out using the Konno-Ohmachi method with a value of 40%. Inversion processing to obtain $V_p$, $V_s$, and density values is performed with an iteration of 5200 steps per data. The existence of zones with an abundance of water on the surface such as springs or watersheds in the study area is used to bind the $V_s$ value and analyze the distribution of its $V_s$ value. The data from all location points is then grided to obtain 3D models for $V_s$ and $V_p/V_s$.


**Figure 1.** HVSR data acquisition location in Pencitrejo Hamlet, Terong Village, Dlingo District, Bantul Regency. The red dots are the location of acquisition data. The 3g point is a spring with a dug well. The 5g point is located near the small river. Image capture from Google Earth 2020

## III. RESULTS AND DISCUSSION

The 3D model of the Vs values is given in Figure 2 while the 3D model of $V_p/V_s$ is given in Figure 3. The $V_s$ value has a range of 282-2970 m/s which according to [13] has the characteristics of a layer of hard soil to hard rock. In the 3D model of the $V_s$ value, it is seen that the study area is dominated by hard rocks and the morphology is similar to the real conditions in the study area. The thickness of the regolith is relatively thin and thickens further westward to the rice field area. For $V_p/V_s$ values have a range of values of 1.64 to 3.53 and the maximum value of $V_p/V_s$ values is only obtained in the western part which coincides with the presence of springs near the rice fields and in the southwestern part located near the river. The maximum closure value of $V_p/V_s$ is thought to be at a depth of about 20 m which can be interpreted as an unconfined shallow aquifer.

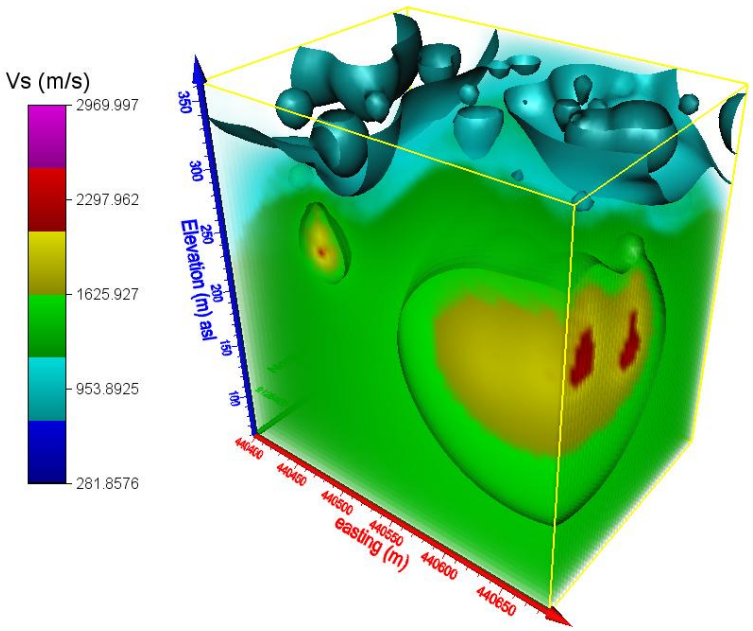


**Figure 2.** 3D profile of the study area with isosurface $V_s$ values of 750 m/s, 1000 m/s, and 1500 m/s

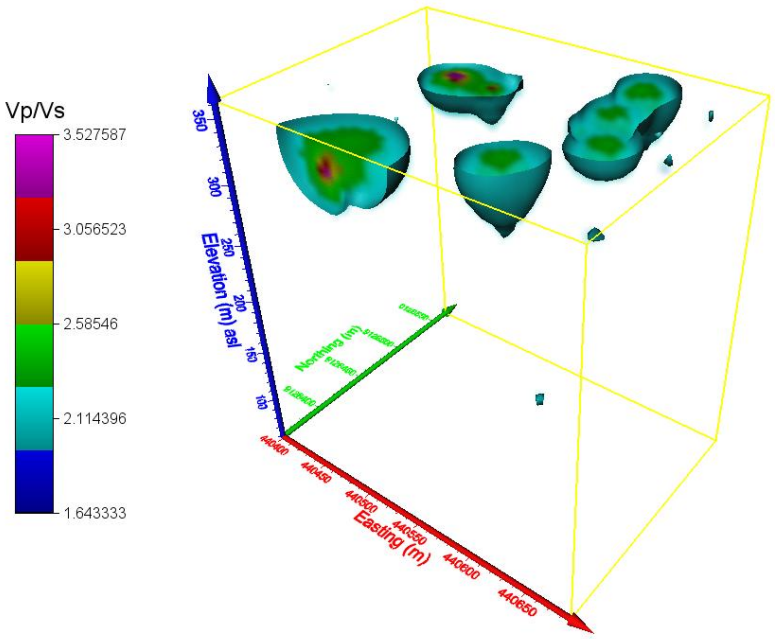


**Figure 3.** The 3D profile of $V_p/V_s$ in the study area showed relatively high values in the southern and southwestern parts of the study area. The isosurface value on all four closures is 2.15 with a maximum value of 3.53 located at a depth of about 20 m

In the west-southwestern part of the study area there are structures with low $V_s$ and $V_p/V_s$ above the dense-tended to aqueous poissonian which can be interpreted as a soil layer structure with potential groundwater aquifers. The maximum Vp/Vs value is 3.53 in the western part located near the rice fields, has a surface physicality in the form of spring and several dug wells are developed around the spring, while in the southwest it is a river valley. In the southeastern part of the study area there is a structure with $V_p/V_s$ over a dense poissonian-tending to be watery but located above the structure with a high $V_s$ which could be interpreted as a surface water located in the crevices of hard and very hard rocks.

## IV. CONCLUSION

Based on analysis of $V_s$ and $V_p/V_s$ values from microtremor HVSR data inversion in the research area with low $V_s$ and $V_p/V_s$ about 2.15 until 3.53 is located in the western-southwest part of the research area with an estimated depth of 5 m to 50 m with centered around the coordinate points of 7.884285 S and 110.459307 E with a radius of about 50 m with a light to the south. The maximum depth of closure of $V_p/V_s$ value is about 20 m. Based on studies using the HVSR method, what is recommended for groundwater exploration is to the west-southwest of the research area, which is an area bordering ricefields to the south of the population dug well next to a small spring with a depth of up to 45 m.

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