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Research Paper

Poison's Ratio And Shear Wave Velocity To Determine The Presence Of Aquifers In Glapansari Parakan Temanggung, Central Java, Indonesia

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Abstract:.*Groundwater availability is strongly controlled by subsurface lithology, porosity, permeability, and groundwater saturation. This study investigates the distribution and depth of potential groundwater aquifers in Glapansari Village, Parakan District, Temanggung Regency, Central Java, Indonesia. Twenty five microtremor stations were measured using the microtremor Horizontal-to-Vertical Spectral Ratio (HVSR) method. HVSR-derived subsurface parameters were interpreted using two-dimensional profiles models of shear-wave velocity and Poisson's ratio. Layers that have a Poisson's ratio value of 0.26 and shear-wave velocity 1500-1600 m/s are interpreted as aquifer zones because they indicate an increase in fluid content in the rock pores. In volcanic environments, these values are generally related to weathered tufa, volcanic breccia, and fracture zones that function as storage and groundwater channel. Aquifer occurs beneath station 5C at an estimated depth of approximately 35 m and can be traced downward to approximately 50 m.*

Key words : HVSR, microtremors, aquifers, Poisson ratio, Glapansari, Parakan, Temanggung

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I. Introduction

Geologically, Glapansari Village, Parakan District is composed of young volcanic deposits resulting from the activity of Mount Sindoro and Mount Sumbing in the form of volcanic breccia, tuf, lapili, volcanic sand, and lava. The characteristics of these rocks have good porosity and permeability so that they strongly support the formation of aquifers. Based on the regional hydrogeological conditions of the Magelang-Temanggung Groundwater Basin, the Glapansari Village area has the potential for the existence of shallow to medium aquifers with medium to high productivity, especially in volcanic sand layers, volcanic breccia, and lava fracture zones.

The Horizontal to Vertical Spectral Ratio (HVSR) method is a method that calculates the ratio of seismic recording data of horizontal components to vertical components. The method has been widely applied to estimate resonance characteristics and subsurface impedance contrasts [1–3]. Inversion of microtremor data can further provide estimates of shear-wave velocity (Vs), compressional-wave velocity (Vp), and Poisson's ratio for groundwater-aquifer identification [4]

The ratio of Vs and Vp in the subsurface of the earth, used to calculate the poison ratio, the greater the poison ratio value will show the presence of water. [5] showed that, with increasing porosity, VP/VS initially decreases if the porosity is saturated with water, whereas it increases if the porosity is saturated with a much less compressible fluid such as melt.

The interpretation of the presence of aquifers in seismic geophysical surveys can be carried out through the analysis of rock elastic parameters, especially **Poisson's ratio (v)** and **shear wave velocity (Vs).** Both parameters are highly sensitive to changes in porosity, weathering rate, and fluid content in subsurface media. In materials that experience water saturation, the speed of shear waves tends to decrease, while the value of Poisson's ratio increases due to the increase in the incompressibility of the medium.

II. Method

One of the methods to determine the condition and physical properties of soil using a geophysical approach is the HVSR method. The Horizontal to Vertical Spectral Ratio (HVSR) method is a method that calculates the comparison of seismic recording data from the horizontal component to its vertical component. The HVSR method was introduced by [1] to estimate the resonance frequency and amplification factor of rocks beds in an area of microseismic data. The HVSR method is typically used in three-component passive seismic (microtremor) seismic. The important parameters generated from the HVSR method are natural frequency and amplification. HVSR which is measured on the soil aims to characterize the seismic wave velocities both P wave and S wave at the depth direction of a place. Natural frequency and amplification are related to subsurface physical parameters[3]. The results of the data inversion are the profiles of the value of the S wave P wave velocities and rock layers density towards the depth [6] [7].

The study area is located in Glapansari Village, Parakan District, Temanggung Regency, Central Java, Indonesia. Twenty five microtremor stations were measured. The coordinates range from approximately 398085–398140 m Easting and 9191390– 9191430 m Northing, with elevations between 1092 and 1105 m above mean sea level. The complete station coordinates are retained from the field report and should be inserted as Table 1.

Table 1. HVSR mekrotremor measurement points

Station	Easting (m)	Norting (m)	Elevation (m)
1A	398086	9191393	1100
1B	398089	9191404	1098
1C	398091	9191412	1096
1D	398093	9191419	1095
1E	398094	9191426	1092
2A	398100	9191391	1101
2B	398102	9191401	1099
2C	398103	9191409	1097
2D	398103	9191418	1094
2E	398103	9191425	1093
3A	398112	9191390	1103
3B	398112	9191390	1100
3C	398112	9191407	1097

Station	Easting (m)	Norting (m)	Elevation (m)
3D	398112	9191416	1094
3E	398112	9191424	1092
4A	398124	9191389	1105
4B	398124	9191397	1102
4C	398123	9191405	1100
4D	398122	9191414	1097
4E	398122	9191422	1095
5A	398137	9191387	1107
5B	398135	9191396	1104
5C	398134	9191404	1102
5D	398132	9191412	1100
5E	398128	9191420	1097

The stations form several measurement corridors. Two corridors are particularly important for aquifer interpretation: stations 1A– 1E in the western part of the study area and stations 5A–5E in the eastern part (figure 1).

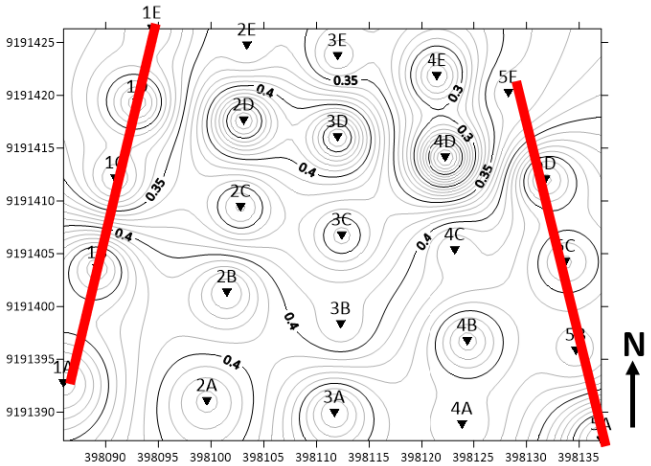


Figure 1. Cross-sections 1A-1E and 5A-5E

Microtremor inversion was used to estimate the vertical distribution of subsurface shear-wave velocity (Vs) and compressionalwave velocity (Vp). The relationship between Poisson's ratio (σ) and Vp/Vs ratio can be formulated as in the following equation :

$$\sigma = \frac{V_p^2 - 2V_s^2}{2\left(V_p^2 - V_s^2\right)} = \frac{\left(V_p/V_s\right)^2}{2\left[\left(V_p/V_s\right)^2 - 1\right]}$$

There s is Poisson's ratio, Vp is the velocity of the P wave (m/s), and Vs is the velocity of the S wave (m/s). Poisson's Ratio value of 0.26 – 0.4 indicates the condition of the water-saturated (saturated) layer. Generally, rocks that contain water are in the sandstone layer

III. Result and Discussion

Profile along stations 1A-1E (figure 2)

At an elevation of 1075-1100 m has Vs < 750 m/s interpreted as a cover soil, weathered tuf, or loose volcanic deposit, relatively high porosity, potentially as a rainwater infiltration zone. This is shown by the poison ratio value of >0.28. From the poison value and the speed of the shear wave, it shows that there is no compatibility of the sandstone at Vs1500 m/s with the ratio value of poison containing water, where in this rock the value of poisons decreases which shows that the porosity value is getting smaller.

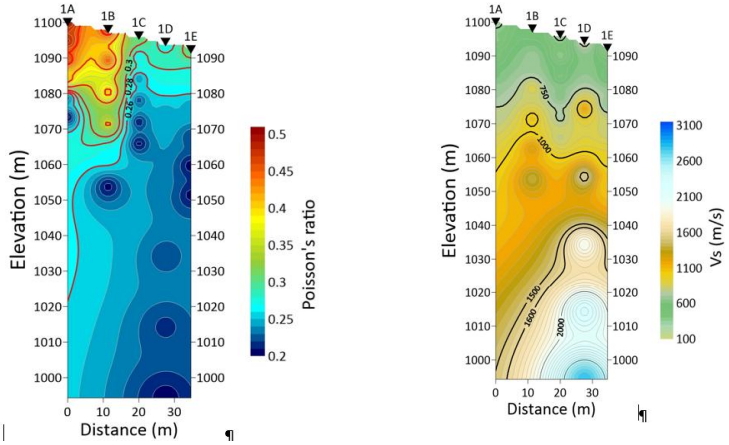


Figure 2. Two-dimensional Poisson's ratio (left) and shear-wave-velocity-related profile along stations1A-1E (Right)

Profile along stations 5A-5E (figure 3)

The existence of the aquifer is located at a depth of 1050-1070 m at a poison ratio value of 0.26-0.3 and a shear wave speed of 1500-1600 m/s in the rock pores. Poisson's ratio is not a direct measurement of groundwater content. It is an elastic property that responds to the relationship between compressional and shear-wave velocities. Consequently, groundwater interpretation should use Poisson's ratio together with shear wave speed, geological setting, layer continuity, and other independent evidence [8–12]. The Poisson's ratio value in the study area is used to identify the saturation level of the subsurface layer. Layers that have a Poisson's ratio value of 0.26 are interpreted as aquifer zones because they indicate an increase in fluid content in the rock pores. In volcanic environments, these values are generally related to weathered tufa, volcanic breccia, and fracture zones that function as storage and groundwater channel.

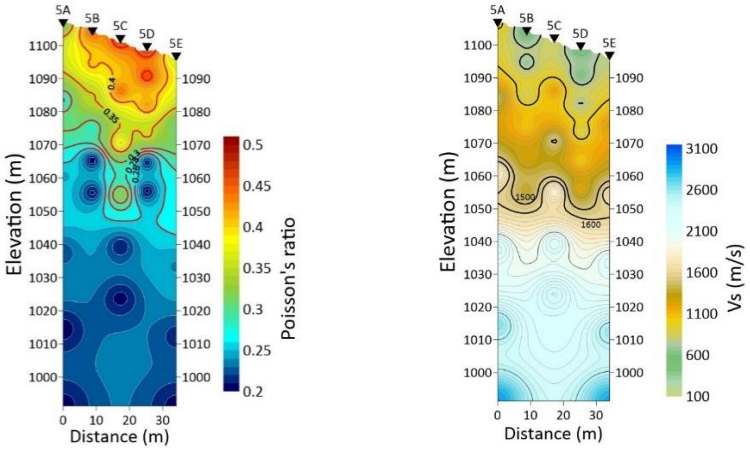


Figure 3. Two-dimensional Poisson's ratio (left) and shear-wave-velocity-related profile along stations 5A-5E (Right)

IV. Conclusion

The existence of the aquifer is located at a depth of 1050-1075 m at a poison ratio value of 0.26-0.3 and a shear wave speed of 1500-1600 m/s in the rock pores. Integration of Poisson's ratio, shear-wave velocity, provides a useful preliminary framework for groundwater exploration. The station 5C target is the principal groundwater exploration target in the study area. It occurs at approximately 35 m depth and continues downward to about 50 m. The progressively stiffer material beneath the target may represent a lower boundary or a more competent formation. The result is consistent with the source interpretation that the first potential aquifer is located beneath station 9 and is interpreted as an unconfined aquifer.

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