



Groundwater Aquifer Identification Using the Microtremor Method (HVSr) in Petarangan Village, Sindoro Mount, Temanggung

Yulianto T., Yuliyanto G., Harmoko U

Department of Physics, Faculty of Science and Mathematics, Diponegoro University, Indonesia
Semarang 50275, Indonesia:

Corresponding Author: tonygeoundip@gmail.com

Abstract: The availability of clean water is the main problem in the slopes of Mount Sindoro, especially in the dry season. This study aims to identify the potential of groundwater aquifers using the Horizontal to Vertical Spectral Ratio (HVSr) microtremor method. This method is used to obtain the parameters of natural frequency, amplification, shear wave velocity (V_s), and Poisson ratios related to the presence of fluids under the surface. Data acquisition was carried out at several points in Petarangan Village. The results of the analysis showed that there was a pressurized aquifer at a depth of 100–145 m at point 1C and 150–180 m at point 2D, as well as an undepressed aquifer at a depth of about 40 m at point 4B. The distribution of the aquifer tends to be in the northern and western zones of the research site. This study proves that the HVSr method is effective in determining groundwater prospect zones as the basis for drilling site recommendations.

Key words : HVSr, microtremors, aquifers, groundwater, Poisson ratio

Received 06 June., 2026; Revised 15 June, 2026; Accepted 17 June., 2026 © The author(s) 2026. Published with open access at www.questjournals.org

I. Introduction

The slopes of Mount Sindoro experience water difficulties, especially in the dry season, thus limiting the community's agricultural activities. Geologically, this region is composed of volcanic deposits such as lava and pyroclastic which have the potential to become aquifers

The geological conditions of the research area are depicted in geological maps, where data are obtained by tracing and searching for rock outcrops throughout the study area (*hunting outcrope*). Each type of lithology is described and plotted on a situation map that has been made beforehand. The physical description of each type of lithology includes the type of rock, fresh color, weathered color, structure, texture, relationship with the surroundings and the position and position of the rock if any. This is important to support the interpretation of subsurface geological conditions based on HVSr data.

Seismic waves are elastic waves that propagate within the earth. Seismic propagation depends on the elasticity properties of a rock. The tool for recording these waves is a seismogram placed above the earth's surface. A seismogram is the result of recording vibrations caused by the propagation of seismic waves from a source. Each seismogram has important information about the source of the seismic wave gel and the medium it passes. Seismic waves consist of two types based on their propagation, some propagate through the earth, called body waves, and some propagate through the earth's surface, called surface waves. (Body waves) Body waves are divided into two based on the direction of their vibration. (Surface waves) Surface waves consist of Raleigh wave (ground roll) and Love wave [1].

Geophysical methods, specifically HVSr, can be used to identify subsurface characteristics through the analysis of the ratio of horizontal and vertical components of microtremor waves. Parameters such as natural frequency, amplification, and Poisson ratio of the V_p/V_s relationship can be used to detect the presence of groundwater.

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 [2] 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 [4] [5].

The following are the results of HVSR measurements in the research area as follows

Table 1. HVSR mekrotremor measurement point

Point	Easting	Northing	Elevation
1A	397232	9191792	1031
1B	397238	9191799	1030
1C	397245	9191006	1029
1D	397250	9191813	1029
1E	397257	9191821	1028
2A	397236	9191782	1034
2B	397244	9191787	1034
2C	397251	9191794	1033
2D	397259	9191799	1033
2E	397266	9191802	1033
3A	397243	9191769	1037
3B	397250	9191777	1037
3C	397259	9191782	1037
3D	397267	9191786	1037
3E	397274	9191788	1037
4A	397251	9191756	1041
4B	397258	9191765	1040
4C	397267	9191770	1041
4D	397276	9191776	1041
4E	397282	9191781	1040
5A	397259	9191741	1046
5B	397268	9191748	1046
5C	397273	9191757	1044
5D	397280	9191765	1044
5E	397288	9191773	1043

The Poisson's Ratio is the ratio of transverse contraction to elongation when the stem is stretched. Poisson's ratio can be measured from the arrival of seismic waves. Ideally, Poisson's ratio is 0.25 or the ideal elastic body. If V_s is low, the V_p/V_s ratio becomes high and s approaches 0.45. The relationship between Poisson's ratio (s) and V_p/V_s ratio can be formulated as in the following equation :

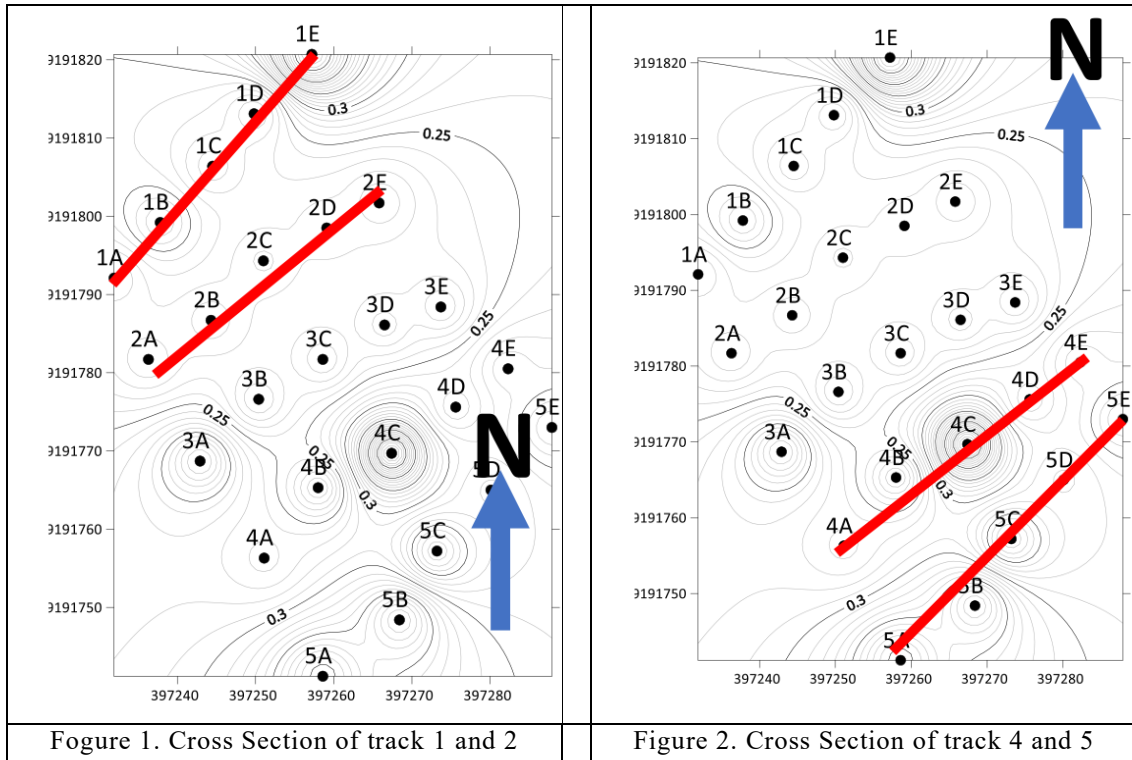
$$\sigma = \frac{V_p^2 - 2V_s^2}{2(V_p^2 - V_s^2)} = \frac{\left(\frac{V_p}{V_s}\right)^2}{2\left[\left(\frac{V_p}{V_s}\right)^2 - 1\right]}$$

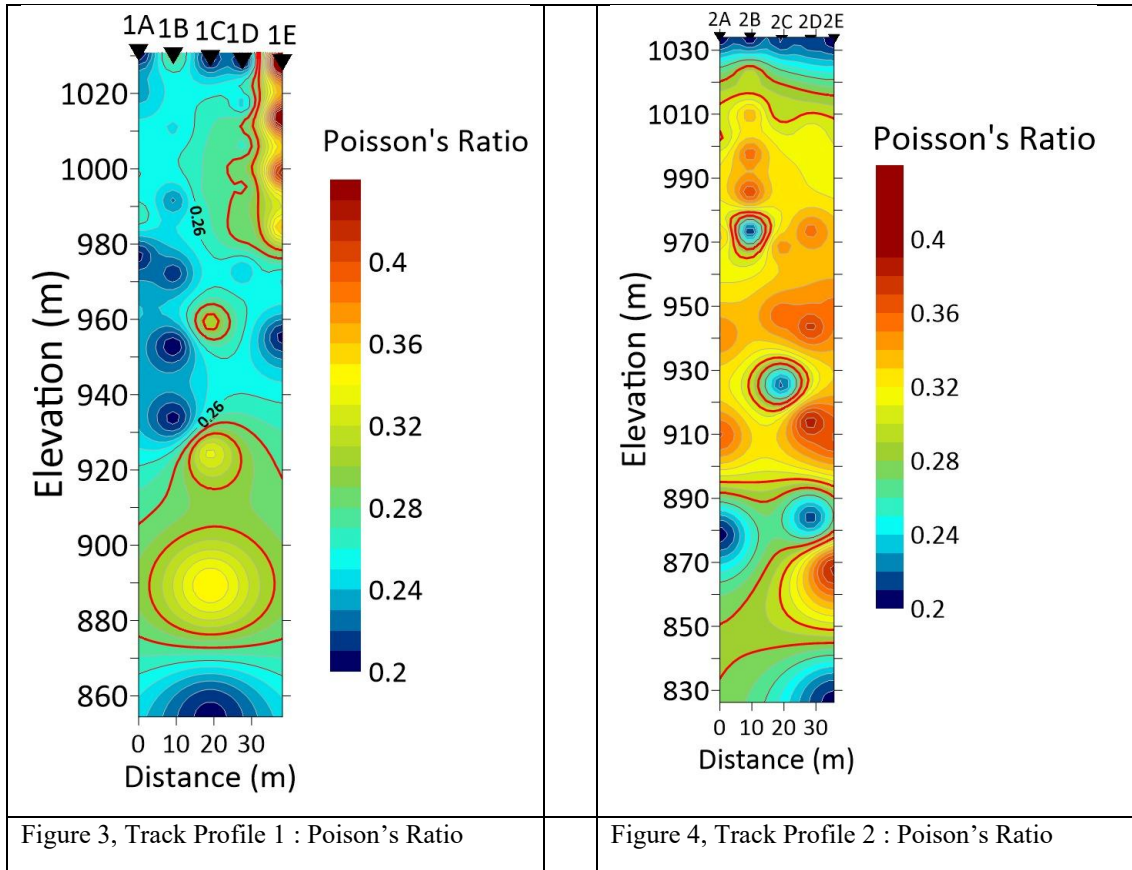
There s is Poisson's ratio, V_p is the velocity of the P wave (m/s), and V_s is the velocity of the S wave (m/s). Poisson's Ratio value of 0.25 – 0.45 indicates the condition of the water-saturated (saturated) layer. Generally, rocks that contain water are in the sandstone layer

III. Result and Discussion

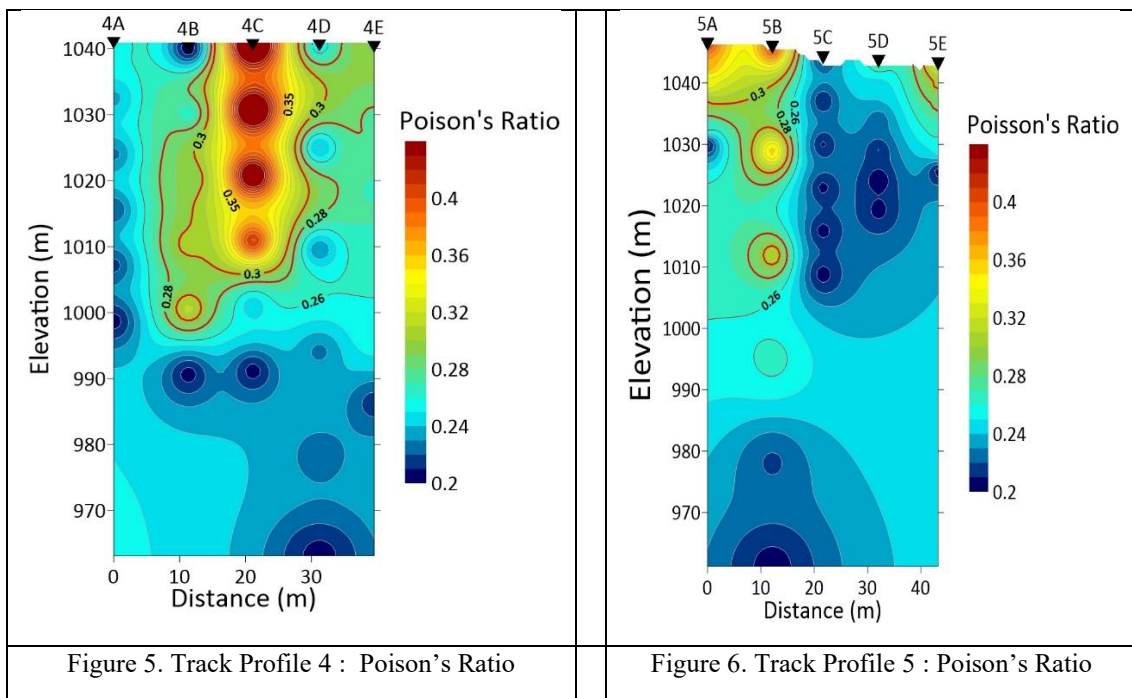
Zones with high Poisson ratio values are interpreted as water saturated layers. The results showed that the dominant aquifer potential was in the northern and western parts of the study area (figure 1). This condition is related to the geological structure and porosity nature of the rocks

This cross-section shows the variation of the Poisson ratio to depth. On trajectory 1, there is a subsurface basin at point 1C with indications of a pressurized aquifer at a depth of 100–145 m. In trajectory 2, the contour pattern shows the presence of an aquifer at a depth of 150–180 m at point 2D. This geometric structure indicates the existence of a water trap (confined aquifer).

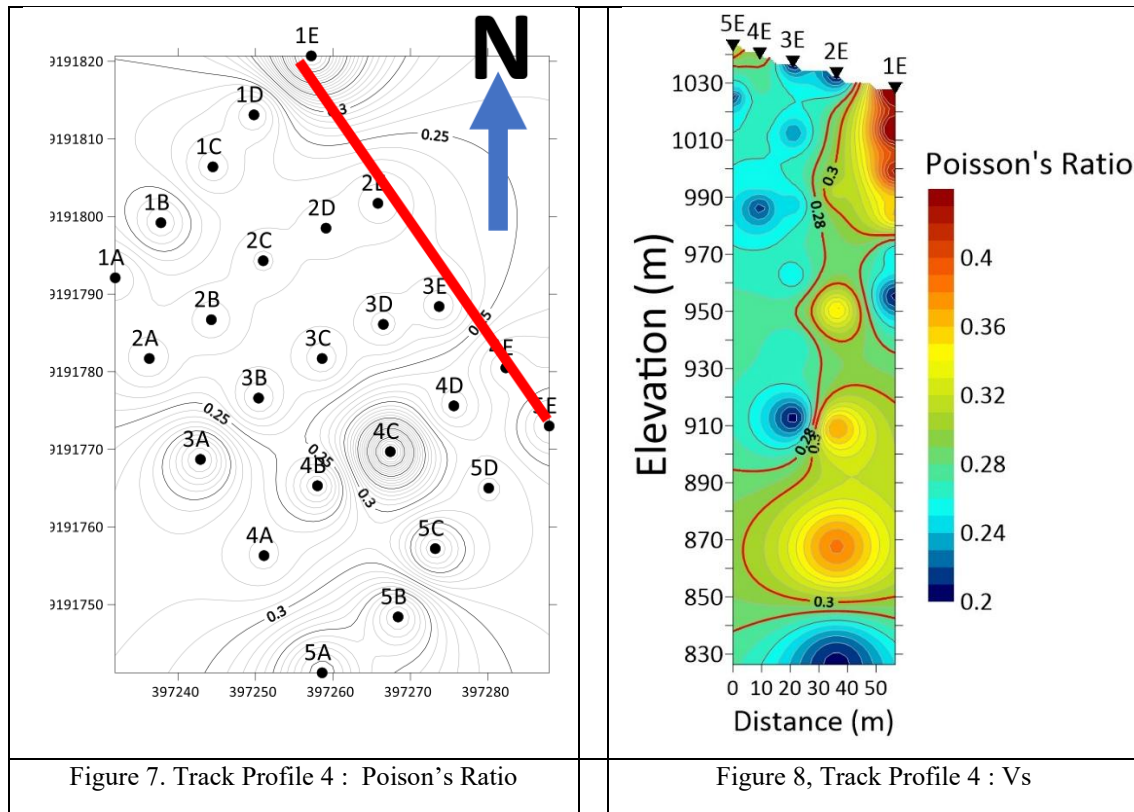




The cross-section shows the existence of a layer of sloping sandstone that has the potential to be a groundwater flow path. At point 4B (Figure 5), the aquifer was identified as undepressed at a depth of about 40 m. This type of aquifer is directly affected by surface conditions and has a high recharge potential. This is shown by a poisson's ratio value of 0.28-0.36 [6]



On Track E (Figure 8) there is a basin below Point 2E with a depth of about 90 m, and deeper at a depth of 110-180 m there is a contour basin pattern that indicates the possibility of a depressed aquifer. Poisson's ratio value of 0.28-0.36



IV. Conclusion

1. There is a pressurized aquifer at the location of point 1C with UTM coordinates 397459, 9191806 with an elevation of 1029 MSL, at a depth of 100-145 m
2. There is a pressurized aquifer at the location of point 2 D with UTM coordinates 397259, 9191794 an elevation of 1033 MSL, at a depth of 150-180 m
3. On Track 4 at point 4 B with UTM coordinates 397258, 9191765 with an elevation of 1040 MSL, there is an undepressed aquifer at a depth of 40 m
4. there is a basin below Point 2E with a depth of about 90 m, and deeper at a depth of 110-180 m there is a contour basin pattern that indicates the possibility of a depressed aquifer

References

- [1]. Telford, W, Keys DA, Sherif, G, 1990, Applied Geophysics, Cambridge University Press, Cambridge
- [2]. Nakamura Y 1989 *A Method for Dynamic Characteristics Estimation of Subsurface using Microtremor on the Ground Surface* Vol.30 25-33
- [3]. Herak M 2008 *Computers and Geosciences* 34 1514-1526
- [4]. Nakamura Y 2000 Proc XII World Conf. Earthquake Engineering New Zealand 2656
- [5]. Nakamura Y, Gurler E D, Saita J, Rovelli A, Donati S 2000 Vulnerability Investigation Of Roman Colosseum Using Microtremor Prepared for 12th WCEE 2000 in Auckland, NZ
- [6]. Dun Wu, Bo Li, Jian Wu, Guangqing Hu, Xia Gao, Jianwei Lu, 2024, Influence of Mineral Composition on Rock Mechanics Properties and Brittleness Evaluation of Surrounding Rocks in Soft Coal Seams, *ACS Omega* 2024, 9, 1375-1388