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Identification Of Groundwater Aquifer Zones In Warehouse Buildings Based On Poisson's Ratio And Shear Wave Velocity Values From Microtremor Method

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Abstract— A research has been carried out to identify the location of the aquifer zone using the microtremor method. The research location is in the form of an unfinished warehouse with a groundwater well that has been made but is considered to have failed to produce water. The determination of the location of the former well uses resistivity methods. The acquisition of microtremor data was carried out at 20 measurement station locations on a land of about 70 m x 40 m with a recording duration of 10 minutes for each station and a sampling rate of 20 data per second. After inversion and gridding, the results of the existence of an aquifer zone at the location of the warehouse building which is a potential location for the location of the former well located on the left front of the warehouse from the entrance to the front of the warehouse building with a depth of 55-63 meters, the northern zone is relatively shallower. The types of aquifers obtained are confineded and semi-confined aquifers, with a relative thickness of "thin" which can be interpreted as a relatively small flow discharge or it can be concluded that no significant aquifer zone is obtained at that location.

Keywords—Aquifer; Microtremor; Inversion; Shear Wave Velocity; Poisson's Ratio.

I. Introduction

In the search for groundwater aquifer zones, the resistivity geoelectric method is the most widely used and reliable geophysical method [1], but sometimes it is faced with field conditions that make it impossible to acquire data. The existence of topographic constraints, the availability of land for the passage of the current cable and potential cables, the presence of vegetation obstacles, buildings, or water bodies or land surfaces that have been covered by pavement are difficult to do to stretch the cable for data acquisition from this method. For this reason, an alternative method is needed to be able to detect the presence of aquifer zones in the subsurface layer. By using the nature of the inability of shear waves to propagate through fluids, geophysical methods that can explore the sensitivity to these shear waves are very necessary to be used. One of them is the microtremor method that uses ambient noise that is sensitive to shear waves with short wavelengths, with a relatively compact, lightweight survey tool, simple tool operation, and relatively short data acquisition is quite a promising method. Several aquifer identification studies have been conducted by using microtremor method [2][3][4][5][6][7]. To detect aquifer zones in a warehouse building that is not too large it is impossible to make measurements using the resistivity geoelectric method, especially in the warehouse building there is still soil clearing work and several piles of material at several points of the location. Therefore, in this study, the identification of aquifer zones was carried out using the microtremor method.

The microtremor method is a passive seismic method using wave sources produced by nature in the form of natural harmonic vibrations with relatively small amplitudes, which can be used to describe the geological conditions of an area. This method is more environmentally friendly because it uses the earth's natural waves without having to provide a distraction, in addition to the easy and more efficient operation of tools and data collection processes makes this method an alternative method that can replace other conventional methods. With this microtremor method, soil dynamic parameters related to the carrying capacity of the soil can be obtained, including the speed of wave propagation in the soil layer and Poisson's ratio. The speed of wave propagation within the soil layer can provide an overview of the subsurface geological structure. The Poisson's ratio can determine the lithology of rocks related to the porosity of the rock, the softness or hardness of the rock, and the looseness or absence of the matrix between the rocks. Poisson's ratio σ can be expressed as configuration of comparison of compression wave velocity (V_p) to shear wave velocity (V_s) [8]:

$$\sigma = \frac{V_p^2 - 2V_s^2}{2(V_p^2 - V_s^2)} \qquad (1)$$

The Poisson's ratio has a value from 0 to 0.5. Water has a Poisson's ratio value of 0.5. The Poisson's Ratio value above 0.25 is a condition of the soil layer that contains a lot of water prospects and high porosity. In this research for community service, the Poisson's Ratio is used to identify the types of soil and fluids in the soil layer in the research area. For the analysis of soil dynamic parameters of shear wave velocity, Table 1 is given a reference for the classification of rock sites based on S wave velocity according to SNI 1726-2019 [9] and Table 2 is the classification of soil types as a reference.

TABLE 1. CLASSIFICATION OF ROCK SITES BASED ON S WAVE VELOCITY [9]

Site classification	**Vs (m/s)**
SA (Hard rocks)	≥ 1500
SB (Rocks)	750 – 1500
SC (Hard, very dense soils, and soft rocks)	350-700
SD (Moderate soil)	175-350
SE (Soft soil)	≤ 175 or any soil profile containing more than 3 m with the following characteristics: 1. Plasticity index, PI >20 2. Water content, w ≥ 40% 3. Flowless shear strength, $S_u < 25\ kPa$
SF (specialized soils requiring specific geotechnical investigations and specific response analyses)	Each soil layer profile that has one or more of the following characteristics: - Prone and potentially failed or collapsed due to earthquake loads such as easy liquefaction, very sensitive clay, weak cemented soil - Very organic clay and/or peat (Thickness H > 3 m) - Very high plasticity clay (thickness H > 7,5 m with plasticity index PI >75) - Soft/semi-firm clay layer with thickness H >35 m with flowless shear strength $\overline{S_u} < 50\ kPa$

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TABLE II. RELATIONSHIP BETWEEN SOIL TYPE AND POISSON'S RATIO [10]

Soil type	Poisson's ratio
Saturated clay	0,4-0,5
Unsaturated clay	0,1-0,3
Sandy loam	0,2-0,3
Silt	0,3-0,35
Sandstone	0,21-0,38
Limestone	0,18-0,33
Sandy soils	0,25-0,4

II. METHOD

In this study, data acquisition was carried out at 20 stations (Table 3) inside the warehouse building with an area of 40 m x 70 m. In one of the station locations, there is a former drilled well as the result of previous research using the traditional method of local wisdom with the condition that it is no longer functional because the aquifer zone was not obtained as expected. At each station, data acquisition was carried out for 10 minutes with 50 ms sampling. Then data processing was carried out using a single station method, which is dividing the spectrum of horizontal components by the spectrum of vertical components and obtaining an amplification curve to frequency. Then an inversion of this curve is carried out to obtain the values of compression wave velocity, shear wave velocity, and density at each station location. Data anti triggering is performed before the inversion process to eliminate unnecessary transient signals that affect the acquired model. The shear wave velocity and Poisson's ratio data from the inversion results for each station are then gridded to obtain a 3D model. To describe the existence of groundwater aquifer zones, the isosurface values for sandstone and Poisson's ratio are selected accordingly and then the depth of the aquifer from the surface can be obtained.

TABLE III. LOCATION OF DATA ACQUISITION STATIONS

Station	X	Y	Station	X	Y
1	428665	9224009	11	428641	9223984
2	428657	9224010	12	428633	9223987
3	428649	9224013	13	428651	9223968
4	428642	9224015	14	428644	9223970
5	428660	9223995	15	428636	9223972
6	428653	9223997	16	428629	9223974
7	428645	9223998	17	428649	9223952
8*	428638	9224001	18	428642	9223955
9	428656	9223981	19	428633	9223957
10	428649	9223982	20	428626	9223960

*Station 8 is located above the former well

III. RESULTS AND DISCUSSION

The isosurfaces of the water-carrying layers are given in Figure 1. The depth of the sandstone layer (golden brown color) is located at a depth of about 50-70 m. The presence of water is seen at a depth of 0-40 m (green color) except in the northern left part of the land which reaches a depth of 55 m. The aquifer zone is searched based on the overlay of the two isosurfaces, located in the north-west or left front of the warehouse.

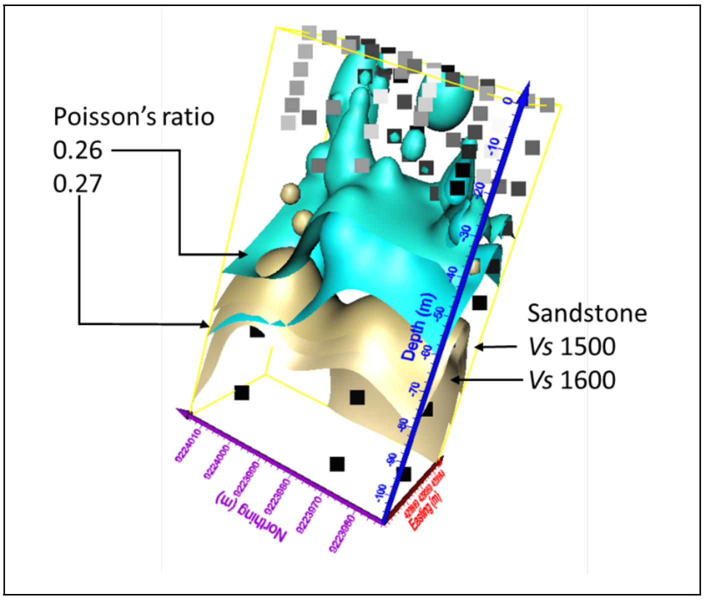

Fig. 1. The minimum Poisson's ratio value indicates the presence of water (0.26-0.27) (green color) squeezed by a sandstone layer (Vs 1500-1600 m/s) (golden brown color) at a depth of about 70 m

Based on Figure 1 above, a depth model of the two isosurfaces is made as given in Figure 2, with the depth of the layers being 38-86 m. The matching of the two types of isosurface layers is given in Figure 3 and the location and depth of the subsurface groundwater aquifer located on the left side of the study site with a contour line with a zero (0) number. The locations of stations 3, 4, and 8 are given in Figure 4. The location of station 8 is the location of the aquifer point of the resistivity method.

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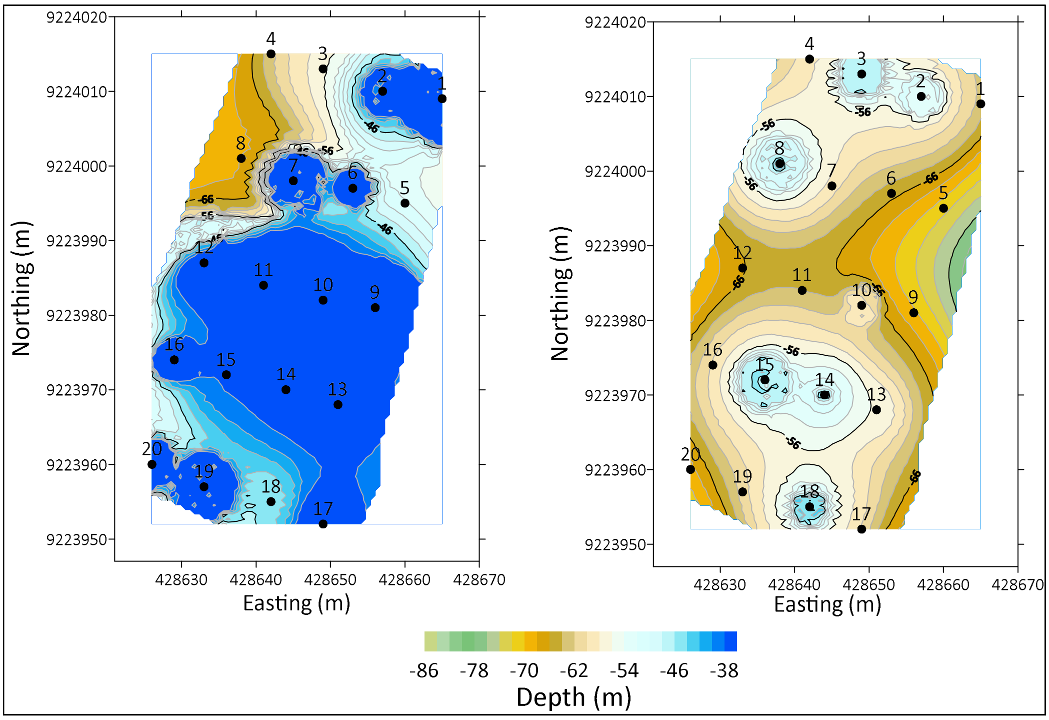

Fig 2. Isosurface contour of the depth of the Poisson's ratio indicating the presence of water left), isosurface depth Vs sandstone (right)

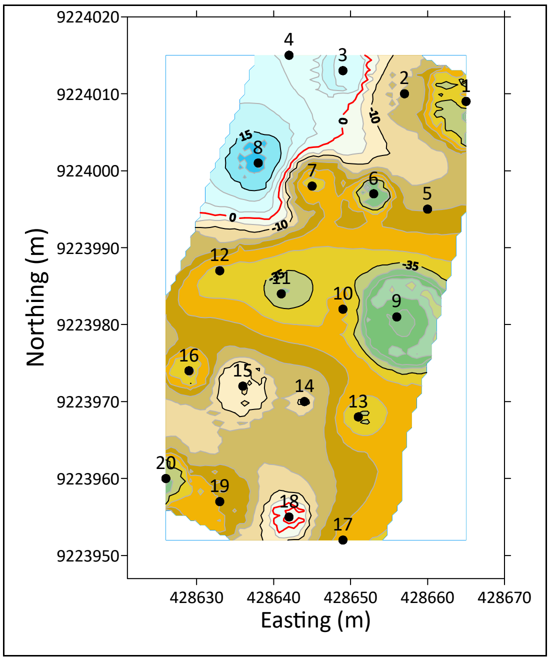

Fig. 3. The location of the aquifer has a blue contour with a red line with the number 0, located below Station 3 and Station 4 extending in the direction between Station 7 and Station 8 and to the south of Station 8

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Station 3 location

Station 4 location

Station 8 location

Fig 4. The locations where there is an aquifer zone underneath are outside the warehouse building. At the location of this station, there are former wells that are the result of estimating the aquifer zone using traditional methods (local wisdom) but have been filled with soil material.

IV. CONCLUSION

There is an aquifer zone at the location of the warehouse building which is a potential location for the location of the well located on the front left of the warehouse from the entrance (around Station 3 and Station 4) to the front of the warehouse building (around Station 8) with a depth of 55-63 meters, the northern zone is relatively shallower. Aquifers have types of confined and semi-confined aquifers, with a relative thickness of "thin" which can be interpreted as a relatively small flow discharge. The remuneration is highly dependent on the flow of fluids in the sandstone layer in the direction from the south..

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