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Research Paper

Characterization of Sinkhole in Ngrombo, Bedoyo, Ponjong, Gunung Kidul Indonesia with the Horizontal to Vertical Spectral Ratio Microtremor Method

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ABSTRACT:*This study aims to determine the characterization of sinkholes in Ngrombo hamlet, Bedoyo village, Ponjong district, GunungKidul regency. The results of the study will be used as disaster mitigation in the Bedoyo Village area.This research uses a three-component microtremor and uses the Horizontal to Vertical Spectral Ratio method, this method is one of the methods that can describe the underground layer using body waves and surface waves. By knowing the value of the shear wave velocity (Vs) we can find out the layer in an area, a small Vs value indicates that the density of a rock is also small. From the results of the study, it is known that at the center of the trajectory, the value of Vs 0 m/s is shown with a diameter of 12m, in the area around the sinkhole also still has a low Vs value of 400 - 800 m/s. on Line 3 and line 4 taken from point 0 east of the sinkhole shows limestone in the underground layer of the area pointing to the East with a Vs value below 1200 m/s which is limestone or clay where the rock is rocks are easily soluble. Sinkhole depth which is 10m from ground level, sinkhole depth may still increase due to low Vs value. vs value obtained compared to the literature.*

KEYWORDS: *Sinkhole, karst, Doline, Microtremor, HVSR*

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I. INTRODUCTION

Karst is a unique soil formation formed in soluble rocks, areas formed by breaking and unification on soluble odors, such as limestone, gypsum, and salt rocks (Ford and William, 2007). In Indonesia, there is also a karst area, which is 8% of the total land area. Karst areas in Indonesia are karsts located in tropical regions (Bahargiati, 2004). A sinkhole is a surface shown in an enclosed basin (Waltham, 2008). Sinkholes are formed because of the process of carstification or the process of forming land formations dominated by the dissolution process this process occurs continuously in rocks easily dissolved by water so that the rock has cavities, because the presence of cavities in the rock makes the rock unable to withstand the load so that there is a decrease or hole in a surface. Early detection of sinkhole is very important, by knowing the characteristics of the sinkhole we can predict the danger of the sinkhole. For civil and development in karst areas geohazard studies are very important because of the collapse in areas that have cavities (Waltham, 2008). Sinkholes can also appear in densely populated areas, sinkholes that appear without any initial indication can harm many people for that research is needed in some areas in order to give early warning. Mount KEid al-Fitr is one of the districts in Ngrombo Hamlet, Bedoyo Village, Ponjong District, GunungKidul Regency. Many Sinkholes Appear in the area of GunungKidulkarenaGunungKidul is one of the karst areas in Indonesia, the number of underground rivers in GunungKidul is the main characteristic of karst areas Karstification in temperate areas is the process of sinkhole formation and underground systems, the rest / residual of the sinkhole will form karst hills (Haryono and Adjie, 2004).

There are several geophysical methods for identifying sinkholes. Geophysical methods that are commonly used to determine the existence of sinkholes are ground-panetrating radar (GPR) electrical resistivity tomography (ERT), and seismic (Dobecki, 2006). Microtremor is one of the methods in geophysics that uses small seismic waves, waves in microtremors are divided into two kinds according to their propagation, namely body waves and surface waves. Body waves are waves that propagate on the earth's interior. Body waves are

divided into two according to the direction of propagation, namely primary waves and secondary waves (Kearey et al, 2002). Surface waves are waves that propagate at the surface boundary. Surface waves are divided into two, namely Reyleigh waves and Love waves (Lay and Wallace,1995). Microtremor data is a series ofsmall field amplitude vibrations with three orthogonal directions (NS, vertical EWand) (Guoet al., 2014). With a three-comminentmicrotremor we can find out the depth of the layer, with this method we can also find out the dominant resonance of the frequency (f0) and the highest value of HVSR will show the characteristics of a layer, the amplification value of an area can be known from the height of the HVSR curve measured by the microtremor in that area (Yulianto, 2019).

This study used Horizontal to Vertical Spectral Ratio (HVSR) Analysis. The HVSR method is an excellent indicator for knowing soft sediments, the amplitude distribution of the resonant frequency may vary within a close measurement location, The HVSR method can show the base frequency when used at a site that has sediments with contrasting impedance relevant to the underlying bedrock (Cultrera Et al, 2004). This method is intended in areas with low to moderate seismic activity (Kyawet al., 2015). To know the characteristics and structure of subsurface rocks, an H / V value is needed so that it can know the underground sedimentary layer. H/V values are derived from frequency factors and amplification factors (Nakamura, 1989). The wave velocity of the surface varies depending on the frequency (orits period). S waves can only propagate on solid medium. The wave velocity S is expressed by the equation (Kearey et al,2002).

$$\boldsymbol{Vs} = \left[\frac{\square}{\boldsymbol{\rho}}\right]^{\mathbf{1/2}}$$

with*Vs* is the Swave velocity (m/s), μ is the modulus of shear /shear (Pa) and ρ is the density of the material through which the wave passes (Kg/m^3). According to Kearey et al.,2002 the formula of the P wave can be written

$$Vp = \left[\frac{\boldsymbol{K} + \boldsymbol{4/3}\ \square}{\boldsymbol{\rho}}\right]^{\mathbf{1/2}}$$

where*Vp* is the wave velocity P (m/s), K is the bulk modulus (μ is the modulus of shear or shear (ρis the density of the material through which the wave passes (kg/m^3)

II. STUDY AREA AND DATA

The acquisition of microtremor data was carried out on Tuesday, July 23, 2019, the data collection location was located in Grombo Hamlet, Bedoyo Village, Ponjong District, GunungKidul Regency. This process is carried out for 5 hours from 10.00 to 15.00 using 3 Seismometers. The location and design of the survey are shown on Figure 1.

FIGURE 1 The location and design OF THE SURVEY AREA

III. METHOD

Data Acquisition is carried out by slicing method with 3-component microtremor, with 6 trajectories forming a circle and 36 retrieval points, data retrieval using 3 microtremor tools with a measurement time interval of 10 minutes and sampling frequency of 150. HVSR data processing using amplification, frequency,

and contour values obtained from the calculation of ambient signals from the time series data components (Z, North-South, East-West) required calculation with Fast Fourier Transform. In data processing, there are several parameters that need to be considered, namely sampling frequency and smoothing used in this study are Kohno &Ohmaci. Microtremor data processing is carried out with the Geopsy application and the results will be contoured with surfer software, 3D imagery using Voxler software..

IV. RESULTS AND DISCUSSION

The results of inversion and modeling of subsurface conditions from this study consist of 6 tracks shown in Figure 2. According to the survey results, it is known that the diameter of the sinkhole is 12m, after processing data it is known that the dimensions of the sinkhole on line 1 is 12m, Vs at the center of the track have a value of Vs 0 m / s, Vs with a value of 0 indicates that there is a vacuum where secondary waves cannot propagate through air or liquid, the vacuum can be estimated to have a diameter of 12m, the sinkhole seen on the surface with the results of data processing shows the same value. The sinkhole is surrounded by sediment worth Vs 800-1200 m/s as per the literature in Table 1 the sediment is limestone, limestone is a soluble rock, the sinkhole area still has the potential to increase in size.

Table 1, Velocity *Vs* ,*Vp* and density form vaious stone (Keceli, 2012).

Soil and Rock type	**VP m/s**	**VS m/s**	**ρ g/cm^3**	**qa kg/cm^2**
Gabro	4500-6000	2700-4000	3.2-3.5	51.4-93
Granite	3300-5640	2000-3760	2.9-3.4	36-86
Schist	3200-5200	1454-3500	2.7-3.4	18-67
Limestone	1200-6190	600-3350	2.2-3.33	65-60
Mudstone	600-1900	300-700	1.8-2.26	2.8-5.8
Dilluvial gravel	900-2200	250-600	1.75-2.2	1.2-3.6
Gravel,dry sand	500-1000	200-300	1.7-1.8	1.3-1.6
Loose sand	600-1800	150-500	1.5-2	0.6-2.9
Aluvial gravel	400-1900	100-430	1.4-2	0.4-1.9
Dilluvial clay	500-1800	100-350	1.4-1.9	0.3-1.3
Alluvial clay	210-600	70-150	1.3-1.5	0.3-0.6

In track 2 the processing data shows a value of Vs 0 along 12 meters at the center of the circle, the value of Vs 0 is due to no layer / sediment that can propagate S waves or secondary waves, in the sinkhole edge area the Vs value begins to climb 800-1600 around the sinkhole, according to Table 1 the value of 800-1600 m / s is limesone, where in that area is the dissolving area of limestone. Line 2 does not show any underground river flow that should be shown with different amplification values / lower, this sinkhole is a suffosion sinkhole where water enters through the soil pores which causes limestone rocks in the area to dissolve.

On track 3 it is seen that at the center of the circle the microwavetremor cannot be reflected back because there is no solid medium in the area Vs obtained from the shear modulus divided by the density of the material, around the sinkhole there is limestone marked with wave velocity S reaching 800-1600 (at a depth of 25-50) showing the shear modulus and there is limestone material so that the S wave can propagate. The soil on the surface is a plantation and surrounded by rice fields it is one of the factors that sinkholes are formed, dense plantations can make the soil in the area saturated and the rocks below that are unable to withstand the load are formed sinkholes.

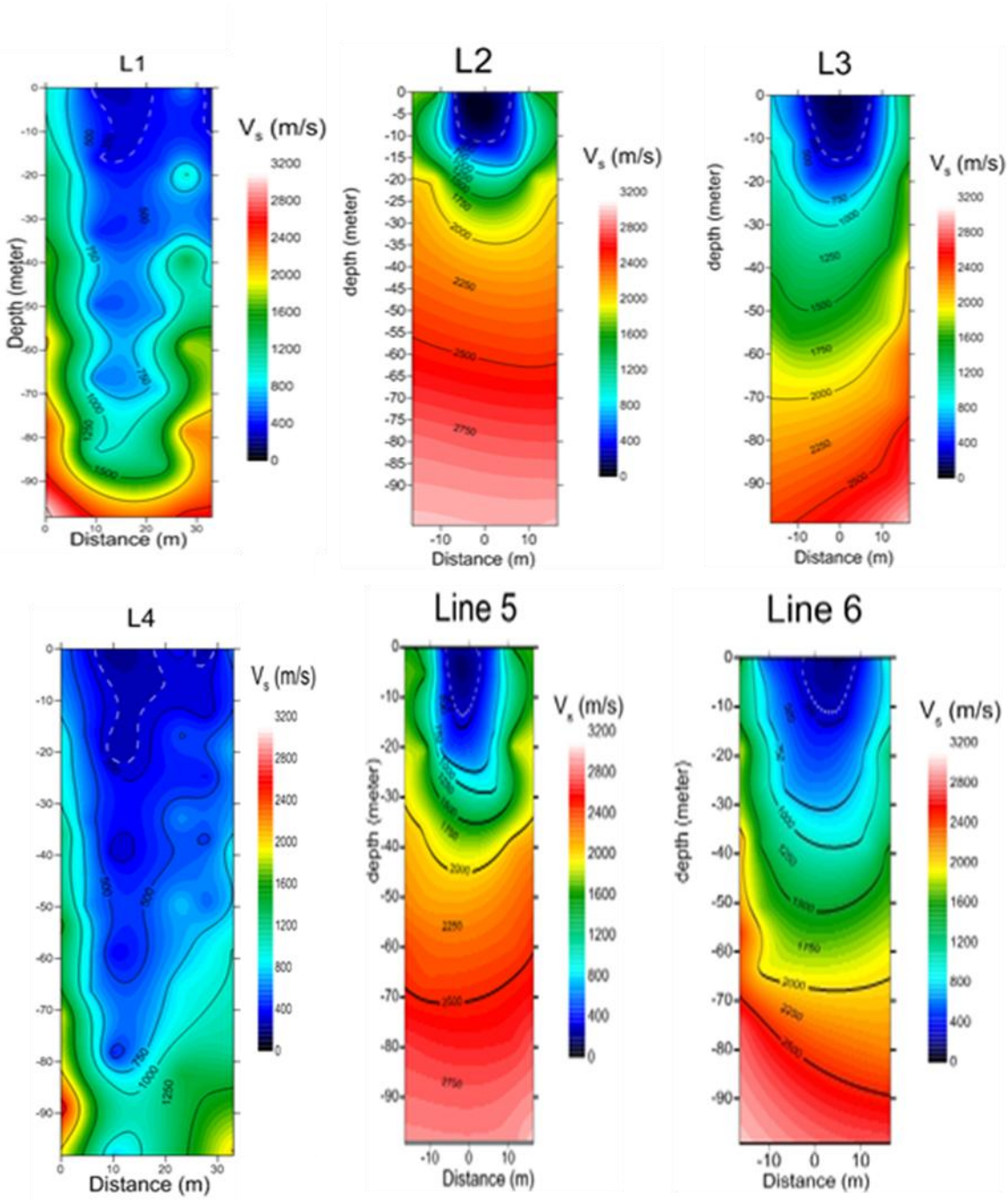

Figure 2 Inversion results and modeling of subsurface conditions from the study area

On the 4 s-wave trajectory it cannot propagate properly because the type of soil traversed is solid soil and soft rock where the density of the soil is smaller and the S wave can propagate on a solid medium, Vs with the number 0 indicates that there is no sediment that can conduct S waves in the area is a sinkhole area with a diameter of 12m and a depth of 10 meters. in the sinkhole area shows a low Vs value of less than 400 where in Table 1 the value is classified as Alluvial clay (70-150 m/s) and dilluvial clay (100-350) sinkhole enlargement may occur because clay is very easily disinfected with water.

The soil density shown in line 5 of the sinkhole circumference area shows a value between 400-800 m/s where the density in the area is small so that the transverse girder cannot propagate properly, clay sediments on line 5 are seen tending to the northwest of the curve can be seen at depths between 20-30 m. There are still easily soluble rocks in the sinkhole area so that the depth and width of the sinkhole will also still increase.

At 6 point 0 taken from the southeast towards the northwest, the sinkohole is seen to have a diameter of 12m and a depth of 10m. The larger the shear modulus the better the secondary wave propagation, the shear modulus is the shear perch against the shear stretch, the shear modulus also shows the stiffness of a sediment,

the greater the number, the greater the Vs. showing hard rocks can be seen in the image where the red color shows Vs+- 2800. sinkholes usually appear due to underground river flows that erode rocks but in this study area no underground river flow is found So that this sinkhole is included in the suffosion sinkhole, water that enters from rainwater or plantation water flow makes limestone erode and eventually a sinkhole is formed.

V. CONCLUSIONS

By using a three-component microtremor and with the HVSR method, the amplification value can be known so that the sinkhole dimensions can be known because the microtremor method uses shear waves, the waves are very susceptible to density differences so it is very good for detecting the lower layers of the soil. From the results of data processing of 6 passes, it is known that S waves cannot propagate in the absence of a medium. value Vs 0 m / s shows that there is no medium for the S wave to propagate, the sinkhole phenomenon in Ngrombo hamlet occurs due to the dissolution of subsurface limestone (suffosion Sinkhole), rainfall is one of the causes of the formation of sinkhole, water entering through the soil pores makes limestone dissolved so that The cave roof section is not able to withstand the weight of the surface. From the measurement results when in the field with research data , it shows that the sinkhole has a circular shape with a diameter of 12m and has a depth of 10m. The sinkhole in this area still has the potential to expand because the Vs value in the sinkhole

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