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VERY LOW FREQUENCY TO DETECT THE GROUNDWATER FLOW PATTERN IN A KARST AREA TODANAN KAB.BLORA

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ABSTRACT

Blora regency is one famous dryness and water deficiency regency in central Java. Geological condition of karst area with secondary porosity make its surface water goes into underground river system immediately. Applied very low frequency (VLF) methods to investigate underground river is usefull to solve dry season problems by underground water potential development in karst area of Kedungwungu village, Todanan, Blora. This research started from 23 to 28 Mei 2015 using T-VLF BRGM with 22000 Hz frequency on each 5 meter along 200 meter at 5 line. Measurement result data are tilt, ellips, H hor, H ver value that process to get RAE profile using matlab. There is red color of high anomaly value in depth 12-18 m on distance 30-40 m of line 1 and high anomaly value of line 2 and 4 in depth 15 m and distance 80 m. There are two point of high anomaly value from data processing result on line 3, they are located in distance 80 m and 40 m. Line 5 profile is shown high anomaly value in depth 16 m and distance 50 m. High anomaly value from data processing is interpreted as water in karst rock cavity and formed an underground river system. Based on data processing and interpretasion, we get profile of each line that inform a model of how an underground river system flow in east direction from underground river estuary on Todanan karst area, Blora.

Key Word: karst, underground river, very low frequency

INTRODUCTION

Water is one of the most important aspects of life because all the living being need water. Some areas in Indonesia experience dryness and water trouble in dry season so the people must buy water with expensive price for fulfilling their daily needs. The areas with dryness and water trouble, for example, an area with karst as the majority geology structure. The use of pump or drill well is difficult to do considering that the characteristics of aquifer system are hard to identify (Bahri *et al*., 2008).

Blora regency is known for one of the regencies in Central Java that always stricken by dryness and water trouble disaster in the dry season (Parwito, 2014). The water trouble was not a meteorological dryness because this area has a high rainfall annual average. Karst area with secondary porosity caused the surface water enter into the underground drainage system. Around 67% from the village area in the Blora Regency (197 from 295 villages) are included in the category of most damaging dryness area. The prople in that area started to face a difficulty in getting a pure water towards the dry season (Anonymous, 2014). The worst dryness struck 5 villages in Kecamatan Todanan, 10 villages in Banjarejo, 8 villages in Sambong, 4 villages in Jepon, and 5 villages each in Kecamatan Randublatung and Jati (Prayitno & Wibowo, 2002).

Kedungwungu village in Kecamatan Todanan is one of the areas with a karst majority geology structure. This karst area had a major problem of dryness, especially in the dry season. So this study aimed to identify the structure of underlayer surface and mapping the groundwater flow pattern in the Karst area of Todanan Blora Regency using VLF (*Very Low Frequency*) method.

VLF method is a geophysics method to measure the stone conductivity by identifying the characteristics of the secondary electromagnetic wave. This secondary wave is produced from the induction of primary electromagnetic wave with a very low frequency from 10-30 KHz. The frequency range is included in a very low group (Suyanto, 2007).

Working mechanism of VLF-EM that exploit the radiation of radiowave and VLF transmitter will induce a conductive earth layering system (Hiskiawan, 2011). This induction radiation pattern will cause a secondary electromagnetic field which give a natural disturbance of earth magnetic field (Hiskiawan, 2011).

The primary electromagnetic field of the radio transmitter has a vertical electricity field component of Ez and a horizontal magnetic field of Hy upright to the x-axis propagation area (Fraser, 2011). In a long distance from the transmitter antenna, the component of primary magnetic field become a horizontal wave. The existence of conductive medium under the surface caused the component of electromagnetic field able to induce the medium so it cause an induction (Grandis, 2009) as can be seen in Figure 1.

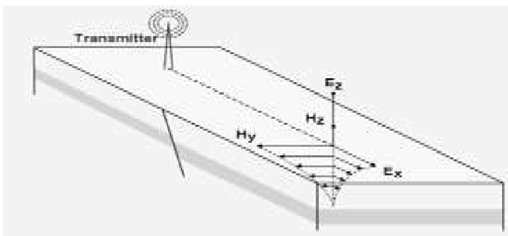

Figure 1. Electromagnetic wave in VLF method.

Eddy current by VLF magnetic field in a conductive soil produces secondary magnetic field with similar frequency and different phase. The vertical magnetic section of Hz is useful to determine the anomaly and then compare with the horizontal magnetic field to observe the tilt angular (Gufron, 2010). The characteristics of motive force (mf) induction turn up es with similar frequency, but a 90o phase was left behind when the primary wave enter into the medium (Kaikonen, 2009). Figure 2 showed the vector diagram between primary field P and its mf induction. The combination between P field and S field (R cosα) is called real component (in-phase) and an upright component of P (R sinα) is called imaginer component (Kalscheuer et al., 2008).

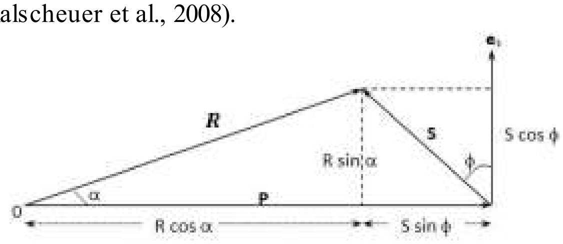

Figure 2. The Relationship of Amplitude and Secondary (S) and Primary (P) Wave Phase.

If the horizontal magnetic field is Hx and the vertical magnetic field is Hz, so the amount of tilt angular can be shown as in Figure 3, which is

$$\tan(2\theta) = \frac{2\left(\frac{H_z}{H_x}\right)\cos\phi}{1-\left(\frac{H_z}{H_x}\right)^2} x100\% \quad (1)$$

and the eliptisity is given as

$$\varepsilon = \frac{b}{a} = \frac{H_z H_x \sin\phi}{\left[H_z e^{i\phi}\sin\theta + H_x\cos\theta\right]^2} x100\% \quad (2)$$

Tangen from the tilt angular and the eliptisity is used to compare the component of S vertical secondary magnetic field and the P horizontal primary magnetic field, also to compare the component of the square from the S vertical secondary field to the P horizontal primary field (Figure 3).

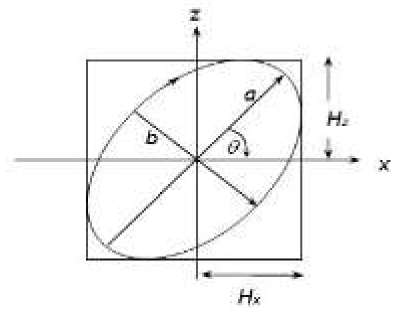

Figure 3. Polarization Parameter

This study used the instrument of T-VLF quantified data, that is tilt value and elips. The anomaly contrast that is calculated can be caused by the more conductive water-filled rock or a resistive air-filled rock cavity from karst area. That parameter hopefully showed a clearer anomaly as the effect of groundwater flow.

METHODS

This research was conducted in the Kedungwungu village, Todanan, Blora (Figure 4) on 23 to 28 May 2015.

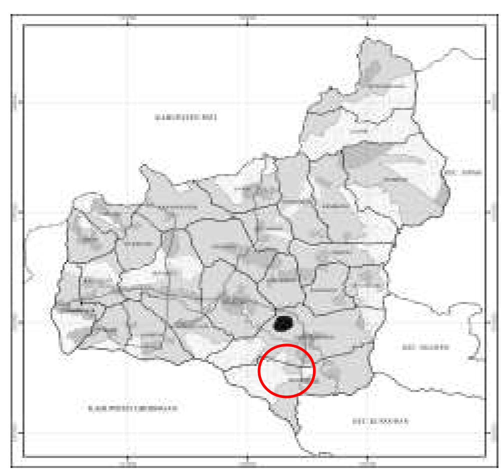

Figure 4. Research Area

To identify the groundwater flow in karst area Todanan, it is necessary to know the value of conductivity. The measurement step is:

1. Operator entering a few parameters (stations, spaces between stations, track number, frequency transmitter) via the [SET UP].
2. After everything is loaded, then start the measurement by pressing [START].
3. When stacking several measures are considered sufficient, press [START] again to stop. (Such as the START button or toggle switch button).
4. Calculate fraser derivatives by the equation:
   Fraser value of derivatives : $\frac{(a+b)-(c-d)}{n}$
   Where a, b, c and d is the value of a *tilt* at the point of measurement sequence and n is the number of data used in the calculation.
5. Calculating the real components and imaginary components (Karous & Hjelt, 1983):
   Real component (%) = 100.tanθ
   Imaginary component (%) = 100.ε

Data processing is performed by software *matlab*.

RESULT AND DISCUSSION

The data collection was conducted with survey design of 5 spread of paths which cut off the Macan Cave in karst area Desa Kedungwungu, Kecamatan Todanan, Kabupaten Blora. This study used VLF method to detect the groundwater flow pattern. The data found was tilt value, ellips, H hor, H ver in which was computed to get the profile of RAE score using matlab software. The profile of subsurface which is RAE score of every path was interpreted and then merged to get a groundwater flow pattern.

The result of data analysis to the five measurement path showed that there was an anomaly contrast of great value in every path. The great value anomaly contrast in the path profile was presented in the Table 1.

Table 1. High Anomaly as the Result of VLF Survey.

Path Profile	Great Value Anomaly Position	
	Gap from the end-path (m)	Depth of the Surface (m)
1	30 to 40	12 to 18
2	80	15
3	40 and 80	16
4	80	16
5	50	16

A high anomaly in each path profile was assumed as a cavity of the water-filled rock which formed a groundwater flow. The finding of the study showed that 5 spread of paths contained an anomaly contrast that indicated the existence of groundwater. The existence of groundwater showed through a conductive area with a high RAE score. "Deep groundwater" as the target in this study had a conductivity character or a good ability to bring an electricity power, so it can be identified with a high anomaly in the RAE profile. It was appropriate with the study conducted by Anita and Sismanto (2011) that the indication of "deep groundwater" was it had a high RAE score. The result of data tabulation which is RAE profile of the five paths was presented in the Figure 5.

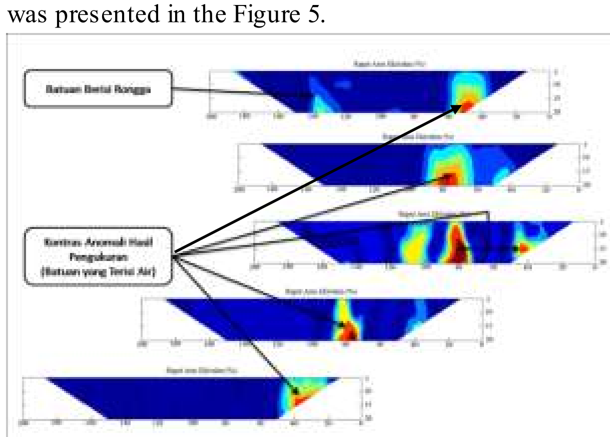

Figure 5. The Profile of Equivalent Current Density (RAE) from VLF Data Tabulation.

The analysis of RAE profile all paths was shown using matlab software with measurement frequency 22000 Hz. The result of the path 1 profile showed a high anomaly in the radius 30-40 m, red color was the highest anomaly contrast among other points. The red area was interpreted as a water that was assumed as an underground river in the depth of 12-18 m from the surface. A high anomaly value in path 2 and 4 was on the radius 80 m in the depth of 15 m. A high anomaly in path 2 and 4 was assumed as the water-filled rock cavity. Path 3 was also showed a high anomaly in the measure point radius of 80 m and 40 m which assumed to be a rock in the underground river structure that was able to pour the water. Path 5 showed a high anomaly in the measure point radius of 50 m with the depth of 16 m which assumed as a water-filled rock cavity.

An underground profile as the result of the study which was RAE anomaly contrast with a great value showed the existence of water-filled rock cavity. The combination of subsurface profile in the fifth path produced a groundwater flow by connecting the great value anomaly points in each path. The pattern of VLF method measurement path aimed to North-South. The interpretation result of groundwater flow in the research area was presented in the Figure 6.

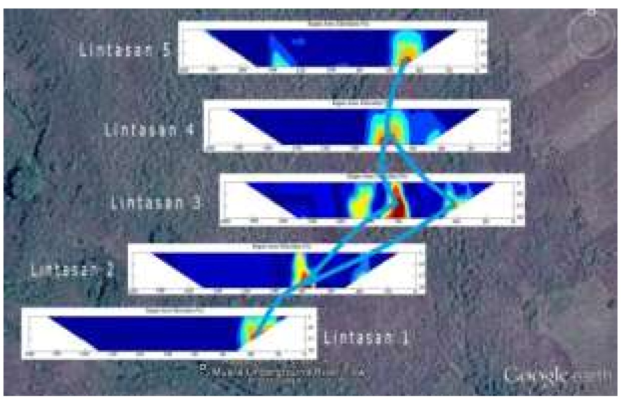

Figure 6. The Profile of Estimated Groundwater Flow Pattern

The finding of this study from the five subsurface profile using matlab software was that RAE value showed the pattern of groundwater flow to the East from the river-mouth of groundwater in karst area Todanan, Blora. The points with groundwater potential can be recommended based on the coordinate of the research finding that had a great value of RAE value anomaly contrast point. A great value anomaly point can be used as the further development and the finding of groundwater as an exploration result using VLF method. according to the result found, VLF method can be used to explore a water source finding as a water need fulfillment in the dry season in the research area.

CONCLUSION

Based on the research conducted through the process of VLF data tabulation and interpretation in the karst area Todanan Kabupaten Blora so it can be concluded as follows.

1. The interpretation result found the subsurface structure between the five paths and the pattern of groundwater flow in the jarst area Todanan Kabupaten Blora.
2. The groundwater flow pattern mapping result showed that the flow go to the East from the groundwater river-mouth.
3. The result of this research get the reference points of the groundwater potential as the further development process to become focus and guided.

BIBLIOGRAPHY

Anita, F. & Sismanto. 2011. Estimasi Aliran Sungai Bawah Tanah dengan Menggunakan Metode Geofisika VLF em, Mode Sudut Tilt di Daerah Dengok dan Ngrejok Wetan, Gunungkidul, Yogyakarta. *Prosiding Pertemuan Ilmiah XXV HFI Jateng & DIY*. 9 April 2011, Purwokerto, Indonesia. Hal. 130-133.

Anonime. 2014. 197 Desa di Kabupaten Blora Rawan Kekeringan. http://www.infoblora.com/2014/04/197-desa-di-kabupaten-blora-rawan.html (6 Mei 2014).

Bahri, A.S, Santoso, D, Paradimedja,D.D, Tofan RM, Santos, FM. 2008. Penerapan Metode VLF-EM-Vgrad Untuk Memetakan Sungai Bawah Permukaan Daerah Karst. *Indonesion Scientific Karst*. Jogjakarta. 19-20 Agustus 2008.

Ford, D.C. & P.W. William. 2007. *Karst Geomorphology and Hydrology*. Chicester : John Willey and Sons.

Fraser, D. C. 2011. Contouring of VLF-EM data: *Geophysics*, 34, 958-967.

Grandis, Hendra. 2009. *Pengantar Pemodelan Inversi Geofisika*. Bandung. Himpunan Ahli Geofisika Indonesia (HAGI).

Gufron. 2010. *Estimasi Penyebaran Deposit Fosfat di Daerah Perum Perhutani KPH Pati BKPH Sukolilo Pati dengan Metode Very Low Frequency Elektromagnetik Vertikal Gradient (VLF-EM-VGrad)*. FMIPA. Jurusan Fisika. Institut Teknologi Sepuluh Nopember Surabaya.

Hiskiawan, P. 2009. High Resolution Deteksi Reaktif Patahan Dangkal dengan Metode Geofisika, VLF-EM. *Jurnal Ilmu Dasar* Vol. 10 No. 1. 2009 : 68 – 76.

Kaikonen, P. 2009. *Numerical VLF Modelling Geophysical Prospecting*. 27, 815-834.

Kalscheuer T, Pederson L.B. & Siripunvaraporn W. 2008. Radiomagnetotelluric Twodimesional forward and inverse modeling accounting for displacement current. *Geophysics.J.Int*.175, pp 486-514.

Karous, M. & S.E. Hjelt. 1983. Linear Filtering of VLF dip angle Measurement. *Geophysics Prospecting V*. 31:782-794.

Parwito, 2014. *Walhi: Jateng terancam bencana darurat kekeringan*. http://www.merdeka.com/peristiwa/walhi-jateng-terancam-bencana-darurat kekeringan.html (29 Nov 2014).

Prayito, T.H. & K.A. Wibowo. 2002. *Warga Blora Semakin Susah Mendapatkan Air*. http://news.liputan6.com/read/37160/warga-blora-semakin-susah-mendapatkan-air (6 Mei 2014).

Suyanto, I. 2007. Analisis Data VLF (Very Low Frequency) untuk Mengetahui Kemenrusan Pipa Gas Bawah Permukaan di Gresik, Jawa Timur. *Jurnal Fisika Indonesia*. 11 (34): 169-179.