Application 4D Resistivity Method for Determining Effect of Water Content; Case Study ITERA Campus

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Abstract. This is a study of the application of the time lapse resistivity method (4D resistivity) to analyze the dynamics of the movement of subsurface fluids (ground water). This study used to analyze the decline in the ground water table due to differences in the rainy and dry seasons. The 4D resistivity study was conducted at the ITERA campus in June (rainy season) and September (dry season). The resistivity method used Electrical Resistivity Tomography (ERT) with the Wenner Alpha configuration. Data acquisition uses 36 simultaneous channel with ARES Multichannel and Multielectrode resistivity meters instrument with length is 385 meters. Based on the first measurement (rainy season), it was found an unconfined aquifer layer with a moderate resistivity value (11 – 80 Ω.m) which was assumed to be tuffaceous sandstone at a depth of 11 – 35 m. Whereas in the second measurement (dry season), it was found an unconfined aquifer layer with a moderate resistivity value (11 - 80 Ω.m) which was assumed to be tuffaceous sandstone at a depth of 11-28 m. Based on the results of time lapse inversion processing, it is found that the change in resistivity for the two sets of data almost the same at all measurement points, except at certain points, which shows a greater percentage. This shows the change in resistivity values if measured at different times. This difference is due to the absorption of rainwater by the surface which then migrates into the inner layer.

1. Introduction
The time lapse resistivity method (4D resistivity) is the application of the resistivity method that is carried out at the same location with different times. The 4D resistivity method is a new method applied at the end of 2000. 4D resistivity research has been conducted by [1], [2], [3], [4], [5].

The application of 4D resistivity is carried out on the ITERA campus because the ITERA campus is a new campus which is accelerating infrastructure development. In accelerating development at ITERA, the availability of fresh water is particular concern because the increased need for fresh water is used to meet the needs and services on campus, one of which is sourced from ground water. Increased need for fresh water sourced from ground water will affect the level of ground water level. In addition, the change of season from the dry season to the rainy season or vice versa will affect the quantity of groundwater discharge at ITERA. This study aims to identify changes or dynamics of subsurface fluids, especially water table.

2. Regional Geology
The ITERA campus area is in the Lampung Formation (QTI) which is dominated by a unit of rock namely volcanic rocks [6]. The volcanic rocks consist of pumiceous tuffs, rhyolitic tuffs, welded tuffs, tuffaceous claystone, and tuffaceous sandstones. The Lampung Formation is a quarter-age volcanic rock (transition from Pliocene to Plistocene). Quarter-age rocks can be categorized as young rocks.
3. Resistivity method
The resistivity method is a geophysical method based on variations in subsurface electrical properties [7]. The resistivity method is carried out by injecting an electric current from the surface through an electrode and capturing or recording the response from the earth (subsurface) in the form of a potential difference value with an electrode as well. Responses recorded from the subsurface will represent the electrical properties of the subsurface conditions in the form of resistivity. The resistivity value obtained from the measurement is not the actual resistivity value, but the apparent resistivity value that has been influenced by the surrounding rock. Pseudo resistivity values assume the earth has a homogeneous layer, so to get the actual earth model (heterogeneous model) inversion modeling process is carried out.

The resistivity method used in this study is 4D resistivity with the Electrical Resistivity Tomography (ERT) method with the Wenner Alpha configuration (Figure 1). ERT measurement is done by injecting electric current to the subsurface of the earth so as to obtain resistivity pseudosection or a distribution model of resistivity value of subsurface material laterally and vertically [8]. The concept of the 4D resistivity method is basically a measurement of repeated resistivity at the same location. Initial time data is used as a reference to see anomalous changes from time. The 4D resistivity method can be applied to see subsurface changes caused by fluid movement.

![Figure 1. Current and potential electrode with Wenner Alpha configuration](image)

The 4D resistivity study uses the Electrical Resistivity Tomography (ERT) method and the Wenner Alpha configuration on the ITERA campus on the same line, during in June month (rainy season) and the September month (dry season) (Figure 2). The instrument in this measurement is ARES Multichannel and Multielectrode resistivity meters. The length of the measuring line is 385 meters with the distance between the electrodes is 11 meters (Figure 3).

![Figure 2. Rain rate of ITERA Campus (MKG ITERA-2019)](image)
4. Results and Discussion

4D Resistivity measurements were carried out on the same line, during in June month (rainy season) and September month (dry season). The first resistivity measurement results (rainy season) and the second (dry season) obtained rock lithology namely tuffaceous (> 80 Ω.m), tuffaceous sandstone (11 - 80 Ω.m), and tuffaceous claystone (2 - 11 Ω.m) (Figure 4). Based on the first measurement (rainy season), an unconfined aquifer layer was found on the tuffaceous sandstone at a depth of 11 - 35 m. In the second measurement (dry season) also found a layer of unconfined aquifer but at a depth of 11-28 m. Resulting in a reduction in aquifer thickness ± 7 m.

In this study also conducted inversion modeling using time-lapse resistivity inversion to see the percentage change in the first and second resistivity measurements. The time-lapse resistivity inversion parameters used are the least-squares smoothness constraint, the simultaneous inversion method and 7 iterations. Based on the results of time lapse inversion processing (Figure 5), it is found that the resistivity changes for the two data sets are almost the same at all measurement points, except for electrode points 12-19, which show a greater percentage. This shows the change in resistivity values if measured at different times. This difference is due to the absorption of rainwater by the surface which then migrates into the inner layer.
Figure 5. Percentage changes of resistivity between two measurement data sets

5. Conclusion
The 4D resistivity measurements done at ITERA on the first and second measurements show the similarity of subsurface models to the resistivity value of rocks. The resistivity values obtained are the low resistivity value (2 - 11 Ω.m) which is assumed to be tuffaceous claystone, the moderate resistivity value (11 - 80 Ω.m) which is assumed to be tuffaceous sandstone, and the high resistivity value (> 80 Ω.m) which is assumed Tuff. However, there is a difference in thickness of the unconfined aquifer on tuffaceous sandstone which is ± 7 m. In addition, based on the time lapse inversion also obtained changes in resistivity for both measurements at electrode points 12-19. This difference is thought to be due to the absorption of rainwater by the surface which then migrates into the inner layer.

Acknowledgement
We thank you to Directorate of Research and Community Service, Ministry of Research, Technology and Higher Education with contract number 009/SP2H/LT/DRPM/2018 to providing the funding for this research. To Lab Geoscience for the resistivity instrument, UPT MKG ITERA to provide the secondary data and also to geophysical engineering ITERA students to assist with acquisition data.

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