Monitoring of rainfall infiltration to under surface using DC resistivity method

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Abstract. The use of non-agricultural land in Universitas Pendidikan Indonesia causes the land absorption to be smaller than the use of soil for agriculture so that it can lead to surface runoff. This study discusses how to monitor rainwater infiltration to subsurface using resistivity method with Wenner’s configuration and weather data. The data retrieval takes place twice with a span of two months and is in the same place. In the model is also seen when the layer of purple rocks have decreased in volume from the first data retrieval on the second data retrieval. While the rainwater infiltration layer more evenly. Monthly weather reference data showed that temperature and evapotranspiration relationships over the months showed the results from September to December were relatively stable with average temperatures of four months being 22.38 ºC and evapotranspiration was 5.02 cm / month. Therefore, the evaporation caused by all water, soil, vegetation and the earth's surface located at the site is 5.02 cm / month. Monitoring of rainfall infiltration within two months from the first measurement having rainfall infiltration of 3.9 mm / h indicates that infiltration rate is very fast and the magnitude of evapotranspiration is 5.02 cm / month.

1. Introduction
The land use is a form of intervention or human intervention of land or land, either permanently or periodically to meet the needs of life both material and spiritual. Land use must be balanced with the maintenance of the land itself so that the results obtained in accordance with the needs of the population. Damage to the soil may affect the magnitude of infiltration capacity. Small infiltration capacity can cause very little soil to absorb rainwater resulting in little groundwater, high waterlogging or flooding and soil erosion [1]. Universitas Pendidikan Indonesia (UPI), Bandung, Indonesia is an area that has a good variety of land use for agricultural and non-agricultural. Agricultural land in UPI is used for mixed garden which is dominated by tall leafy trees and grasses. The use of non-agricultural land causes soil absorption to be less than the use of soil for agriculture so that it can lead to surface runoff.

The DC resistivity method is used for subsurface investigations, especially in aquifer formation layer [2]. Resistivity survey investigations are carried out on the basis of the physical properties of rocks or soils against electric currents, where each different rock will have different resistivity values. The method developed in the early 1900’s, but began to be widely used since the 1970’s this is related to the availability of computers to process and analyse resistivity data. Groundwater is found in geological...
formations called water aquifers. The depth of the aquifer in one area is not the same as the other, depending on several factors such as climate/season, vegetation, topography, soil porosity and permeability [3]. DC resistivity also widespread used in leachate infiltration and landslide mitigation [4-7]. Rainfall infiltration capacity of the research location has been identified in previous study with value 23.59 cm/h to 28.18 cm/h by soil texture test [8]. Nevertheless, this study enhances the prior information as a comprehensive integration to verify infiltration of rainfall to the ground by time lapse, also with different approach.

2. Methods
The research location is located on grass field, Universitas Pendidikan Indonesia, Bandung. This study aims to monitor the infiltration of rainwater to subsurface using Wenner's method of resistivity DC resistivity. The geographical location is at coordinates 6 ° 51'38.46 "S and 107 ° 35'21.05" E.

![Figure 1. Research location (left) dan measurement lines (right).](image)

Data retrieval takes place twice with a span of two months and is in the same place. The first collection was conducted on Saturday, October 14, 2017 with the data obtained in the form of three trajectories. The second data retrieval takes place on December 12, 2017 for track 1, on December 16, 2017 for track 2 and December 17, 2017 for path 3. Second data collection is not carried out in one day due to weather conditions at it was raining. The rainfall used in the duration of 4 months is from September 19, 2017 to December 27, 2017. Then, there is an interval of two months from the first data retrieval. Rainfall data obtained from the Portlog® device with an interval of 10 minutes, then the data summed every 10 minutes interval in 24 hours duration so that will get the value of rainfall in that time.

3. Results and Discussion
Based on the resistivity section, the result shows that the rainfall infiltration is at a depth of 6 - 9 m, identically with a low aquifer. The results data processing that the infiltration in grassy surface has varying depth in any measurement path which has a span of approximately 2 months from the first measurement using software Voxler demo.
Figure 2. 3D model results from the 1st resistivity measurement profiles on October, 2017 (left) and 2nd resistivity measurement profiles on December, 2017 (right).

Figure 2 shows that comparison of visualization results of data look quite contrast. In the first data-visualization, it is clear that rainfall infiltration does not spread evenly. While on the second data retrieval, rain water infiltration spread evenly with rock layers whose volume is getting thinner. This is due to the infiltration process due to the high rainfall intensity at the time before the second data collection. The 1st measurement model shows that the depth of rainwater infiltration has varying depth in each measurement path starting from a depth of 0.75 - 5 m. At the first measurement, the weather conditions a few days earlier was good and there were only a few drizzling showers, so that when the weather data were retrieved it was good to retrieve the final track data. Rain water flows from a 40 m stretch to a 2 m stretch. Rainfall infiltration in December was more than in October due to more rainfall capacity in December so that water would fill the ground below. At the time of data retrieval of the two times ranges from the second data retrieval for two months. Prior to data retrieval of two weather conditions a few days earlier it was more frequent to rain in the late afternoon causing more moist soil during data retrieval. Reciprocally when taking data, there was drizzle for a while. It was then observed that the observed rainwater was in a layer at a low depth. This is because; water has not been absorbed perfectly by the soil layer. Rainwater is on a stretch of more than 10.4 meters and a stretch of 55 until 72 m. When compared with the first measurement of rainwater filling on a 2 meter stretch and within two months the capacity of rainwater becomes more then the infiltration rate is very fast. The value obtained of 449.9781508 for the first data while for the second data 4324.079443. Lithology of this area in the form of silt clay, and sandstone so that if the infiltration rate is very fast. Then, it is predicted that the texture of the soil area is sandy clay which has an average infiltration rate of 79.96 cm / hour to 89.16 cm / hour and infiltration capacity of 23.59 cm / hour to 28.18 cm / hour [8]. This previous study, we improve with updated data from weather station. Then, the weather data during 4 months measurement with 10 minutes interval was processed by Thornthwaite method to reveal temperature (T) and evapotranspiration (ETP) among time lapse measurement [9].

Table 1 shows the relationship between temperature and evapotranspiration at various months that the temperature and evapotranspiration results from September to December were relatively stable with the average temperature of the four months was 22.38 °C and the evapotranspiration was 5.02 cm/month. Therefore, the evaporation caused by all water, soil, vegetation and the earth's surface located at Universitas Pendidikan Indonesia is 5.02 cm/month.
Table 1. The relationship between average temperature and evapotranspiration on September until December 2017 [9].

| No | Month   | T (°C) | ETP (cm/month) |
|----|---------|--------|----------------|
| 1  | September | 22.39  | 5.13           |
| 2  | October  | 22.57  | 5.33           |
| 3  | November | 22.05  | 5.05           |
| 4  | December | 22.53  | 5.32           |

4. Conclusion
This study can be concluded that the method of resistivity shows the response in accordance with the model. In detecting infiltration anomalies, the method is sensitive to lateral changes that show the infiltrated of rainfall and weather data analysis when arranged laterally. However, the appropriateness of the resistivity value and the weather data still need further study to get correlation between the two methods. Monitoring of rainfall infiltration within two months from the first measurement having rainfall infiltration of 3.9 mm/h indicates that infiltration rate is very fast and the magnitude of evapotranspiration is 5.02 cm/month. This result needs to be followed up by stake holder in order to manage the surrounding of research location.

5. References
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