Study of soil physical properties in UIN Sunan Gunung Djati campus area using geoelectrical resistivity method

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Abstract. Study of Soil physical properties are important characteristics of the soil. The description of soil physical properties is very important to investigation the function of the soil as a plant growth medium. The aim of this study was to determine the physical properties of the soil based on geoelectric resistivity data. The study was conducted in UIN Sunan Gunung Djati campus area. The method used in this study was geoelectrical resistivity of wenner configuration method. The results showed the value of resistivity, porosity and soil fraction. Range value of soil resistivity was 50-800 Ωm. Soil porosity was 5-50%. The soil fraction component consists of coarse sand, fine sand and clay. Soil resistivity was inversely proportional to soil porosity. The high soil resistivity is likely due to the low soil moisture, causing generally campus area still open. Based on the soil fraction component, soil texture in the campus area tends to be Loam Sandy. It is good for aeration and water holding. This condition is very good for plant growth.

1. Introduction

Soil in the ecosystem acts as a natural resource factor. As a basic resource, it is a need that is consumed or used directly organisms in supporting growth [1]. The soil is an important component for all terrestrial ecosystems, because the soil is directly involved in controlling water, carbon, nitrogen and other element cycles and gas exchange in ecosystem [2]. Exploration of soil physical properties becomes a very important study to find out the texture, structure, porosity, density, water retention and transmission, soil color, temperature and soil strength because these factors directly effect on growth plant directly and indirectly [3,4]. In other fields, for example in civil engineering purposes, exploration of soil physical properties that relating the characteristics underground surface such as rocks profile, is very important to be used as an estimate of construction design [5].

Information about soil physical properties in the campus area of UIN Sunan Gunung Djati is still lacking or it can be said there is no data. Soil resistivity, porosity, and soil texture are very important physical parameters for to know the real condition of soil quality in an area. Research on soil resistivity and porosity provides important information about soil quality in Riau University campus area, Pakanbaru [6]. Therefore, the research of mapping the soil physical properties in campus area of UIN Sunan Gunung Djati needs to be done. The results of these studies can be used as a basis for assessing land as a medium for plant growth as well as a basis for designing a green campus in the
future. Besides, this research can also be used as guidelines and estimates in constructing building design in the campus area.

The Wenner configuration geoelectrical resistivity method was used in the analysis of physical parameters in this study. This method is commonly used in analyzing soil physical properties. The geoelectrical resistivity method is a method that injects currents into the ground surface by utilizing four parallel metals to determine the geological state of the soil based on the measured soil resistivity \cite{7,8}. This method is very efficient because it does not damage the soil, it is very sensitive or accurate to describe the underground surface with it digging \cite{6,9,10}. The Wenner configuration resistivity geoelectrical method are easily and efficiently analyzes the soil structure in the backyard of ITS University, Surabaya \cite{8}. The purpose of this study was to determine the resistivity, porosity and soil texture in the UIN Sunan Gunung Djati Bandung campus area, so that the data of soil quality in the campus area were obtained.

2. Methods

The use of environmental physics concepts, especially to determine the conditions in the soil or soil fertility in terms of biology, requires a method of data collection. The method used in this research is the geoelectric method. This research was conducted in the construction area of Campus 2 of UIN Sunan Gunung Djati Bandung on Jalan Cimencrang, Bandung City with coordinates 6°56'19"S 107°42'16"E (figure 1). The number of measurement paths are 3 lines (L.1, L.2, and L.3). Each track has ± 192 meters with the initial space along 6 meters. Masagi Resistivity Meter Multichannel is used in the processing of data acquisition. The geoelectric method applied in this study is the geoelectric imaging using the Wenner configuration. Wenner configuration is one of the configurations that are often used in geoelectrical exploration with the same spacing arrangement \((r_1 = r_2 = r_3 = r_4)\). Wenner configuration is used because it has a high sensitivity to vertical changes, this is very important in determining the boundary layer for identification of rock lithology at the study site \cite{11,12}. The resistivity calculation is obtained from the difference potential and current data. The resistivity formula used is:

\[
\rho = k \frac{\Delta V}{I} \quad \rightarrow \quad k = \frac{2\pi}{\left(\frac{1}{r_1} - \frac{1}{r_2}\right) - \left(\frac{1}{r_3} - \frac{1}{r_4}\right)}
\]

Where \(\rho_a\) is the apparent resistivity \((\Omega m)\), \(\Delta V\) is the read potential \((mV)\), \(I\) is the current value and \(K\) is the geometrical factor \cite{13}.

The relationship between resistivity and porosity can be calculated using the Archie equation:

\[
\rho = a \rho_w \phi^{-m}
\]

![Figure 1. (a) Study location, (b) Scheme of track study.](image-url)
Where \( \rho_w \) as a prisoner of the type of liquid contained in rock pores (\( \Omega_m \)), \( a \) is an empirical constant of the soil rock that is valued 1.00, \( \emptyset \) its porosity and \( m \): empirical constants of cementation that is valued 2.00. While the equation to calculate the relationship between porosity and density of the rock can be calculated by Todd equation [14];

\[
d_s = \frac{d_d}{1 - \emptyset}
\]

Where \( d_s \) is the density of the material; \( d_d \) is the dry density; \( \emptyset \) is porosity.

3. Results and discussion

Based on the results of the calculation resistivity values shown in table 1, it was found that the soil resistivity values in the campus area 2 of UIN Sunan Gunung Djati ranged from 50-800 \( \Omega \)m with range of porosity are 5-50%. The relationship of resistivity and porosity inversely (figure 2), the greater soil resistivity the smaller porosity value. These results are consistent with other research in the Riau University campus area, Pakanbaru, which reports that soil porosity is inversely proportional to the resistivity value, the greater resistivity the smaller porosity [6]. The high soil resistivity in the UIN campus area is likely due to the low soil moisture in the area. This condition is influenced by high soil temperatures, causing generally campus area still open. The rise and fall of soil temperature will affect the resistivity of the soil, high soil temperatures result low soil moisture, thus declining soil resistivity value [7].

| Resistivity (\( \Omega \)m) | Porosity (%) |
|--------------------------|-------------|
| 0.1                      | 55          |
| 50                       | 50          |
| 100                      | 37.5        |
| 250                      | 32.5        |
| 400                      | 25          |
| 600                      | 15          |
| 800                      | 5           |

Soil porosity is an indicator of soil structure quality [15]. Porosity describes the proportion of empty space occupied by water and air of soil volume. The amount of soil porosity depends on 1) packing density, 2) distribution of particle size 3) shape of particles and 4) cementing [16]. Based on soil porosity data, we can estimate the soil fraction or type of sediment material. Based on table 2 shows that the soil fraction in the campus area is coarse sand, fine sand and clay. Based on the soil fraction, the soil texture tends to be loam sandy. It shows that the soil in the campus area is very supportive for plant growth. This is because the soil is mostly sand dominated, so the soil has large pores, making root plant easier to penetrate in the soil with good drainage and aeration. The clay fraction will help the soil to holding water. This condition is very good for plant growth, and then it will make easier to realize a green campus of UIN Sunan Gunung Djati.
Figure 2. The relationship of the soil porosity and soil resistivity.

Table 2. The range of porosity value with the type of sediment material.

| Type of Sediment Material | 3.1. Porosity (%) |
|---------------------------|-------------------|
| Soil                      | 50-60             |
| Clay                      | 45-55             |
| Silt                      | 40-50             |
| Medium coarse sand        | 35-40             |
| Sand                      | 30-40             |
| Medium fine sand          | 30-35             |
| Gravel                    | 30-40             |
| Gravel and sand           | 20-30             |
| Breccias                  | 10-20             |
| Flake                     | 1-10              |
| Limestone                 | 3.2. 1-10         |

4. Conclusion
Soil physical properties in UIN Sunan Gunung Djati Bandung campus area that can describe in this research are range of soil resistivity between 50-800 with range of porosity 5-50%. The soil fraction consists of coarse sand, fine sand and clay. Based on the three components, soil texture tends to be loam sandy. Such soil texture will be very supportive for plant growth.

Acknowledgment
We acknowledge to Universitas Islam Negeri Sunan Gunung Djati Bandung. We thank to all participant for their help with filed collection and/or technical support.

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