Combined DC Resistivity Survey and Electric Conductivity-Dielectric Permittivity Measurement at Sag Pond near Lembang Fault, West Java, Indonesia

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Abstract. Lembang Fault is a normal fault situated at the southern flank of Tangkuban Parahu Volcano in West Java Indonesia. The fault’s movement may have caused the formation of sag pond in the vicinity of its which is characterized by the soil layers of the sag pond. The characteristics of the soil can be examined based on its electrical properties such as conductivity (the inverse of resistivity) and dielectric permittivity. Direct field measurement was conducted using DC-resistivity Wenner-Schlumberger method on the sag pond as well as laboratory resistivity measurement of cores taken from the sag pond. Two resistivity cross-sections were obtained after performing 2D inversion of the data which reveal that the resistivity distribution consist of a resistive layer (40-60 ohm.m) overlying a medium resistive layer (30-35 ohm.m). The third layer has relatively low resistivity of 16-25 ohm.m. At the intersection of these two lines we took coring samples down to depth of 5 m below surface and measured the electrical conductivity and dielectric permittivity for each 1 cm of sample using EM-50 data logger. Results from both field and laboratory measurement were analysed to get a better understanding of the sag pond.

1. Introduction

Soil is porous media which consists of minerals, water and air [1] possessing physical, chemical and electrical properties [2]. Electric conductivity and dielectric permittivity are parameters that control the electrical properties of the soil [3]. Electric conductivity is the ability of the soil in conducting electricity, which is affected by clay content, water content, salinity, moisture, mineralogy, organic, and temperature [4]. Dielectric permittivity is the ability of a material to store electric energy when given a potential difference [3], and dielectric permittivity of soil relies on its minerals, air and water content [3, 5, 6].

Previously, Ground Penetrating Radar (GPR) survey has been carried out at a sag pond around Lembang Fault, West Java, Indonesia [7], providing results that are considered not sufficient for
interpreting the soil layers in the sag pond. In this study, we applied 2D DC resistivity method at the same location and soil sampling for laboratory analysis to obtain information of electric conductivity and dielectric permittivity of the soil.

2. Methods
DC resistivity data were collected in the village of Parongpong Karyawangi, West Java, Indonesia on May 2015 using Mc Ohm OYO type 2115 A. A Wenner-Schlumberger configuration with electrode spacing 1 m was deployed as to provide higher vertical and horizontal sensitivity. The resistivity measurement covers two intersected lines (Line 1 and Line 2 in ‘Figure.1’) where which the sampling was taken at the intersection point of these lines.

Soil samples were taken in the field by using a 4 cm diameter hand Auger. The samples were taken vertically down to 5 m depth. In laboratory, measurements of the electrical conductivity (EC) and dielectric permittivity of the samples were conducted for every 1 cm using the EM 50 data logger.

![Figure 1. Location resistivity measurements in Lembang, north of Bandung, West Java.](image)

3. Result and Discussion
Resistivity sections resulted from the data inversion of Line 1 and Line 2 are depicted in Figure 2 – Figure 5. Resistivity values beneath Line 1 whose length is 58 m (‘Figure 2’ and ‘Figure 3’) vary from about 15 to 60 ohm.m with relatively high resistivity (40-60 ohm.m) at shallow depth near the surface (until 125 cm below surface) followed by medium resistive layer (25-25 ohm.m) and low resistivity (15-25 ohm.m) which is concentrated mainly in the western part of the section. The high resistivity layer is associated with the presence of vegetated top soil, whereas the medium layer may indicate higher water content in the soil and the low resistivity zone may be attributed to the enhancement of conductivity due to higher contents of water and clay.
Figure 2. 2D resistivity cross-section of Line 1 and resistivity profile obtained from sampling. The resistivity profile is obtained from 1/EC measured vertically at 1 cm spacing.

Figure 3. 2D resistivity cross-section of Line 1 and dielectric permittivity profile obtained from sampling. The dielectric permittivity profile measured vertically at 1 cm spacing.

Measurement of the electric conductivity in laboratory was conducted along 500 cm vertically sampled soil at every 1 cm. The electric conductivity profile which is expressed in its inverse value or resistivity is depicted in ‘Figure 2’ overlapped with the resistivity section obtained from 2D inversion. The range of electric conductivity values is between 0.01 and 2.45 dS/m. This range is equivalent to a range of resistivity between 4.08 to 1000 ohm.m. ‘Figure 3’ shows the profile of dielectric permittivity vs depth at the same sampling site and 2D resistivity sections. The dielectric permittivity vary from about $7\mu_0$ to $25\mu_0$.

2D resistivity cross-section of Line 2 extending from South to along 29 m is shown in ‘Figure 4’ and ‘Figure 5’. The resistivity values beneath Line 2 are similar to those of Line 1, which vary from about 15 to 60 ohm.m with relatively similar pattern. However, the low resistivity zone beneath this line is concentrated mainly in the southern part. The same as Line 1, the electric conductivity profile which is expressed in its inverse value or resistivity is depicted in ‘Figure 4’ overlapped with the resistivity section obtained from 2D inversion. From the surface down to about 249 cm, the electric conductivity values vary between 0.03 and 1.61 dS/m which is equivalent to a range of resistivity between 6.21 to 334 ohm.m. ‘Figure 5’ shows the profile of dielectric permittivity vs depth at the same sampling site and 2D resistivity sections. The dielectric permittivity values vary from about $8.78\mu_0$ to $25.58\mu_0$ which is almost the same as that of Line 1.
From comparison of resistivity values revealed from the Wenner-Schlumberger data inversion and the resistivity profiles obtained from sampling (‘Figure 2’ and ‘Figure 4’) it is seen that both exhibit decreasing tendency towards greater depths. This may be attributed to higher clay content and or water content. The moderate resistivity zone may correlate to the presence of water in sand layer.

High water content generally is indicated by high value of dielectric permittivity, this feature also shown by dielectric constant profile from the site (‘Figure 7’, right). Judging from both resistivity and dielectric profiles and usual dielectric values of geological materials (‘Figure 7’, left) it most likely that the high resistivity zones accompanied by high dielectric value as found in the western part of Line 1 and the southern part of Line 2 are due to high water content as water infiltrates and accumulates likely at or near the fault that controls the formation of sag pond.

![Figure 7](image7.png)

**Figure 7.** List of dielectric constants of typical geological materials [8] (left) and profile of dielectric constants obtained from the laboratory measurement.
4. Conclusions
Investigation of resistivity distribution using 2D Wenner-Schlumberger DC resistivity method of a sag pond situated in Lembang, West Java, Indonesia has been conducted accompanied by measurements of electric conductivity and dielectric permittivity of soil samples taken at the intersection of two DC resistivity lines. The results show that addition of sampled electric conductivity and dielectric permittivity profiles significantly help the interpretation of the inverted resistive sections. Low resistivity zones that are found beneath the lines are interpreted to be attributed likely by the presence of water.

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