Resistivity characteristics of soil saturated with variation of salt water-fresh water mixture

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Abstract. Peat soil has a specific physical character if compare with the other sediments. It has amount of organic matter and has relatively porosity and permeability. This preliminary research is to predict the salt water content in the soil and peat soil aquifer later on. This research is to investigate the resistivity characteristic of peat soil saturated with variation of salt water-fresh water mixture. Six undisturbed soil and peat soil samples were taken from difference sites in the coastal area. The soil and peat soil samples then saturated with difference amount of salt-fresh water mixture. The resistivity measurement then was measured to the soil and peat soil saturated with the salt-fresh water mixture. The result show that the resistivity decreases drastically as the increasing of a little amount of salt water in the salt-fresh water mixture.

1. Introduction
Occurrence of peat soil in the coastal area is a common in the eastern part of Sumatera Island. More ever, the peat soil covers mostly the sediment on the land of the Sumatra Basin [1]. Peat is a wetland formed from piles of organic matter derived from the remains of trees, grass, moss, and decaying animal bodies. These deposits accumulate over thousands of years to form thick deposits [2]. In general, peat is found in waterlogged areas, such as swamps, basins between rivers, and coastal areas.

In the coastal area, the main problems of groundwater are the occurrence of the salt water in the in the aquifer [3,4]. The salt water content will vary depend on the hydrostatic pressure and the physical condition of the soil. The occurrences of salt water in the shallow aquifer have been reported by some researcher [5-7].

In the geophysical methods, interpretation of the data some times can not give any informations about the quantity of the subsurface matter [8]. The geoelectrical resistivity data show the physical caracter of the subsurface which the low resistivity value implies that the electrical current is easy to flow in the subsurface. Whilst the verse versa, the high resistivity value implies that the electrical current is difficult to flow in the subsurface [9]. However, the resistivity value cannot inform the quantity of the target material in the subsurface. This limitation needs to be addressed as the subsurface aquifer is saturated with different of fluid.

Several publications reported that the resistivity value of earth material depended on the fluid content in the pore soil [10-14]. However, thus this research will focus on the preliminary study of characteristic soil and peat soil around the Dumai area. The final target of these series of research is to make the decision on the qualitative interpretation of the subsurface saturated by mixture of salt-fresh water content in the coastal aquifer.
This study is actually a preliminary research. The final target of the main research is to improve the geoelectrical resistivity interpretation in terms of the content of salt water in the aquifer of coastal area. Thus, this paper was focused on the physical characteristics of peat soil in Dumai area. This research shows how the electrical resistivity character of peat soil saturated with the different content of salt-fresh water mixture.

2. Methodology

Figure 1 shows the map of study area. The yellow words are indicating the location where the soil and peat soil sample were taken. The SS means Soil Sample and the PS means Peat Soil. In this study, six undisturbed soil and peat soil samples have been collected from the different sites in Dumai area. The soil and peat soil sample were taken using soil sampler. The soil and peat soil samples then were placed in the plastic box container and the soil and peat soil were measured their physical characteristics in the lab. The soil and peat soil samples then saturated with different salt-fresh water mixture. Before the salt-fresh water mixture was saturated to the peat soil, the salt water, fresh water and different salt-fresh water mixture were measured their anion content and their physical character such as salinity, resistivity and conductivity.

The resistivity measurement of soil and peat soil that was saturated with salt-fresh water mixture was done using digital multimeter and the power supply for the DC electrical current used the 12 Volt battery. This study employed the direct soil resistivity measurements using Wenner configuration with 5 cm electrodes spacing. For the small electrode spacing imply that the earth material is homogeneous and thus the apparent resistivity is correlated to the true resistivity value. These measurements finally can be used to interpret the surface resistivity measurement for the particular area in the future.

**Figure 1.** The map of study area showing the location of soil and peat soil samples.
3. Results and Discussion

Table 1 shows the major anion content of fresh water, and salt-fresh water mixture. The standard value of anion and cation content from Hounslow can be found at the bottom of the table. From the table 1, it can be seen that the dominant content is the chloride and the Ca is the minor concentration among all the water samples. Generally, it can be concluded that the increasing of seawater content results the increasing of each major chemical element.

Table 1. Chemical concentration of seawater and seawater-fresh water mixture.

| Sample ID | Sea Water | Chloride | Sulphate | Ca | K | Na | Mg |
|-----------|-----------|----------|----------|----|---|----|----|
|           | (%)       | (mg/L)   | (mg/L)   | (mg/L) | (mg/L) | (mg/L) | (mg/L) |
| M0        | 0         | 14       | 5        | 11.4 | 2.2  | 2.21 | 0.6 |
| M05       | 5         | 486      | 76       | 25.9 | 30.1 | Sat  | 50.2 |
| M10       | 10        | 1171     | 163      | 37.8 | 57.1 | Sat  | 87.5 |
| M25       | 25        | 4042     | 231      | 88.1 | 125.4 | 2474 | 271.2 |
| M50       | 50        | 7478     | 874      | 187.6 | 192.8 | 4876 | 665.4 |
| M75       | 75        | 10610    | 1231     | 283.1 | 298.7 | 7923 | 995.1 |
| M100      | 100       | 17712    | 2072     | 341.8 | 387.0 | 10672 | 1285 |
| Hounslow  | Seawater  | 19000    | 2700     | 410  | 390  | 10500 | 1350 |

Table 2 shows the direct resistivity measurement of soil (SS01, SS02, SS03) and peat soil (PS01, PS02, PS03) samples. The soil samples were saturated with the fresh water, salt-fresh water mixture and salt water. In the table shows that the soil and peat soil has the relatively equal of their resistivity value, however, they differ a little bit at when they are saturated with the fresh water. When the soil sample is saturated with 5% of salt-fresh water mixture, the resistivity value decreases drastically. This means, we can concluded that the soil with 10% of salt-fresh water mixture content will appear with resistivity less than 6 ohm.m.

Table 2. Resistivity measurement of soil saturated with salt-fresh water mixture.

| Seawater | SS01 | SS02 | SS03 | PS01 | PS02 | PS03 |
|----------|------|------|------|------|------|------|
| (%)      | (Ω.m) | (Ω.m) | (Ω.m) | (Ω.m) | (Ω.m) | (Ω.m) |
| 0        | 54.780 | 55.370 | 64.451 | 65.728 | 63.350 | 68.641 |
| 5        | 5.764 | 5.954 | 15.857 | 14.952 | 13.730 | 15.879 |
| 10       | 4.184 | 4.261 | 4.683 | 5.803 | 5.138 | 5.506 |
| 25       | 3.127 | 3.190 | 3.969 | 3.991 | 3.423 | 3.115 |
| 50       | 2.305 | 2.337 | 2.380 | 2.400 | 2.956 | 2.766 |
| 100      | 0.687 | 0.689 | 0.756 | 0.759 | 0.758 | 0.732 |

4. Conclusion

This preliminary study was successfully to show the physical characteristic of the soil and peat soil saturated with the variation of salt-fresh water concentration in the subsurface. It show that the increasing of saltwater content cause the decreasing of resistivity value drastically. Through this preliminary study, the percentage of salt water content in the aquifer can be predicted. The result of this study is very possible to use in the real resistivity measurement on the surface.
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