The Effects of Salt Content on Measurement of Soil Resistivity

Amir Razlan Bin Mohamad Zain
Faculty of Electrical Engineering
Universiti Teknologi MARA Malaysia
40450 Shah Alam, Selangor, Malaysia
E-mail: amir.razlan12@gmail.com

Abstract— **The resistivity of soil or ground is one of the important factors to be considered when choosing for a suitable grounding spot or area. Problems may occur if the ground area around a facility is not suitable for grounding hence the need to move the grounding spot to an area far away from the facility and caused increase in the overall cost of installation. It is known that some parties involves in the grounding work uses salt treatment as a solution to this matter. This project aims to investigate whether this act of adding salt to grounding soil is a proper solution to the high resistivity of soil. Experiments were conducted where different concentrations of salt water which also known as Sodium Chloride (NaCl) were poured onto a number of segments and the effects of NaCl on the soil resistivity were monitored for a period of 360 hours. It was found that NaCl addition successfully decrease the value of soil resistance but the effect is temporary and at the end of the monitoring period the value of resistivity has increased back to almost the original resistivity value.**

Keywords — Soil Moisture, Ground Resistance, Salt Water (Nacl), Soil Resistivity, Salt Content, Earth Tester.

I. INTRODUCTION

In power systems, grounding is very important to ensure a reliable protection for all electrical equipments. When a ground fault occurs, large currents and raised potentials appear at places where they don't exist in normal operating conditions. Over time, soils with high moisture and salt content and exposed to high temperature can influence the coil resistivity hence affects the effectiveness of the soil as grounding area of fault currents. The purpose of this project is to determine the effects of added salt in the ground to the values of the soil resistivity. Good grounding improves equipment reliability and reduces the chances of damage due to lightning or fault currents. However there are other factors that determine the soil resistivity such as high moisture and temperature.

Poor grounding not only contributes to unnecessary down time, but a lack of good grounding is also dangerous and increases the risk of equipment failure. Without an effective grounding system, we are exposed to many difficulties and will be troubled by electric shock, instrumentation error, harmonic distortion and power factor problems. Soil resistivity plays a key role in designing grounding systems. Ground resisting is a technique used to determine the effectiveness of a certain ground that will be used for grounding spot for buildings. A good grounding is not only for safety measures but also to prevent damage to industrial plants and equipments.

The reactions of the NaCl with the copper grounding rod result in ionization process. Thus during the ionization process what happened during electrolysis were that in general when you passed a current through a solution with charged ions, the ions will migrate towards electrode of opposite charge. Ionization phenomenon is a local process that begins in those areas where the density of the current leaked into the soil reached higher values and where conductive plasma path can locally grow.

Referring to electrolysis theory in a salt solution of NaCl, the dominant ions are Na^+ (positive ions) and Cl^- (negative ions). When a current is supplied to a solution (containing both of these ions) via copper electrode, the chloride ions (anions) will move towards the positive electrode (anode), and the sodium ions (cations) will migrate to negative electrode (cathode). These migrating ions carry charges with them through the solution and thus completing the circuit. Below are the reactions that occur at anode and cathode electrode;

At anode: 2 chloride ions will donate electrons to anode
$2Cl^- (aq) \rightarrow Cl_2 (g) + 2e^-$

At cathode: cathode will accept hydrogen ions from water
$2H^+ (aq) + 2e^- \rightarrow H_2 (g)$

At Copper: Cu gives up 2 electrons into solution which will result in turning electrolyte into blue/green
$Cu (s) \rightarrow 2e^- + Cu^{2+} (aq)$

Therefore the salt water will migrate its charged ion to the rod of the salt water and will migrate its charged ion to the grounding rod since the copper grounding rod has the ability to attract charged particles. Furthermore, salt particles are easier to be separated when there is a short circuit or a lightning strike towards a building.

II. METHODOLOGY

Ground resisting technique can be viewed as a process to determine the ideal resistivity for the grounding area of a building or facility. Outdoor experiment was carried out on the grounding zone of the University Technology MARA high voltage laboratory facility. The experiments were carried out by dividing the grounding zone into two parts. Part A covers the grounding zone behind the high voltage laboratory while part B covers the grounding zone in front of the laboratory. Figure 1 shows the grounding zone for Part A which is behind the high voltage laboratory while Figure 2 shows the grounding zone Part B which is in front of the high voltage laboratory.

Figure 1: Grounding zone part A


Figure 2: Grounding zone part B

The grounding zone of each part was divided into smaller areas which consist of six segments each. For grounding zone part A, the area of each segments is 9 meter^2 while for the grounding zone part B, the area were divided into smaller area of 2.4 meter^2 each. Ideally the grounding zone should have zero ohms of resistance but the ground resistance values vary with the type of soils. Figure 3 shows a segmentation of grounding zone for part A while figure 4 shows a segmentation of grounding zone for part B.

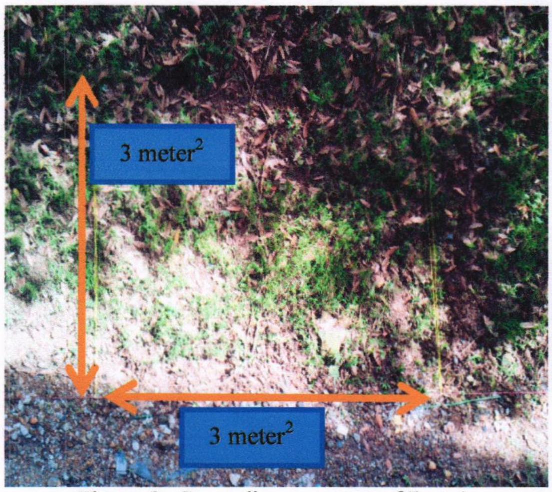

Figure 3: Grounding segment of Part A

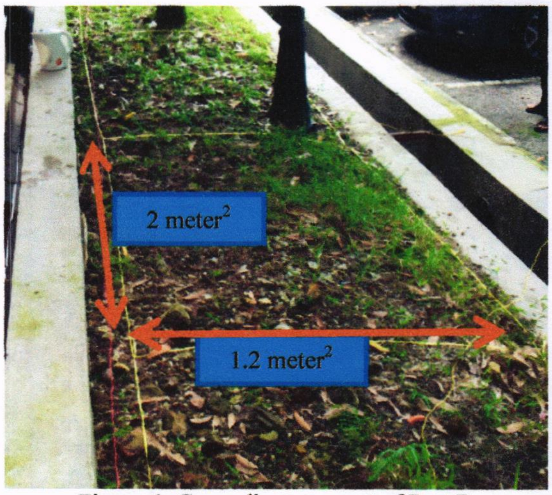

Figure 4: Grounding segment of Part B

For this research, the Earth Tester Type 3235 equipment was used to determine the resistivity of the soil. The Earth Tester Type 3235 consists of 3 electrodes which are the ground conductor, the bonding of the conductor to the ground electrode, and the ground electrode itself.

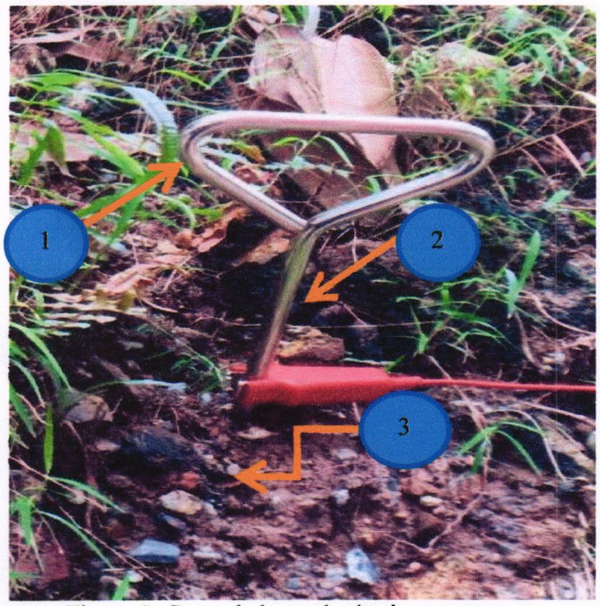

Figure 5: Ground electrodes basic components

The ground resistances are divided into 3 different basic components which are:

i. Resistance of the ground electrode itself: Ground rods are usually made highly conductive or having very low resistance such as copper.

ii. Earth electrodes contact with the surrounding: The ground electrode or the grounding rod is buried inside the earth. The standard shows that this resistance will be equal to zero provided that the ground electrode is freely touching the earth. No insulator such as paint or grease should be covering the ground rod and the ground rod must firmly grip the earth.

iii. Resistance of the surrounding around the ground electrode: The ground electrodes are firmly grip around the earth which is made of concentric hells. Those closest to the ground electrode have the smallest amount of area thus making the greatest degree of resistance.

Figure 6 below shows the steps taken to perform the investigation of salt treatment effects on soil resistivity

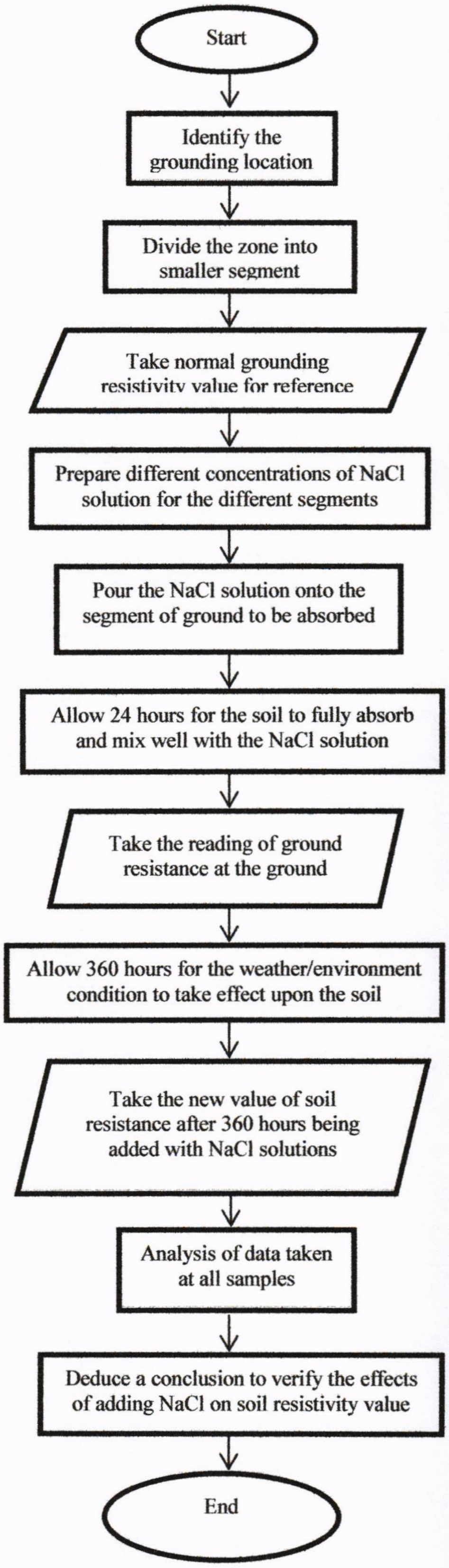

Figure 6: Flow chart of soil resistivity measurement

After the grounding zone were divided into major parts and then again divided into smaller segments of 6, the first set of data was collected. This data are the measured resistivity for the grounding zones before being poured with the NaCl. These data are the mean values derived from five measurements made in each segments. After the readings were taken, NaCl was then poured onto the grounding zone. The amount of the NaCl varies with each segment in the grounding zone. The variations of the NaCl poured onto the grounding segments are shown in Table 1 below.

Table 1: Quantity of NaCl poured onto the grounding segments

	Grounding Zone / Salt Content (Kg)	
Segments	Part A	Part B
1	0.225	0.225
2	0.45	0.45
3	0.675	0.675
4	0.9	0.9
5	1.125	1.125
6	1.35	1.35

After the NaCl was poured for the first time, the grounding zones were left untouched for the next 24 hours before the data for the grounding zone with the effect of NaCl can be measured. This is mainly to give time for the NaCl to react with the grounding rod. During the 24 hours waiting period there were no rain recorded. Finally, the grounding zones were left untouched for the next fifteen days to determine how long the effects of adding NaCl to the ground last will. It was recorded that heavy rain of around 2 to 3 hours each hit the grounding zone on 6 days waiting period out of the entire hit the grounding zone with more than 6 days of this waiting period out of the entire.

III. RESULT AND DISCUSSION

Outdoor experiments were carried out on the grounding zone by measuring the resistivity of the grounding before and after adding the NaCl. The readings for the normal grounding zone without the effect of NaCl are showed in Table 2 below. The data tabulated showed that the resistivity on the grounding zones for both part are at an acceptable range of values which are close to zero ohms.

Table 2: Resistivity of normal grounding zone

	Resistivity (Ω.m)	
Segments	Part A	Part B
1	1.2	1.6
2	1.0	1.7
3	0.8	1.4
4	1.1	1.3
5	0.8	0.8
6	0.4	0.5

To see the effects of adding NaCl to the ground, measurement of soil resistivity was made 24 hours upon the addition and the values of the resistances are tabulated in Table 3 below.

Table 3: Resistivity values after 24 hours of NaCl addition

	Resistivity (Ω.m)	
Segments	Part A	Part B
1	1.1	1.5
2	0.9	1.4
3	0.5	0.9
4	0.3	0.4
5	0.4	0.2
6	0.1	0.2

Data of the resistivity with the effect of the NaCl showed that the resistivity for both grounding zones dropped rapidly. Segment 6 which had the highest density of NaCl added into its' ground showed a drop of nearly 65% to 75% in resistivity. Meanwhile segment 1 which had the lowest density of NaCl added showed a very low percentage drop of its resistivity to around 9%. The grounding spots were left again for the next fifteen days. This was to determine whether the NaCl still affects the resistivity of the grounding. Thus the data collected are as Table 4 below:

Table 4: Resistivity values after 360 hours of NaCl addition

	Resistivity (Ω.m)	
Segments	Part A	Part B
1	0.9	1.4
2	0.8	1.5
3	0.7	1.4
4	1.1	1.0
5	0.8	0.5
6	0.6	0.4

The tabulated results in table 4 showed that the resistivity of the grounding zone after 360 hours has increased. The rising values of its resistivity were due to the number of rains that had fallen since the last 360 hours. The increased value of resistivity for part B is faster than part A. As showed in figure 1 and 2 previously the soil in part A is at a slope of around 45° and because of its nature this slope does not absorb as much rain as a flat surface. As for part B, the flat surface will allow the soil to absorb more the rain thus making it a lot more moisturized. Thus the uncertain weather had destroyed the effects of NaCl on the soil.

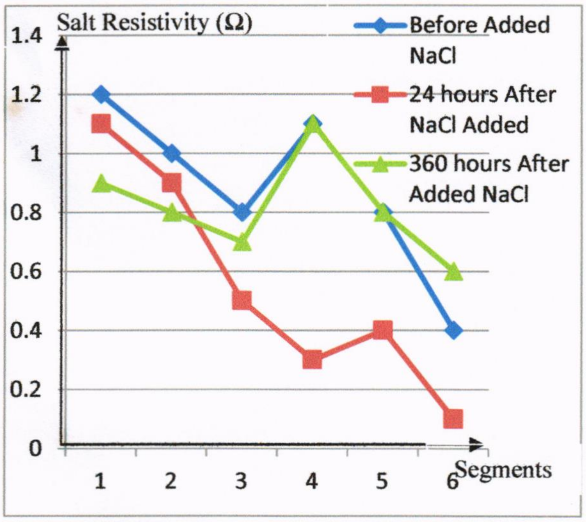

Figure 6: Resistance values for grounding zone A before and after adding NaCl

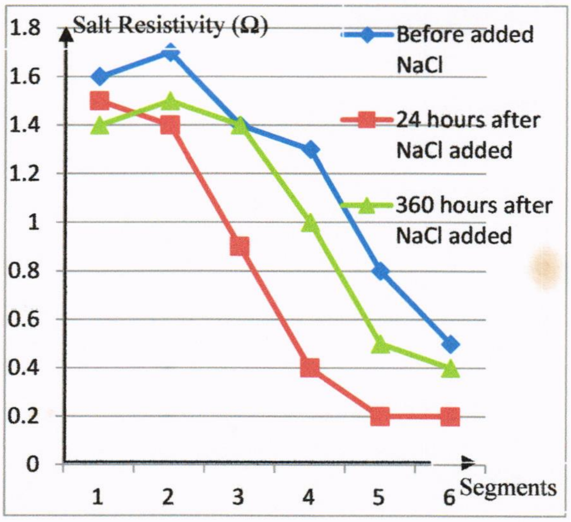

Figure 7: Resistance values for grounding zone B before and after adding NaCl

From the graphs in figure 6 and 7 above it can be seen that after 24 hours of NaCl addition, the soil resistivity decreased significantly of up to 75% at the segment which was added with the largest amount of NaCl. A different trend observed at both segment 4 of Part A and Part B mainly due to the presence of a large tree on these segments that might be the reason to a higher moisture level hence the much significant decrease in resistivity. After 360 hours of salt addition the value of resistivity has increased again and some of the segments resistivity has gone back to its original value.

IV. Conclusion and Recommendation

Salt water treatment particularly NaCl is found to be an effective way to reduce the value of ground resistance but the withdraw of this method is that it only gives temporary effects and can be unreliable especially for countries like Malaysia which has large number of rain throughout the year. This treatment showed that the higher density of NaCl will resulted with a lower resistivity of the soil. Therefore when using this method to maintain low resistivity of a grounding, regular monitoring need to be made to ensure the resistivity is at its' lowest value. Furthermore NaCl need to be added regularly especially during the monsoon seasons.

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