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An Investigation of Soil Resistivity Level at UTHM Pagoh Campus

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Abstract: The most cost effective and efficient method for achieving and maintaining the required earth resistance value during the installation of buried pipes is to consider the soil resistivity at the chosen location. Indirect measurements of soil parameters such as moisture content, pH, resistance level, temperature, and soil texture can be inferred from soil resistivity. Understanding these soil parameters is curcial for ensuring the secure and effective operation of underground pipe networks used for water conveyance globally. To prevent corrosion related surface defects and structural failures, it is essential to prioritize maintenance and pipe replacement as part of an effective pipeline system. Corrosion an leaks are common issues that can compromise the integrity and functionality of buried pipes. In the case of Sime Darby Property Selatan Sdn. Bhd. (SDPS), a total of nine recorded cases of buried galvanized iron (GI) pipes in Universiti Tun Hussein Onn Malaysia, Pagoh Campus are have experienced leakage problems since 2018. This highlights the significant of investigation and addressing these recurring issues to ensure a reliable water supply. To assess the soil resistivity and its impact on underground pipe corrosion, the study employed the Wenner Four Pin Method, which enables real-time soil resistivity measurements. This technique provide valuable data on soil resistivity, allowing for an evaluation of its correlation with underground pipe corrosion and the flow of electrical current through the ground. The primary objective of this study was to measure the voltage and current at different soil depths using Wenner Four Pin Method and categorise the soil type at the chosen location. However, it is crucial to recognise that even in non-corrosive environments indicated by high soil resistivity level, corrosion can still occur. Localized corrosion phenomena can be influenced by various factors that must be considered in corrosion prevention strategies. In summary, this study emphasizes the important of soil resistivity investigation in achieving and maintaining the required earth resistance value during the installation of buried pipes. Despite high resistivity level typically associated with non-corrosive conditions, the occurrence of corrosion in non-corrosive environments highlights the need for comprehensive assessments and localized consideration in corrosion prevention efforts.

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1. Introduction

There are huge underground pipe network used to convey water all over the world. To guarantee a secure and effective pipeline operation, corrosion-related surface defect and structural failure must be carefuly avoided. Maintenance and pipe replacement are crucial components of an effective system because corrosion and leaks are frequent issues. Materials are prone to corrosion whether they are submerged in water, exposed to the environment, or buried in the earth. However, since replacing pipes is a very expensive procedure, maintaining the current level of conservation would need an annual reinvestment rate.

There are several methods available to detect soil corrosivity. Here are some techniques that are commonly used are soil resistivity measurement. Soil resistivity is considered to be the most comprehensive indicator of soil’s corrosivity [1]. It indicates the soil's ability to conduct electrical current, which is related to its moisture content, mineral composition, and electrolyte concentration. Soil resistivity can be measured using specialized instruments such as Wenner four-point probes or Wenner-Schlumberger probes. Besides, soil sampling and analysis. Soil sampling and laboratory analysis can provide valuable information about the chemical composition of the soil and the presence of corrosive substances. The underground pipeline is exposed to facilitate the assessment of the extent of corrosion and analyse the soil samples to evaluate the relationship between corrosion and soil properties [2]. Analysis may involve determining the soil pH, moisture content, chloride concentration, sulfate concentration, and other parameters associated with corrosion potential. Other than that, cathodic protection is a proven corrosion control method for protection of underground and undersea metallic structures. Corrosion current flows between the local action anodes and cathodes due to the existence of a potential difference between the two [3].

When studying the corrosion risk of underground pipes, resistivity is an important physical parameter that must be assessed. The electrical resistivity approach does the same thing, using contrast in resistivity distribution to identify different subsurface materials [4]. Furthermore, knowing the soil resistivity at the chosen location and how it changes with temperature, depth, moisture content, and other variables helps to determine how to achieve and maintain the desired earth resistance value over the installation's lifespan for the least amount of money and hassle.

The first and biggest public higher education hub in Malaysia is the Pagoh Higher Education Hub, which is located in Bandar Universiti Pagoh. Sime Darby Property Selatan Sdn. Bhd. (SDPS). Universiti Tun Hussein Onn Malaysia, Pagoh Campus, Johor was one of the university involved in the development. The construction was equipped with the installation of a underground ground piping system. However, a total of nine recorded cases of buried galvanized iron (GI) pipes in Universiti Tun Hussein Onn Malaysia, Pagoh Campus are have experienced leakage problems since 2018 according to Sime Darby Property Selatan Sdn. Bhd. (SDPS), in contrast to those that were insured by the expected pipe lifetime guarantee.

This study used the Wenner Four Pin technique to assess the soil resistivity at a few selected locations around Campus Pagoh. In order to achieve this research, the objectives that need to be reached were to measure the voltage and current for the different depth of soil by using Wenner Four Pin Method and utilizing a resistivity calculation, to analysed the data. Then, categorize the corrosion level based on soil resistivity according to corrosivity ratings.

2. Materials and Methods

The material and methods section will be describing all the information required to obtain the results of this study.

2.1 Soil resistivity

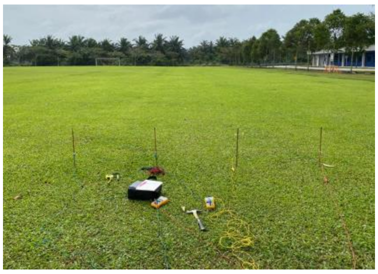
Three tests will be carried out at each chosen location to gather data at the same depth, at depths of 1 meter, 1.5 meters, and 2 meters. To prevent mistakes in equipment settings and data reading, all procedures must be carried out prior to the test's commencement in the sequence specified. The procedure as follow;

a. Four equally spaced and in-line electrodes are placed into the ground for the Wenner 4 pin test. Current is injected into the soil through the two exterior electrodes, sometimes known as the current electrodes. The soil resistance is calculated using the voltage measured by the two inner electrodes, also referred to as the potential electrodes.

b. The technique used by the Fluke 116 to determine soil resistivity makes the assumption that the auxiliary electrodes are put into the ground. Therefore, in this study, the electrodes were spaced 1 meter, 1.5 meters, and 2 meters apart. It should be noted that the spacing distance serves as the main factor for determining the spacing-to-depth ratio. Prior to adjusting the depth, determine the electrode spacing.

c. Two wires are connected to the Fluke 116 multimeter from the current electrode, and to collect the data, the switch function keys are turned to the ampere and voltage symbols. On the multimeter's LCD display, the data reading is shown. The data were also gathered using the same method for the potential electrodes.

(a) Material used in soil resistivity



(b) Method used in soil resistivity

Figure 1: Materials and method used in soil resistivity

2.2 Analyse the data for soil resistivity

Calculate the Soil Resistivity (ρ): The soil resistivity can be calculated using the Wenner formula:

$$\rho = 2\pi a R$$

Where:

ρ = Soil resistivity in Ohm-meters (Ω.m)

a = Wenner spacing in meters (m)

R = Resistance in Ohms (Ω)

2.3 Categorize the soil resistivity type

The soil resistivity of the area where the earth electrode is installed is a crucial factor in determining a suitable earthing installation. Following is a list of the typical soil resistivity values for various types of soil that may be encountered in earthing buildings and electrical installations:

Table 1: Corrosivity rating

Soil resistivity (ohm.cm)	Soil resistivity (ohm.m)	Corrosivity Rating
>20,000	> 200	Essentially non-corrosive
10,000 to 20,000	100 to 200	Mildly corrosive
5,000 to 10,000	50 to 100	Moderately corrosive
3,000 to 5,000	30 to 50	Corrosive
1,000 to 3,000	10 to 30	Highly corrosive
<1,000	<10	Extremely corrosive

3. Results and Discussion

The results and discussion section will provide the results of soil corrosivity categories based on soil resistivity level.

3.1 Soil resistivity

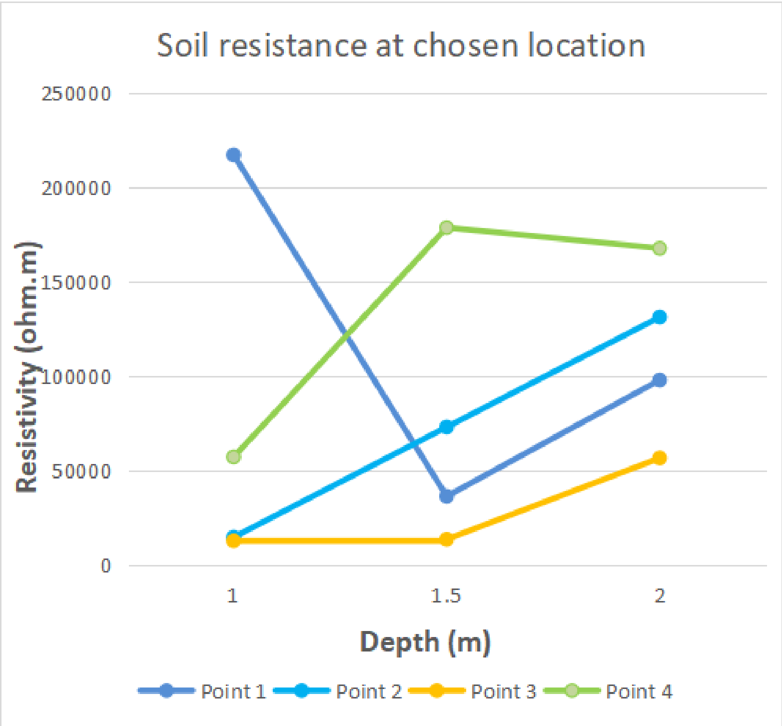


Figure 2 Graph line on soil resistivity for Point 1, Point 2, Point 3 and Point 4

Based on Figure 1, it can conclude that the highest soil resistivity is at Point 1 with depth of 1.0 meters the soil resistivity is 216,982.39 Ohm meter. Thus, this shows that the highest graph line for soil resistivity indicates the highest recorded resistivity values in the data set. This line represents soil conditions with the greatest resistance to the flow of electric current. Therefore, the lowest soil resistivity is 12,758.32 Ohm meter at Point 3 with depth of 1.0 meter. This data corresponds to locations where the soil exhibits the lowest resistivity values, indicating areas with enhanced electrical conductivity and potentially favorable conditions for grounding systems or other electrical engineering applications. [5]

3.2 Categorize corrosion level

Corrosivity rating based on soil resistivity refers to a classification system that categorizes soils according to their corrosive potential towards buried metallic structures. The rating is typically determined by considering the resistivity value of the soil, with lower resistivity indicating higher corrosivity [6].

Table 2 below shows the soil corrosivity rating for Point 1 located at zone 3H area, indicating the level of corrosiveness based on measured resistivity.

Table 2: Soil corrosivity rating for Point 1

Depth (m)	Resistivity, (ohm.m)	Corrosion Rate
1.0	216982.39	Essentially non-corrosive
1.5	36295.35	Essentially non-corrosive
2.0	97802.43	Essentially non-corrosive

Table 3 below shows the soil corrosivity rating for Point 2 located at football field, indicating the level of corrosiveness based on measured resistivity.

Table 3: Soil corrosivity rating for Point 2

Depth (m)	Resistivity, (ohm.m)	Corrosion Rate
1.0	14660.01	Essentially non-corrosive
1.5	72935.47	Essentially non-corrosive
2.0	131126.98	Essentially non-corrosive

Table 4 below shows the soil corrosivity rating for Point 3 located at zone 2B area, indicating the level of corrosiveness based on measured resistivity.

Table 4: Soil corrosivity rating for Point 3

Depth (m)	Resistivity, (ohm.m)	Corrosion Rate
1.0	12758.32	Essentially non-corrosive
1.5	13552.93	Essentially non-corrosive
2.0	56551.84	Essentially non-corrosive

Table 5 below shows the soil corrosivity rating for Point 4 located at railway area, indicating the level of corrosiveness based on measured resistivity.

Table 5: Soil corrosivity rating for Point 4

Depth (m)	Resistivity, (ohm.m)	Corrosion Rate
1.0	57108.35	Essentially non-corrosive
1.5	178518.75	Essentially non-corrosive
2.0	167542.94	Essentially non-corrosive

3.3 Discussions

Numerous studies have highlighted the relationship between soil resistivity and corrosion of buried structures. High soil resistivity acts as a protective barrier, limiting the flow of electrical current and reducing the corrosion rates of metal components. This is explained by the slower corrosion-causing electrochemical processes and the decreased movement of corrosive ions in the soil.

High soil resistivity is typically related to non-corrosive conditions, however it's crucial to maintain that this is not the only factor that affects corrosion behaviour. In a thorough evaluation of the corrosion risk, additional parameters including soil pH, soil texture, moisture content, and the presence of corrosive materials should be taken into account since they can still affect corrosion rates.

It is crucial to understand that the non-corrosive soil conditions brought on by high soil resistivity observed in this study are particular to the chosen locations and might not be typical of all soil environments. Different geographical regions, soil compositions, and environmental conditions can significantly affect corrosion behavior. Therefore, site-specific factors should be considered when assessing the corrosivity of soil in different locations or infrastructure projects.

In conclusion, the non-corrosive soil conditions resulting from high soil resistivity offer significant advantages for the corrosion prevention of underground pipes and other buried structures. The reduced electrical conductivity inhibits corrosion processes, minimizing maintenance needs and extending the service life of the infrastructure. However, a comprehensive approach considering other influential factors and regular monitoring practices are still essential to ensure the long-term integrity of the buried structures.

4. Conclusion

The study aimed to investigate the soil resistivity level at Universiti Tun Hussein Onn Malaysia, Pagoh Campus, and its potential impact on construction, electrical grounding systems, and other infrastructure projects. The research was conducted using a field study approach, collecting soil samples from representative sites and analyzing their resistivity levels.

Based on the findings and analysis, the following conclusions can be drawn:

1. Soil resistivity levels at Universiti Tun Hussein Onn Malaysia, Pagoh Campus vary significantly across different areas of the campus which can impact the effectiveness of grounding systems and electrical installations. Factors such as soil type, moisture content, and geological composition contribute to these variations.

2. The resistivity levels obtained fall within the acceptable range for most construction and electrical grounding purposes. However, certain areas may require additional attention and specialized grounding systems due to their higher or lower resistivity levels. It can be used to maintain a grounding system safe and reliable without compromising its performance.

3. The resistivity data collected can serve as a valuable reference for future infrastructure development projects at Universiti Tun Hussein Onn Malaysia, Pagoh Campus. Engineers and construction professionals can utilize this data to design and implement efficient grounding systems, ensuring the safety and stability of the campus infrastructure.

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References

[1] Willmott, M.J., & Jack, T.R. (2006). *'Corrosion by soils'*. Uhlig's Corrosion Handbook, 1, 329-348.

[2] Roysuke, U., Motoharu, J., &Toshiyuki, Y. (2022). Characterisation of a river embankment using a non-destructive DC electrical survey. *Near Surface Geophysics*.

[3] Zaki, A. (2006). *Principles of corrosion engineering & corrosion control*. Plant's Engineers Reference Book.

[4] Yao, S., Wang, M., Duan, S., & Chen S., (n.d.). Exploring sandstone body in weak electrical resistivity contrast with AMT data. *International Journal of Geoscience*, 8, 277-285. 10.4236/ijg.2017.83012

[5] Rahadjo, P., Leong, E., & Tan, S. (2017). Characterization of soil resistivity for geotechnical and electrical engineering applications. *Geotechnical Research*, *4*(2), 137-148.

[6] American Petroleum Institute (API). (2015). *API recommended practice 571: Damage mechanisms affecting fixed equipment in the refining industry*. American Petroleum Institute (API).