The use of dolomite to overcome grounding resistance in acidic swamp land

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ABSTRACT

This research addresses the effectiveness of grounding systems in acidic swampland, which poses a challenge in protecting people and electrical equipment from the risk of electric shock. The increasing use of swampland for electrical installations necessitates a solution to reduce the high grounding resistance resulting from poor soil resistivity values. This study proposes using dolomite as an admixture to improve soil conductivity and lower grounding resistance. Experimental methods were conducted by embedding rod electrodes of various materials in dolomite-mixed media with varying compositions. The results showed that adding dolomite significantly decreased the grounding resistance, although there were inconsistencies in the test results; on average, the decrease in resistance reached 25%. Galvanized electrodes proved to be the most effective in this system. These findings provide new insights in the field of grounding systems and offer practical solutions that are environmentally friendly and sustainable. This research is expected to be an important reference for developing more innovative and effective grounding system techniques in the future.

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1. INTRODUCTION

People think that the grounding system is an important part of protecting living things, especially people and electrical equipment parts, from getting shocked by touch voltage [1], leakage current, and direct or indirect lightning strikes [2]. Currently, the expansion of the electric power network has affected a variety of land conditions, including wetlands and swamps. This means that the use of swamp land for the construction of electrical installations is inevitable over time. Consequently, the most effective grounding system is required to safeguard living organisms from the dangers of touch voltage. The difficulties associated with the design and implementation of an effective grounding system are on the rise in numerous locations, such as swamps [3]. The resistivity value of the soil type is the primary factor that influences the grounding system [4]. It can result in a high grounding resistance in swamps with high resistivity values, particularly those that are acidic. As a result of this issue, the grounding system's protective function may be rendered less effective, safety risks for users may increase, and the electrical system's reliability may be disrupted. Consequently, a solution is required to mitigate grounding resistance in acidic swampy regions.

Currently, the research on grounding systems in acidic swamps is extremely limited and can be considered to be very minimal, with the majority of studies concentrating on dry land or in laboratories [5], [6]. This limitation generates or generates a knowledge gap regarding the efficacy of grounding systems in wetlands that possess distinctive land characteristics. It is crucial to comprehend the impact of these conditions on grounding resistance and the optimization and effectiveness of grounding systems in light of the growing use of swamp land for electrical installations. In earlier research, many references used a mix of materials to lower grounding resistance, such as bentonite [7], [8], hydrogel [9], silica [10], charcoal, salt, and cement [11]. However, these materials are expensive and hard to get for grounding at the spot where the round rod electrode is embedded, where the electrode is embedded vertically into the ground [12].

One interesting solution suggested in this study is to mix dolomite with other materials to lower grounding resistance in acidic swamp land. Dolomite, due to its ability to enhance soil conductivity and raise soil pH (potential hydrogen), has the potential to suppress or reduce grounding resistance [13], [14]. It is hoped that by mixing the right amount of dolomite with acidic swamp land in this study, the grounding resistance will go down by a large amount. For this study, the type of electrode used in the grounding system was a grounding rod electrode. Different types of rod electrodes were used to find the most reliable and effective combination. In this context, this study not only aims to identify and apply solutions to reduce grounding resistance [15], but also to explore the scientific potential that is still hidden in swamp land. By conducting in-depth field research, it is hoped that an effective method can be found to improve the safety of the electrical system while paying attention to environmental sustainability.

It is anticipated that this research will offer novel perspectives on grounding systems, particularly those that operate on acidic, swampy soils. The use of dolomite in testing is looked into in this study, which not only adds to academic knowledge but also helps engineers and people who build infrastructure for electrical installations. Thus, the results of this study are expected to be a useful guide for further research and may encourage the development of new techniques for better and more innovative grounding systems. The benefits of this study, such as a lower grounding resistance, will also lower the risk of touch voltage and leakage current for people who use electrical equipment and do installations. Additionally, the utilization of cost-effective dolomite can serve as a sustainable and environmentally friendly alternative.

2. METHOD

The research site or field conducted an experiment [16] to test the study's method. The focus was on using dolomite materials to lower grounding resistance in acidic swamps. The initial step in the process was to create a hole with a diameter of 4 inches and a depth of 1 meter for the grounding electrode planting medium. In the center of the hole, a cylindrical grounding electrode rod with a length of 1 meter was inserted vertically into the ground. The rod electrode materials consist of iron, galvanized iron, and copper-coated iron [17]. Measurements using a grounding measuring instrument as shown in Figure 1, but before that on the grounding electrode planting media, researchers added or filled dolomite in the hole or media that had been prepared with variations in composition (25%, 50%, 75%, and 100%) around the electrode in the hole, as shown in Figures 2 and 3 where the electrode has been embedded. The three-point method, which had a measuring electrode and an extra electrode, helped the researchers get accurate results when they measured grounding resistance [18], [19]. The researchers achieved this by incorporating dolomite into the grounding electrode planting medium. The researchers took grounding resistance measurements every six months, resulting in a total of 25 measurements. This was enough to look at trends in grounding resistance at the test site or on acidic swamp land. This method made research valid and repeatable because it was used again or adopted by other researchers in wetland areas, taking into account a range of environmental factors or mixed materials. Table 1 presents the materials and research materials needed to reduce ground resistance in acidic swamp land.

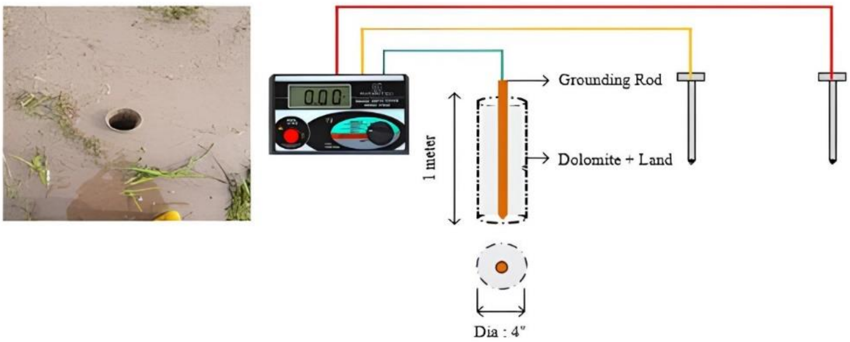


Figure 1. 3-point measurement method and construction by adding dolomite

Figure 2. Grounding resistance reduction study with dolomite in acidic water swamp

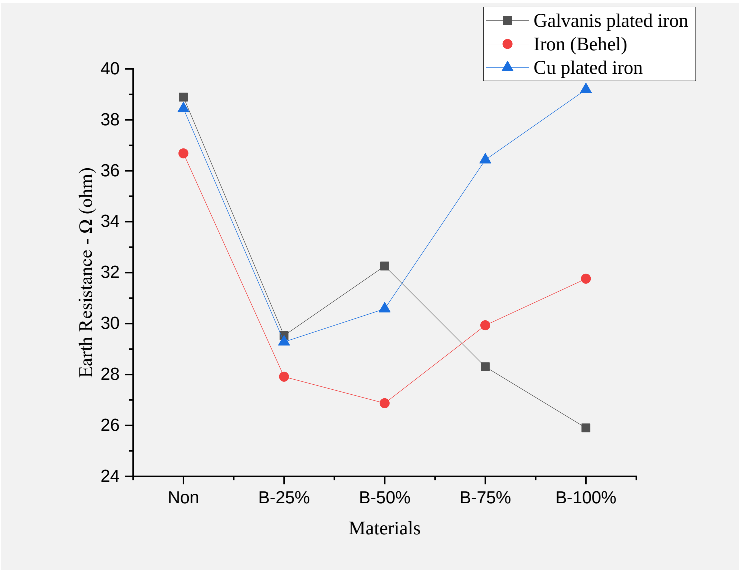


Figure 3. Graph of grounding resistance (Ω) using dolomite with different rod electrode types

Table 1. Type measurement tools and specifications of electrode rods

Information	Electrode type and size
Electroda shape	Round rod
Electrode material	- Galvanized plated iron - Iron - Cu plated iron
Electrode length	100 cm (1 meter)
Electrode diameter	- Galvanis plated iron 16,56 mm: 0,01656 meter - Iron 15,37 mm - Cu plated iron 15,15 mm
Eelectrode embedding depth	1 meter
Earth resistance tester	Kyoritsu R 1450 A digital
Grounding resistance reducing compound	Dolomite

3. DISCUSSION

A graph of the grounding resistance (Ω) when dolomite is used with different types of rod electrodes is shown in Figure 4. This graph shows the results of the study. The researchers conducted measurements for six months, averaging them each month. In swampy areas with a pH below 5, the grounding resistance showed variations according to the composition of the dolomite and the type of electrode used. This study revealed that a mixture of dolomite effectively reduces grounding resistance. The average decrease reaches 25%, depending on the composition of the mixture. In addition, the use of galvanized rod electrodes proved to be the most effective in reducing resistance. Increasing water content in swampy areas affects resistance, where acidic soil conditions cause an increase in resistance. The study's results back up the idea that dolomite can make soil more conductive and lower its grounding resistance. However, the way dolomite interacts with swampy soil is more complicated than expected.

These results suggest that a mixture of soil and a higher concentration of dolomite yields superior results compared to a mixture with a lower concentration of dolomite. Though dolomite can lower grounding resistance, it is not as strong as organic materials like mangrove charcoal or mixed materials like salt and bentonite [20], [21]. This research not only addresses practical inquiries regarding the reduction of grounding resistance, but it also contributes to the advancement of electrical protection system knowledge. These results can be relied on and repeated, which opens the door for more research using different mixes of materials [22], [23] or different kinds of conductors and grounding electrode rods [16], [24]. Valuable insights into the function of grounding systems in extreme environments are provided by the challenges encountered during research in swampy areas, such as muddy conditions.

In the analysis of grounding resistance using dolomite, the study showed differences in resistance reduction in acidic swamp land with and without dolomite mixtures using various types of electrodes: iron electrodes, copper-coated electrodes, and galvanized electrodes. The iron electrode (red line) had some less resistance when dolomite was added in the 25% and 50% mixtures, but the changes were not consistent and there was no clear pattern of less resistance. The copper-coated electrode (blue line), on the other hand, had more stable results but still wasn't consistent; the resistance dropped only in the 25% dolomite mixture, which wasn't the same as the amount of dolomite that was used. The galvanized electrode (black line), on the other hand, had better results. The resistance kept going down even when dolomite was added in amounts as high as 25%. It was at its lowest when a 50% mixture was used. This shows that the galvanized electrode is more effective in reducing grounding resistance with a dolomite mixture. There is no clear pattern to how much resistance goes down when dolomite is added, but using galvanized electrodes with a mix of 25%, 75%, or 100% dolomite has been shown to work in acidic swamp land to lower grounding resistance.

The researchers conducted an experiment to compare grounding resistance values between field measurements and simulations. The researchers obtained the simulation results and presented them in Table 2. The grounding resistance simulation on acidic swamp land using a mix of dolomite materials showed a difference of 1 Ω (ohm), which was higher than the measurements taken in the field and had a 4% range.

Table 2. Simulation results of grounding resistance values (Ω)

Measurement (Ω)	Non	25%	50%	75%	100%
Galvanized plated iron	37.89	30.37	33.17	29.10	26.63
Iron	35.74	28.70	27.64	30.87	32.66
Cu plated iron	37.45	30.11	31.45	37.46	40.30

Figure 4 shows an analysis of a galvanized electrode with a mixture of dolomite. The grounding resistance changes depending on how much dolomite is used. The figure shows five conditions, without dolomite (acidic swamp soil), 25%, 50%, 75%, and 100% dolomite. Without dolomite, the grounding resistance is higher in Figure 4(a). This shows that the acidic soil doesn't conduct electricity well, as shown by the hot spots at the electrode's tip. In Figure 4(b), with the addition of 25% dolomite, the hot contours begin to spread and the resistance decreases. However, in Figure 4(c), with 50% dolomite, a hot spot appears in the center of the electrode, which increases the resistance. In Figures 4(d) and 4(e), with 75% and 100% dolomite, the hot contours spread around the electrode, decreasing the resistance. This indicates that dolomite can increase soil conductivity and improve the efficiency of the grounding system.

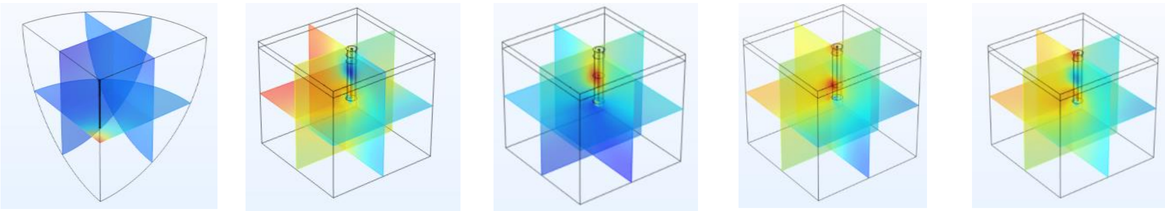
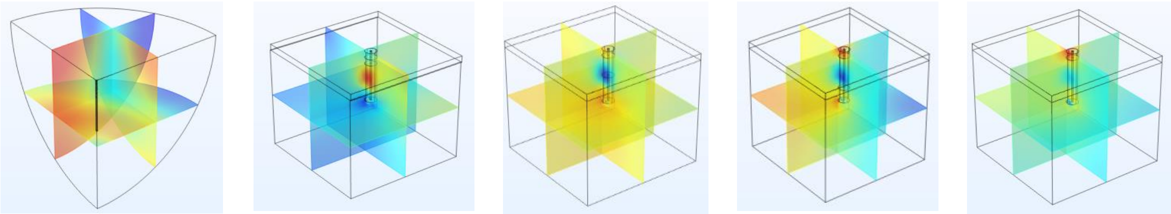

(a) (b) (c) (d) (e)

Figure 4. Galvanized electrode with dolomite mixture; (a) acid swamp land; (b) 25% dolomite; (c) 50% dolomite; (d) 75% dolomite; and (e) 100% dolomite

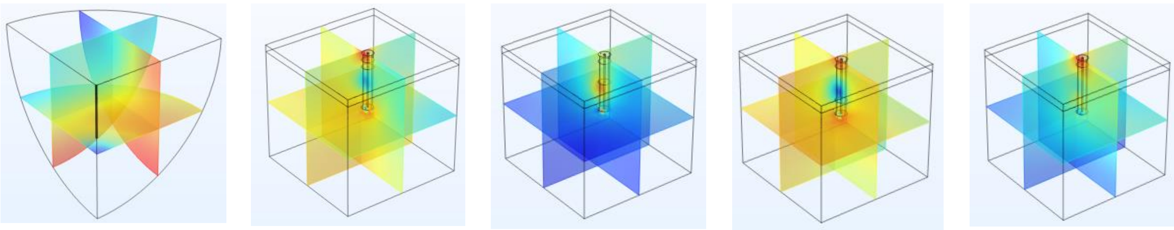
When iron electrodes are mixed with dolomite, as shown in Figure 5, the grounding resistance changes depending on how much dolomite is used. This figure shows five conditions, without dolomite (acidic swamp soil), 25%, 50%, 75%, and 100% dolomite. In figure 5(a), without dolomite, the resistance is higher, indicating that the acidic soil has low conductivity, with isolated heat flow on the surface. In Figure 5(b), with 25% dolomite, the heat contour appears in the center of the electrode and spreads so that the resistance begins to decrease. Figure 5(c) shows a positive trend with 50% dolomite, where the heat contour spreads throughout the soil, decreasing the resistance. However, in Figure 5(d) with 75% dolomite, the heat contour is blocked on the surface, slightly increasing the resistance. In Figure 5(e), the electrode surface blocks the heat contour with 100% dolomite, causing it to spread slightly and increase the resistance once more.



(a) (b) (c) (d) (e)

Figure 5. Iron brace electrode with dolomite mixture; (a) acid swamp land, (b) 25% dolomite, (c) 50% dolomite, (d) 75% dolomite, and (e) 100% dolomite

The shape of the grounding resistance simulation with a copper-coated electrode and a dolomite mixture is shown in Figure 6. There are five conditions shown: without dolomite (acidic swamp soil), 25%, 50%, 75%, and 100% dolomite. Without dolomite, there is no heat flow on the electrode in Figure 6(a), and the resistance is higher. This means that the acidic soil does not conduct electricity well, and there is only heat flow on the surface. In Figure 6(b), with 25% dolomite, the heat contour begins to flow on the electrode surface and spreads, so the resistance decreases. However, in Figure 6(c) with 50% dolomite, the resistance decrease is inconsistent because the heat contour does not spread to the soil wall. Figure 6(d) shows that at 75% dolomite, the heat contour is only at the base and tip of the electrode, without spreading to the soil. In Figure 6(e), when 100% dolomite is used, the resistance goes up again because the heat contour is blocked on the electrode surface and can’t spread to the soil around it.



(a) (b) (c) (d) (e)

Figure 6. Copper-coated iron electrode with dolomite mixture; (a) acid swamp land, (b) 25% dolomite, (c) 50% dolomite, (d) 75% dolomite, and (e) 100% dolomite

The simulation results show that heat spread occurs mostly at the base of the electrode rod. This is due to the muddy surface of the acidic swamp, which has the highest resistivity value. The height of the mud varies between 5 cm and 15 cm, which tends to experience physical changes. The addition of dolomite causes hardening and corrosion of the electrode rod, especially on the iron electrode. In addition, weather factors and fluctuations in swamp water make the surface soil muddy, and during the dry season, the soil becomes tough and brittle.

More than anything else, this study adds a lot to what we know about grounding systems in acidic swampy areas and backs up the original idea that dolomite works. Additionally, the results suggest that using dolomite in the right proportions can be a cost-effective way to deal with the issue of high grounding resistance, as well as an alternative that is better for the environment and will last longer [25].

4. CONCLUSION

This study shows that adding dolomite to acidic swampland can make it much easier for things to stick to the ground. The average reduction is up to 25%, and it is dependent on the composition of the dolomite. Galvanized coated electrodes demonstrated the highest effectiveness, yielding the lowest resistance at 75% and 100% dolomite proportions. These results are a significant contribution to the field of electrical engineering, particularly in the development of safer and more effective grounding systems in high-risk environments. Consequently, touch voltage and leakage current reduce the potential for accidents. However, there were problems with the study's measurements that weren't always consistent. These problems could have been caused by changes in the environment and the way that dolomite and the acidic marsh soil were interacting with each other. These constraints suggest the necessity of enhanced control over variables that influence the results. Further research is required to acquire knowledge and information regarding the reduction of grounding resistance in acid swamp soil. For this study, different combinations of materials should be looked at, and tests should be done in different places to see how well the grounding system works in different types of soil. It is anticipated that additional research will enhance the reliability of electrical systems in high-risk areas and broaden the comprehension of the interaction between dolomite and soil characteristics.

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AUTHOR CONTRIBUTIONS STATEMENT

This journal uses the Contributor Roles Taxonomy (CRediT) to recognize individual author contributions, reduce authorship disputes, and facilitate collaboration.

Name of Author	C	M	So	Va	Fo	I	R	D	O	E	Vi	Su	P	Fu
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Muhammad Irfan Jambak		✓				✓			✓	✓	✓	✓		
Zainuddin Nawawi	✓		✓	✓			✓	✓	✓	✓	✓	✓	✓	

C : **C**onceptualization
M : **M**ethodology
So : **So**ftware
Va : **Va**lidation
Fo : **Fo**rmal analysis
I : **I**nvestigation
R : **R**esources
D : **D**ata Curation
O : Writing - **O**riginal Draft
E : Writing - Review & **E**diting
Vi : **Vi**sualization
Su : **Su**pervision
P : **P**roject administration
Fu : **Fu**nding acquisition

CONFLICT OF INTEREST STATEMENT

The authors declare that there is no conflict of interest.

INFORMED CONSENT

We have obtained informed consent from all individuals included in this study.

ETHICAL APPROVAL

In this study, we are not related to using animal or human media to be used as research material. Where this research is in the form of research using swamp land, grounding rod electrodes and dolomite and measuring instruments to conduct research on reducing grounding resistance in acidic water swamp land.

DATA AVAILABILITY

- The authors confirm that the data supporting the findings of this study are available within the article [and/or its supplementary materials].
- The data that support the findings of this study are available from the corresponding author, upon reasonable request.

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