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TO REDUCE TROPICAL SOIL RESISTANCE GROUNDING BY MIXING ADDITIVE MATRIALS OF BENTONITE, LIME, AND BUILDING DEBRIS: A PROSPECT OF SECURITY IMPROVEMENT TOWARDS LIGHTNING STRIKE IN URBAN ENVIRONMENT

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ABSTRACT: In general, tropical soil is characterized by low Cation Exchange Capacity of clay mineral, low base saturation, high aluminum solubility, low pH and low organic matter content. This characteristics resulted in the low ability of the soil to carry electrons. For this reason, it is necessary to additive treatment to the soil which will be used as grounding media. This research aims to compare the effect of soil resistance decrease between soil mixing with bentonite, lime and building waste debris. The direct measurements were conducted by using *Earth Ground Resistance Tester* tool. It can be concluded that the addition of additives has an effect on the decrease of *grounding* resistance value. The best response to the decrease in resistance consecutively was in the mixture of soil with debris, then followed by soil with lime and soil with bentonite. This finding was prospective for the development of artificial grounding media to reduce the risk of lightning hazards in dense residential areas while reducing the burden and utilizing debris waste from negative externalities of development.

Keywords: risk of lightning, grounding resistance, building debris, grounding media

1. INTRODUCTION

One of the crucial problems of atmospheric physical phenomena is the high incidence of lightning, especially in the transition season or during the rainy season. Lightning had been an important problem in modern society due to the power of lightning which can disrupt and cause damage to building infrastructure, telecommunications systems and electronic devices and disrupt comfort. This problem was a climax in urban areas where the placement of a grounding position in densely populated and narrow landed settlement could be an obstacle between houses.

In connection with grounding, that can be referenced in Prasetyo and Suriadikarta (2006) in reality that almost thirty percent of land in Indonesia, especially in Sumatra, Kalimantan, Sulawesi, Maluku, Papua and parts of Java, was dominated by Ultisol and Oxisol soil. These soils are characterized by low Cation Exchange Capacity (CEC), low base saturation, high aluminum solubility, low pH and low organic matter content (Wahyudi, 2009). All of these characteristics make water holding capcitiy of the tropical soils very low especially in dry season (Bakri, 2006) and caused the low ability to flow electrons (Martin *et al.*, 2018). The problem then led to the need to conduct a study of the decrease in grounding resistance for tropical soils which generally had low electrical conductivity by creating artificial grounding media packed in containers such as flower pots for grounding planting medium.

This research was conducted in March 2018 on Lungsir Subdistrict, Bandar Lampung_Indonesia, by adding additives with soil concentration: bentonite / lime / building debris with the ratio of 25%:75%, 50%:50%, and 75%:25% consecutively.

2. LITERATURE REVIEW AND HYPOTHESIS DEVELOPMENT

Martin, et.al., (2016) stated that mixing bentonite into the Oxisol soil in Gedung Meneng (Unila) could reduce the value of grounding resistance to 1.97%-60.00%, while activated mixing with bentonite lowered the value of grounding resistance by 79.97% - 85.24%. Moreover, it was also reported that the mixing with gypsum ($CaSO_4[24H_2O]$) could also reduce the value of grounding resistance of Oxisol soil in Gedung Meneng even though it was not as high as bentonite does, but it was still lower than control.

3. RESEARCH METHODS

This research used *single grounding rod* with a tree point measurement method (*tree point method*). Grounding planting medium used cans. The reason for choosing this method is because it does not require a large location. This research was intended to be conducted in narrow land. Besides, the installation was also simple and easy. The technological package of grounding as compatible flower pots for narrow land of urban settlements.

4. DISCUSSIONS AND ANALYSIS OF RESULTS

Table 1. Resistance value mean of the measurement result for each treatment

Treatment	Resistance (Ω)	Treatment response againts the controlling resistance value (Ω)
K0	349.4	
K1	448.6	+ 28.4
K2	227.9	- 34.8
K3	200.7	- 42.6
P0	302.2	
P1	231.5	- 23.4
P2	173.5	- 42.6
P3	162.3	- 46.3
B0	533.8	
B1	453.1	- 15.1

B2	987.3	+ 85.0
B3	1169.4	+ 114.1

Information : (+ or -) signs indicate the increase or decrease of resistance value when compared with control.

K0 = (0% lime : 100% soil)
K1 = (25% lime : 75% soil)
K2 = (50% lime : 50% soil)
K3 = (75% lime : 25% soil)

B0 = (0% bentonite : 100% soil)
B1 = (25% bentonite : 75% soil)
B2 = (50% bentonite : 50% soil)
B3 = (75% bentonite : 25% soil)

P0 = (0% debris : 100% soil)
P1 = (25% debris : 75% soil)
P2 = (50% debris : 50% soil)
P3 = (75% debris : 25% soil)

4.1 Lime

From the measured resistance value, the addition of 25% lime to the soil has not been able to reduce the grounding resistance. Meanwhile, with the addition of 75% lime, the measured resistance value is smaller than the addition of 50% lime (Table 1).

The lime used in this research was agricultural lime (aglime). Aglime contains high calcium and magnesium content. Aglime has base reaction, when it is added to the soil, it can increase the pH of the soil. This is in accordance with the results of a study by Sumarwoto (2004), after lime addition, the pH of the soil was 4.20 and it increased to 5.99, land Cation Exchange Capacity increased from 24.16 to 30.81

The pH of soil was increased after lime addition. It was due to the increase of Ca^{2+} ion content. The increase of Ca^{2+} ion content can cause neutralization effect as the result of the substitution of H^{+} and Ca^{2+} ions (Sukristiyonubowo, et. al., 1993). Besides being able to increase soil pH, lime addition can also increase the negative charge of the soil so that the soil Cation Exchange Capacity increased. An increase in soil Cation Exchange Capacity means an increase in the ability of the soil to absorb cations, which also indicates the increase of negative electrical charge of the soil absorption complex. Therefore, the flowability of electron charges originating from lightning strikes is high, which in turn can reduce the value of resistance.

4.2 Debris

When seeing it from the measured resistance values in the debris group, it is seen that the greater the addition of debris to the soil, the smaller the measured resistance value. Building debris is generally consisted of water, cement and coarse aggregates (sand/gravel). The main ingredients of cement are limestone and silica (*clay*). The role of Ca^{+2} and Mg^{+2} cations derived from lime the soil granulation as a cation bridge. With the soil structure which has been formed, soil pore spaces are also created, especially water-holding pores which can reduce resistance through the role of water as an electrolyte. While, clay is the main source of silica compounds. Silica compounds have the ability to absorb large amounts of water because they have a large surface and large pore volume. Water, which was adsorbed by soil minerals, is an electrolyte so that it can increase electrical conductivity, which means it can reduce the resistance value.

4.3 Bentonite

For bentonite, the best response was found in the treatment level of 25% of bentonite. For treatment level of 50% and 75%, there were cracks in the mixed media, so that the electron flow was cut off when measuring the resistance value. This is what causes the resistance value to be greater than the controlling resistance value.

Bentonite is a type of clay containing montmorillonite. Montmorillonite, with the chemical formula of Al2O3.4SiO2xH2O, is included in 2:1 group. Clay minerals, which are included in 2: 1 group, have strong elastic properties, shrink when dry and enlarge when wet, because of this behavior, some types of soil can form wrinkles or cracks when dry (Aphin, 2012).

The measurement results of the three additives used, debris has the smallest resistance value compared to lime and bentonite. Thus, the building debris, in the future, will be a very prospective resource to be utilized in making artificial grounding media rather than the environmental burden in urban areas as a negative externality of development. Debris can be used as an additive that is more effective than bentonite or lime which are relatively more expensive. Therefore, people in urban areas are expected to be more prosperous because they are not burdened by the problem of handling building debris.

5. CONCLUSIONS

The best response in reducing the resistance consecutively is in a mixture of soil with debris, then is followed by soil with lime and soil with bentonite.

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