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Assessment of the Effect of Tyre Ash as a Conductive Backfill on Resistance to Ground Values of Earthing Electrodes in Sandy Soils

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***Abstract*— An essential way of seasoning the soil with metallic salts is backfilling the earthing rods with conductive backfill materials in order to reduce its resistance to ground values. Tyre ash as a conductive backfill material for predominantly sandy soil is experimented with in this study. Based on experimental data obtained from using the 62% method of testing for resistance to ground values of earthing rods, it was observed that tyre ash when used as a conductive backfill material could reduce the resistance to ground values of earthing rods to about 70% in predominantly sandy soils.**

***Index Terms*— Conductive backfill, Earthing electrodes, Resistance, Resistivity, Soil, Tyre ash.**

I. Introduction

Conductive backfilling is a well accepted way of reducing earth electrode resistance. According to [1], earth electrode resistance is the resistance between an earth electrode and 'true' earth. Soil resistivity is the key that determines what the resistance of a ground electrode will be [2]. Soil resistivity is determined largely by the contents of its electrolytes, which consist of moisture, mineral and dissolved salts. Acquiring a low earth resistance can be addressed in several ways notably chemical treatment of the soil. The chemicals are aimed at reducing the resistivity of the soil, thus indirectly reducing the earth electrode resistance. Conductive backfills have been used since the 1930's to aid in the chemical treatment of the soils. Such backfills as Bentonite, Marconite and Gypsum among others condition the soil immediately surrounding the electrode resulting in reduction of soil resistivity. A great problem usually associated with the treatment of soil is the leaching of the chemical components of these conductive backfills.

A recent study conducted in Ghana by [3] led to the acceptance of tyre ash as a ground resistance reducing material. In their studies, tyre ash as a conductive backfill was compared to the commercially available Ground Enhancing Material (GEM) as a ground resistance reducing material to achieve the same reduction in the earth electrode resistance of 74%. Further studies proved that when tyre ash is mixed with cement, about 64% reduction in ground resistance value is attainable with zero corrosion rates. Achieving the right soil conductivity during earthing is sometimes difficult due to different soil conditions. Soil conditioning, which seeks to aid in reducing soil resistivity, involves addition of right amounts of metallic salts uniformly to the soil in order to attain the required conductivity. This technique requires that the conditioning metallic salts come into contact with the soil.

Using tyre ash as a conductive backfill could to some extent have effects on the resistance of earth electrodes. According to research, the use of palm kernel oil [4], rice straw ash [5] and coke powder as backfill materials of earth electrodes affects the resistance to ground values of the electrode. No field studies have been conducted with the aim of investigating the usefulness or otherwise of tyre ash as a conductive backfill of earth electrodes,

This paper therefore analyses the use of tyre ash as an earth electrode resistance reducing agent in conductive backfill applications; and to determine the effect of tyre ash as a backfill material on the resistance

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II. MATERIALS AND METHDS

A. Materials

To perform the needed field works, the following materials were utilized:

- Tyre ash;
- One end threaded 0.01524 m in diameter by 0.5 m length copper earth rod;
- A 4-terminal digital earth tester;
- Four insulated wire conductors;
- Measuring tape;
- Hammer;
- Gloves; and
- A pipe of diameter 0.1524 meters.

The tyre ash was obtained locally from the normal burnt car tyres. Four insulated wire conductors were used as connecting leads from the earth tester to the mounted copper rods.
The Wenner 4-pin method of testing soil resistivity and the 62% method of testing for the resistance to ground values of earthing rods were used.

B. Methods

Preparation of Study Sites

A predominantly sandy site was prepared and two sets of earth rods, four in each row at a distance of 30, 18.6, and 9.3 meters and at a locus point were installed for the electrode resistance to earth measurement. The first column of electrodes was marked as reference electrodes and the second set as working electrodes. For each rod in a column, the rod was hammered down to a depth of 0.5 m. The first rod in each column of the working electrodes is first of all prepared and mounted in a specific way. The hole was augured and the rod placed in, backfilled with tyre ash to a diameter of 0.1524 m with the aid of 0.1524 m diameter pipe. The related procedure is presented in Fig 1, Fig. 2, Fig. 3, and Fig. 4.

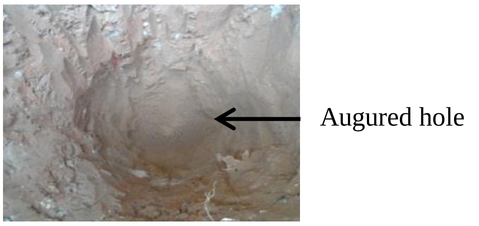

Fig. 1 Augured Hole at Sandy Study Site

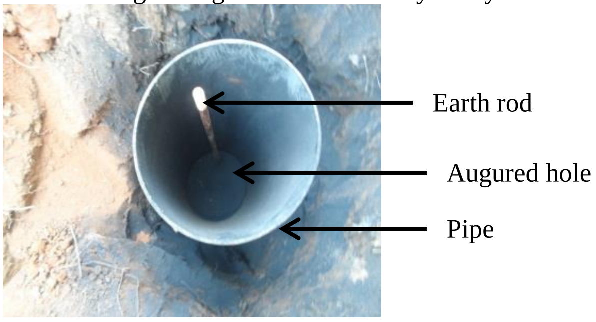

Fig. 2 Installed Earth Rod in Augured Hole with Pipe Informing the Boundary of the Backfill

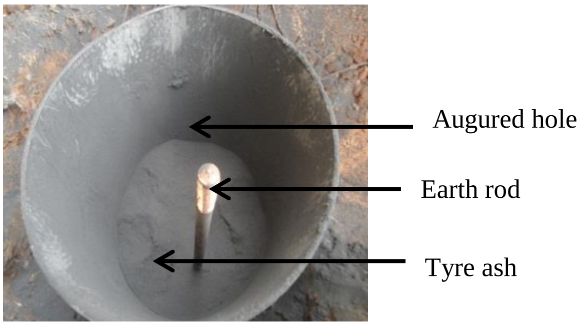

Fig. 3 Tyre Ash in Augured Hole

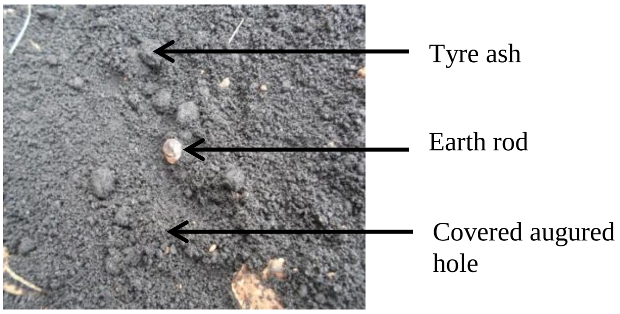

Fig. 4 Installed Earthing Rod in a Tyre Ash Conductive Backfill Material

C. Laboratory Investigations

Samples of soil from the sandy site and samples of tyre ash were analysed at a Soil Science Facility. The subsequent outcomes are presented in Table I.

D. Testing the resistivity of sandy soil

The wenner 4-pin method was used in testing sandy soil resistivity.

E. Testing for the resistance to ground values of earthing rods in sandy soil

The 62 % method was utilized in the testing.

F. Determination of the percentage reduction in resistance to ground values

Based on the resistance to ground values of earthing rods obtained in a period of twelve months, from February 2013 to January 2014, the graphs presented in and Fig.5 and Fig. 6 for sandy site show how the resistance to ground values vary with time. Table V present the percentage reductions in the resistance to ground values of earthing rod on each of the sandy study sites. The percentage reductions were computed using Equation (1).

$$P_{reduction} = \frac{R_{ref} - R_{bf}}{R_{ref} + R_{bf}} \times 100 \qquad (1)$$

where, $P_{reduction}$ = the percentage reductions in resistance to ground values of earthing rod
R_{ref} = resistance to ground values of reference earthing rod
R_{bf} = resistance to ground values of tyre ash backfilled earthing rod

III. RESULTS AND DISCUSSIONS

A. Results

Presented are some measured physical and chemical parameters of samples from the sandy study site and of tyre ash. The values of samples of extractable bases of samples from the sandy study site and of tyre ash are also presented. The values of selected heavy metals tested for in samples from the sandy study site and for tyre ash are also presented.

B. Resistivity of Sandy Soil

Results obtained for the soil resistivity test conducted on the sandy study site are presented in Table 1.

C. Physical and Chemical Parameters Determined

Results obtained for some measured physical and chemical parameters of sandy soil and tyre ash determined at a soil research facility are presented in Table II. The values of samples of extractable bases of samples from the sandy study site and of tyre ash and selected heavy metals tested for in samples from the sandy study site and for tyre ash are presented in Table 3 and 4 respectively.

D. Results from Field Measurements

The resistance to ground values of earthing rods obtained from the field measurements are presented in Fig. 5 and Fig. 6.

E. Results for the computation of percentagereductions in resistance to ground values of earthing rod

Table V gives the percentage reduction in resistance to ground values of earthing rod at the clayey study site.

F. Discussions

Resistivity of Sandy Soil

The resistivity of the sandy soil is 122.52 Ωm as presented on Table 1.

G. Physical and Chemical Properties of Three Soil Types, and Tyre Ash as a Conductive Backfill

From the laboratory analysis, as presented in Table II, Table III and Table IV, it can be seen that most of the trace elements are common to both soil types and tyre ash but in different proportions. However, Lead which is a heavy metal found in tyre ash was not detected in any of the three soil types of the study sites. Chromium was not detected neither in the soil types nor in tyre ash. The trace elements found in conductive backfilled tyre are known to range from good conductors (Copper, Carbon) to moderate conductors (Zinc) to poor conductors (Lead) of electricity. The tyre ash was also found to retain 70% volume of water.

H. Resistance to Ground Values of Earthing Rods and Percentage Reductions

From Fig. 5 and Fig. 6, it can be seen that the resistance to ground values of tyre ash backfilled earthing rod was lower than the resistance to ground values of the reference earthing rods. Also the resistance to ground values of the earthing rods could be found to be fluctuating throughout the study period. Initially tyre ash backfilled earth rod displayed an increase in the resistance to ground value of the earthing rod. However, with time reduction in the resistance to ground of the earth rod to a percentage of 39.82% and 39.80% was observed. In the month of July and December, a high percentage reduction in the resistance to ground values of the earthing rod being over 70% was obtained. This could be due to the high leaching of the trace elements in the sandy soil whiles the tyre ash backfilled soil maintains some amount of its trace elements due to the loamy texture of tyre ash backfill material.

Table I Resistivity Values of Soils on the Three Study Sites

Study Site	**Resistance (Ω) of Soil as given by Megger DET 3/2 Meter**	**Apparent Resistivity of Soil on Study Sites, (Ωm)**
Sandy Study Site	6.5	122.52

Table II Some Measured Physical and Chemical Parameters of Samples from the Sandy Study Site and of Tyre Ash

Parameter	**Values obtained from Study Site Three**	**Values Obtained from Tyre Ash**
Particle size % by weight, (2 mm) Sand Silt Clay	2 - 0.5 = 70.6 0.05 -0.002 = 9.4 < 0.002 = 20.0	2 - 0.5 = 42.6 0.05 - 0.002 = 54.9 < 0.002 = 2.5
Texture	Sandy clay loam	loamy
Available water content (vol. %)	75.060	70.0
pHw (1:1)	3.6	5.4
Organic carbon (%)	0.27	26.97
Available phosphorus (mg/kg)	25.54	1247.66

Table III Samples of Extractable Bases of Samples from the Sandy Study Site and of Tyre Ash

Extractable Bases	Value, cmol/kg obtained from Sandy Study Site	Value, cmol/kg obtained from Tyre Ash
Calcium (Ca)	2.0	17.8
Magnesium (Mg)	11.4	19.4
Potassium (K)	0.72	4.91

Table IV Selected Heavy Metals Tested for in Samples from the Sandy Study Site and For Tyre Ash

Heavy Metal	Value, mg/kg obtained from Sandy Study Site	Value, mg/kg Obtained from Tre Ash
Cadmium (Cd)	0.016	0.228
Chromium (Cr)	Not-detected	Not-detected
Iron (Fe)	0.062	0.047
Zinc (Zn)	1.579	3.214
Lead (Pb)	Not-detected	0.442
Copper (Cu)	0.022	0.277

Table V Percentage Reductions in Resistance to Ground Values of Earthing Rod at Clayey Site

Time (Month)	Percentage (%) Reduction in Resistance to Ground Values of Earthing Rod at 9.3 m	Percentage (%) Reduction in Resistance to Ground Values of Earthing Rod at 18.6 m
Feb. 2013	-12.60	-11.96
Mar. 2013	39.82	39.80
Apr. 2013	56.89	56.50
May 2013	66.25	66.00
Jun. 2013	29.17	28.01
Jul. 2013	70.64	70.75
Aug. 2013	59.00	58.04
Sep. 2013	60.00	58.76
Oct. 2013	58.01	58.56
Nov. 2013	60.62	64.08
Dec. 2013	70.87	71.14
Jan. 2014	60.00	58.90

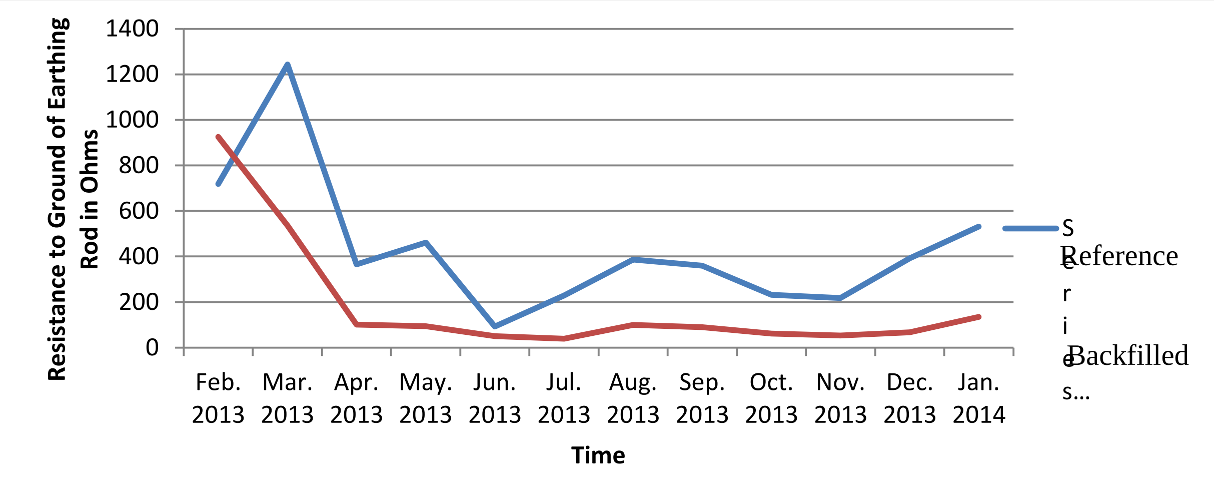

Fig. 5 Plot of Resistance to Ground Values against Time at 9.3 m from Test Electrode for Sandy Site

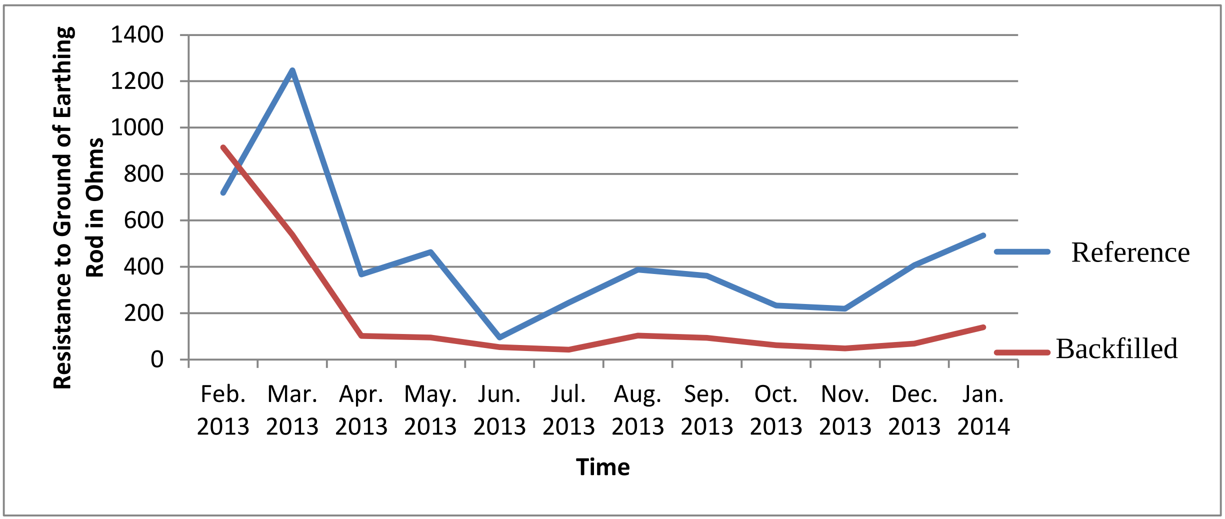

Fig. 6 Plot of Resistance to Ground Values against Time at 18.6 m from Test Electrode for Sandy Site.

IV. CONCLUSIONS

This paper investigated the effect of tyre ash used as a conductive backfill for ground electrode. It can be concluded that:

- Tyre ash reduces the resistance to ground values of earthing rods. For sandy soils, a reduction in resistance of about 70% is attainable.

- The level of reduction in resistance to ground values of earthing rod depends on the soil type and its moisture content.

REFERENCES

[1] Adegboyega, A. G. and Odeyemi, O. K. (2011), "Assessment of Soil Resistivity on Grounding of Electrical System: A Case Study of North-East Zone, Nigeria", Journal of Academic and Applied Studies, Vol. 1, No. 3,

[2] Switzer, K. (2012) "Achieving an Acceptable Ground in Poor Soil", www.Ecmweb.com. Accessed: September 17, 2012.

[3] Eduful, G. and Yeboah, D. (2009), "Using Tyre Ash as Ground Resistance Improvement Material-Health and Environmental Perspective", IET Electric Power Applications, Draft, pp.1 - 5.

[4] Eduful, G., Cole, E. J. and Tetteh, F. M. (2009), "Palm Kernel Oil Cake as an Alternative to Earth Resistance-Reducing Agent", International Journal of Applied Engineering Research, Vol. 4, No. 1, pp.115 - 121.

[5] Kumarasinghe, N. (2008), "A Low Cost Lightning Protection System and its Effectiveness" 20th International Lightning Detection Conference, Tucson, Arizona, USA, pp. 1 - 6.

[6] Bruand, A., Hartmann. C. and Lesturgez, G. (2005), "Physical Properties of Tropical Sandy Soils: A Large Range of Behaviours", www.fao.org. Assessed: September, 20, 2013.

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