Corrosive effect of the type of soil in the systems of grounding more used (copper and stainless steel) for local soil samples from the city of Tunja (Colombia), by means of electrochemical techniques

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Abstract. In this work electrochemical techniques were used to determine the corrosion behaviour of copper and stainless steel electrodes, used in grounding varying soil type with which they react. A slight but significant change in the corrosion rate, linear polarization resistance and equivalent parameters in the technique of electrochemical impedance spectroscopy circuit was observed. Electrolytes in soils are slightly different depending on laboratory study, but the influence was noted in the retention capacity of water, mainly due to clays, affecting ion mobility and therefore measures such as the corrosion rate. Behaviour was noted in lower potential for copper corrosion, though the corrosion rate regardless of the type of soil, was much higher for electrodes based on copper, by several orders of magnitude.

1. Introduction

According to the technical regulation of electrical installations RETIE, all electrical systems must have a grounding system, to prevent people in contact with it, remain subject to dangerous tensions. The objectives of a grounding system are the safety of people, the protection of installations and electromagnetic compatibility [1,2].

The electrodes in a grounding system must ensure conductivity and the resistance to corrosion, which must be minimum 15 years from the date of installation. The method of immersion in salt spray for 1000 hours, is the most used to test the corrosion resistance of electrodes for grounding systems [3].

The purpose of this work is to analyse the influence of soil characteristics on morphology and properties defined for the grounding electrodes [4]. Decay rates were established by electrochemical techniques using potentiodynamic curves and linear polarization resistance measures.

2. Materials and methods

2.1. Experimental soils samples

For the analysis, two types of soil characteristic of the city of Tunja, Colombia were referenced [5]. The experimental design matrix was then defined with two soil types and two types of electrodes.

Soil samples are taken to the laboratory (Universidad Pedagógica y Tecnológica de Colombia (UPTC) to obtain data such as texture, pH, percentage of organic matter, phosphorus, aluminium, potassium, calcium, magnesium, cation exchange capacity and electrical conductivity characterization throws us two types of soil as well: sandy loam and clay loam. The electrolyte used in the cell was obtained from soil samples prepared with a relative humidity of 20 percent.

2.2. Electrodes
According to table 15.2 of technical regulation of electrical installations RETIE [1], test electrodes copper and stainless steel were taken. These electrodes are the most used in grounding systems.

2.3. Experimental Equipment
2.3.1. Potentiosta-galvanostat. The Gamry G-750 Potentiostan-Galvanostats, an electrode Ag/AgCl and an electrochemical cell was used for generate the potentiodynamics and LPR curves and is located in the Materials Lab of the Universidad Antonio Nariño, Tunja, Colombia.

2.3.2. Tellurometer measurement of soil resistivity. The Wenner four–pin method, is the most commonly used technique. In brief, four probes are driven into the earth along a straight line, at equal distances an apart, driven to a depth b. The voltage between the two outer (current) electrodes to give a value of resistance R [6].

The equipment used, located in the laboratories of the Universidad Antonio Nariño, Tunja, Colombia, consists of a eurotest^{TM} 61557 MI 2086 and his accessories.

2.4. Experimental design
The experimental matrix considered two factors (Table 1) type of soil, with two levels: sandy loam and clay loam; and electrodes type, with two levels: copper and stainless steel.

Table 1. Experimental matrix.

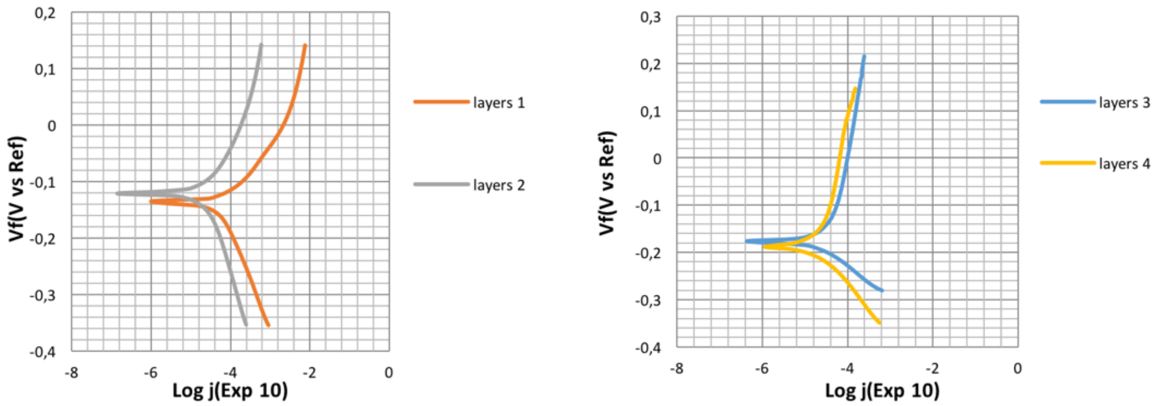
Soil	Electrode	Variables Response
Sandy Loam	Copper	Ecorr (mV)
	Stainless Steel	Jcorr (μA/cm^2)
Clay Loam	Copper	CR (mm/yr)
	Stainless Steel	LPR (Ω*cm^2)

2.5. Electrochemical tests
2.5.1. Tafel. Tafel polarization curves are used to obtain an accurate estimate of the corrosion rate of a metal in a solution. The current in the cell is measured over a sweep potential and is presented in logarithmic form. A scan is made from -250 to 250mV with respect to the open circuit potential.

2.5.2 Linear polarization resistance. The linear polarization resistance following the ASTM G5 standard, standard reference method of anodic polarization, potentiostatic and potentio-dynamic [7].

3. Results
The obtained results was resume in the next potentio-dynamics graphics. In the potentio-dynamics graphics, the x axis is the base 10 logarithm of current (Amperes) and the y axis is the Potential E in Volts (see Figure 1) [8].

The main response variables for each experiment were the corrosion potential, the corrosion current, anodic and cathodic pending by means of Tafel approximation and linear polarization resistance, obtained by linear regression (see Table 2).



(a) (b)

Figure 1. Curves for the different soils (a) copper (layers 1 is for sandy loam and layers 2 is for clay loam) and (b) stainless steel (layers 3 is for sandy loam and layers 4 is for clay loam).

Table 2. Experimental data from the electrochemical test.

Soil	Material	Ecorr (mV)	Icorr (μA/cm^2)	βa (mV/dec)	βc (mV/dec)	CR (mm/yr)	LRP (Ω-cm²)
Sandy Loam	Copper	-1,10E+02	1,13E+00	8,67E+01	-2,51E+02	1,99E+00	6,01E+03
	Inox	-2,19E+02	6,35E-02	3,74E+02	-7,75E+01	3,35E-01	1,54E+05
Clay Loam	Copper	-1,29E+02	1,76E-01	1,55E+02	-2,42E+02	3,08E-01	8,20E+04
	Inox	-1,96E+02	2,96E-02	2,87E+02	-1,01E+02	1,56E-01	2,18E+05

4. Discussion

Comparisons for each factor are made in the Figure 2, 3, and 4. The scale for each plot is particular, but it indicates the change in the response variable for each of the considered factors, where Figure 2 shows the lowest corrosion potentials of copper in the two soil types, Figure 3 shows the lowest corrosion currents for stainless steel and Figure 4 shows the lowest corrosion rate for stainless steel.

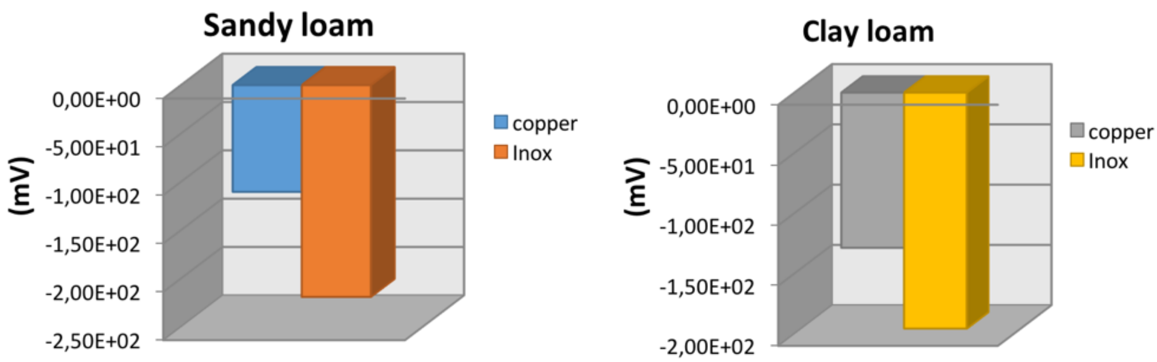


Figure 2. Ecorr (mV) Corrosion potentials for the two types of soils.

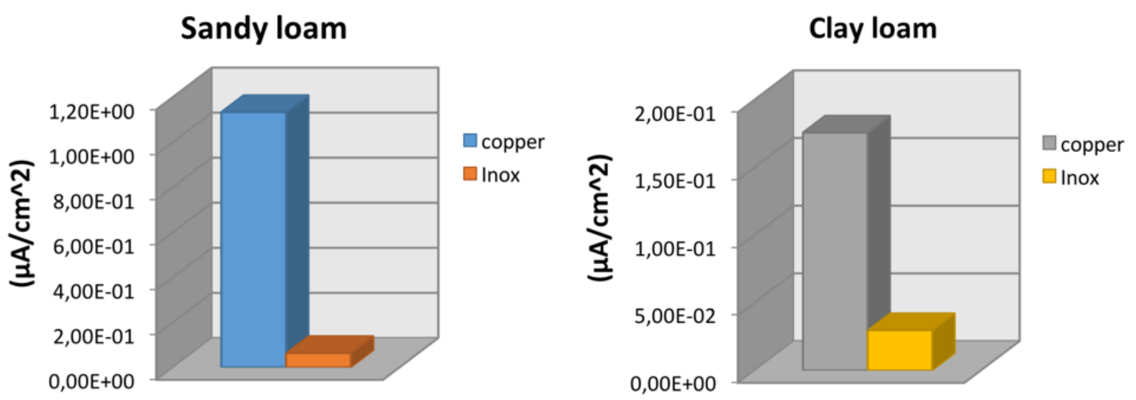


Figure 3. j_{corr} Corrosion current for the two types of soils.

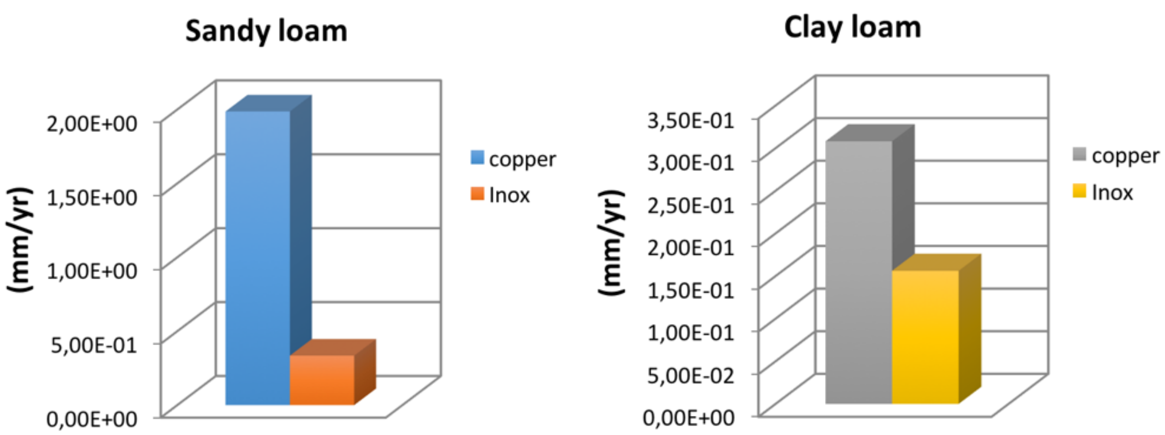


Figure 4. Corrosion rate.

5. Conclusions

Corrosion rates for different types of electrodes and soils were established. Appreciable differences in the currents and corrosion potentials are observed.

The copper electrodes are more corrosives than the stainless steel electrodes, in both types of soils under study. Corrosion rates are determined by electrochemical techniques that serve as reference for future studies.

The resistivity of the two types of soil was modelled by the wenner method. Cannot establish a direct relationship between the soil resistivity and corrosion rates. Should be consider other control variables as moisture, ph, redox potential and others that will be the subject of further studies.

References

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