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Full Length Research Paper

Physical Characteristics and Electrical Resistivity of Electric Cables Sold in Delta State. A case Study of Isoko Metropolis

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Abstract: There is a record increment of substandard electrical accessories in Nigeria, mostly in rural areas. This study was done to assess the qualities of electric cables sold in Delta State, Nigeria. Samples of commonly used electric cables (1 mm^2, 1.5 mm^2, and 2.5 mm^2), were randomly procured from ten major electrical stores within Isoko metropolis of Delta state. The selected cables were subjected to core size and electrical resistivity tests. Results of the tests showed that most of the cables failed to meet NIS recommendations for electric cables and wires. The physical characteristics results depicted that 80% of the 1 mm^2 cable diameter fell below 1.3 mm;70% of the 1.5 mm^2 cable diameter fell below the 1.38 mm; while 80% of the 2.5 mm^2 cables fell below the 1.78 mm recommendations. In terms of electrical resistivity, 40% of the 1 mm^2 cable met the NIS recommendation of 2.15 X 10^{-7} for 1 mm^2cable;50% of the 1.5 mm^2 cables were able to meet the NIS recommendation of 2.0 X 10^{-7}; likewise, the results revealed that it is only 30% of the 2.5 mm^2 cables met the NIS recommendation of 1.85 X 10^{-7}. This study had revealed that most of the electric cables sold in the rural parts of the country are not up to NIS recommendations. Therefore there is an urgent need for the regulatory agencies to beam their searchlight to the rural area of the country, in order to save the people from imminent electrical disasters.

Keywords: Electric cable, electrical disaster, physical characteristics, resistivity, standards

INTRODUCTION

Electric wires and cables played a key role during electrical installation. The carrying capacity of electric cable is highly dependent on the installation and environmental conditions (Brian, 2007; Alhashimi *et al.*, 2019).Electric cable specifications (types and sizes) are made in accordance to the circuit operating voltage and electric current capability. According to Popova *et al.*, (2012) electric cables specifications are affected by the prevailing environmental conditions, such as: ambient temperature range, moisture levels, and exposure to sunlight and chemicals (Michael, 2003). Heavy electrical installations demand more electrical wiring requirements. This is because they handle very large currents, besides higher voltages, frequent changes of equipment layout, corrosive, or wet or explosive atmospheres (Jones, 1991). Cables consist of four basic materials, which are: conductor materials, insulation, mechanical protector and filler materials (Adebayo, 2012). Copper and aluminum are the materials used as conducts in power and lighting cables. Copper has lower resistivity and this higher

conductivity than aluminum. Copper cable may be bare, or coated with a thin layer of another metal, such as: tin, gold, silver, etc. These metals are less prone to oxidation than copper; hence the life span of the cable will be increased, and also making soldering easier. Cables can be securely fastened and organized, such as: trunking, cable trays, cable ties, cable lacing etc. (Jonathan, 2003; Frank, 2007).

Substandard and counterfeits electrical cables is has become international problem. They are designed and produced without following any international approved standards. In 2009, the British Approvals Service for Cables (BASEC) issued an alert public warning about 'Kaydour' branded multi-core PVC sheathed XLPE insulated steel wire armoured cable. BASEC's discovered during laboratory tests that the cable had serious faults, including excessive conductor resistance and excessive armour resistance (Voltimum, 2020). In a survey carried out by African Press Organization (APO), the reported that 75% of electric cables used English speaking Africa countries are counterfeits and substandard. Further the stated that in Anglophone Africa countries, extension cords (49%), electrical wires (47%), and fuses (43%) as being the most counterfeit items after electric cables (APO, 2015). Another survey conducted by the Ghana Standards Authority (GSA) in 2017, showed that about 70% of all electrical cable imported into the country were substandard, and this might lead electrical fires. According to the Ghana standard organization, substandard electrical cables cause about 80% of electrical fires incidence in the country (Korankye and Mustapha, 2017).

According to the Standards Organization of Nigeria (SON), substandard and counterfeits electrical cables are responsible for majority of the electrical fire outbreak across Nigeria. This is because they are susceptible to short-circuit or overloading, which can lead to electrical fire. Some basic characteristics of a substandard cable are: smaller core (strand) diameter, the metallic conductor falling to meet pure metal specifications, substandard insulating materials, smaller insulating materials thickness, shorter length per coil, very high conductor resistance, low tensile strength of insulation, and poor tensile properties of the metallic conductor; against the requirements of NIS IEC 60228 for conductor (Universal Cable, 2017; Adekoya, 2019). Dangerous impacts of substandard electric cables include: (i) overheating, due to the smaller diameters of the substandard cables, their ability to conduct electricity effectively are reduced drastically, hence causing overheating of the cable (ii) electrical disruptions, due to their ununiform size (area) and composite materials, this can lead to overloading, short circuits and power outage; (iii) electrocution, the poor insulating materials of the substandard cables, can lost its insulating properties which will lead to electric shock or electrocution; (iv) fire outbreak, the general shortfall in the substandard cables can create electric arc or sparks, which can lead to electrical fire (Universal Cable, 2017). Common electrical cables and wires are mainly produced from aluminum and copper, but the substandard are made of steel and iron.

Nigeria government is aggressively fighting the anti-counterfeiting and substandard equipment war. Made in Nigeria products are strictly regulated by these regulatory agencies, to promote competition in the domestic and international market. This it is doing by setting and empowering various agencies to register and monitor the quality of products being sold in Nigeria markets. The Nigeria government had made it mandatory for all the electric cables local manufacturers and importers, that their products must have the Mandatory Conformity Assessment Programme (MANCAP) mark, which is a certification scheme implemented by the Standards Organization of Nigeria (SON). This ensures that locally produced electric cables and other electrical appliances conformed to the standards set by the Nigerian Industrial Standards (NIS) (Cotecna, 2020). Within the past decade, these regulatory agencies have destroyed electric cables and other electric appliances worth billions of dollars. In September 2020 in line with SON objectives, it located and destroyed four truckloads of substandard electric cables intercepted in Lagos State Nigeria (Vanguard, 2020).

In 2019, SON raided Kogi and Lagos Sates, where the destroyed tons of electric cables that failed to meet NIS standards. The increment in the occurrence of the rate electrical appliances failure in Nigeria lately has necessitated the need to determine the physical and electrical properties electric cables in circulation in Delta States. Much literature had been recorded on the electrical and physical properties of electric cables sold in various parts of Nigeria; but required literature on the physical and electric qualities of electric cables sold within Isoko metropolis of Delta State, Nigeria are still lacking. Therefore, the objective of this study is to carry out appraisal of core diameter and electrical resistivity of electric cables sold within Isoko metropolis of Delta State. Results obtained from this study will be used to compare the cable qualities with international set standards, and the need to set up quality control unit with the region.

MATERIALS AND METHODS

Study area

Isoko metropolis is home to one of the major tribes in Nigeria. There are two local government areas within the metropolis, such are: Isoko south and Isoko North. The major towns and villages within the metropolis are Oleh, Ozoro, Iyede, Owhe, Emede, Ellu, Igbide, Ewhne, Ofagbe, Oyede, Irri, Uzere, Aradhe, Olomoro, Okpe and Emevor. Isoko region has an average population of about

340,994, and occupying a land mass of about 1,181 km² (Agbi *et al.,* 2020). Isoko metropolis can be classified as an educational and commercial centre; because it housed a university campus, a polytechnic, one technical college and several oil exploring companies and facilities. A lot of buildings constructions are ongoing in the region; hence the sales of electrical accessories met for electrical wiring are on the increase.

Acquisition of materials

Ten (10) major electrical stores were chosen within the Isoko metropolis. The electrical stores were selected randomly across the metropolis. For the purpose of this study, three cable sizes commonly used for electrical wiring in the metropolis were selected. The electric cable sizes are: 1mm^2, 1.5 mm^2 and 2.5 mm^2. Five samples per cable size were randomly collected from each store. The sampled cables cut across all the brands in the market, within the Isoko metropolis. All the cables sampled were coded in accordance to the store where the cables were collected.

Physical and electrical test of the electric cables

The electric cables were subjected to standard testing methods, to ascertain their compliance to NIS standards. The two tests carried out on the cables were the size (core diameter) and resistivity tests. Four cables were tested in each set, and the average value recorded.

Physical test

The size (core diameter) of the cable was measured with a digital micrometer screw gauge, having accuracy of 0.001 mm. The area of the cable core was calculated using Equation 1

$$Area = \frac{\pi d^2}{4} \quad (1)$$

Electrical resistivity

The resistance of the electric cable core was measured using standard instruments, and the resistively was calculated using the expression provided in Equation 2.

$$\text{Resistively}(\rho) = \frac{RA}{l} \quad (2)$$

Where R = measured resistance of the electric cable core
d = Measured diameter of the electric cable core
l = measured length of the electric cable core.

Statistical analysis

The results obtained from this research were statistically analyzed using the MS Excel 2015 (Microsoft Corporation Redmond, WA 98052). The summary of the readings was plotted in Microsoft Excel 2015.

RESULTS AND DISCUSSION

Physical characteristics of the electric cables

The results physical characteristics of the cables obtained from the laboratory test presented in (Figures 1 to 3) and (Table 1). The results revealed that, most of the electric cables sampled from the Isoko metropolis fall below NIS recommended criteria (core diameter and area) and presented in (Table 2). According to NIS recommendation, each cable diameter must not fall below the allowable diameter limit; otherwise, the cable is regarded as substandard cable. As presented in (Figure 1), only 20% of the 1 mm^2 cable had diameter recommended by NIS, the remaining 80% cable had diameter between the recommended NIS standard. The results showed that the diameter of the cables obtained from two electrical stores (N1 and N3) were very poor, recording a diameter of 0.75mm and 0.78 mm respectively. Generally, the results displayed in (Figure 2) showed that only 30% of the 1.5 mm^2 cable meets the NIS criteria, as 70% of the cable has diameter below 1.38 mm. Furthermore, the results showed in (Figure 3) that 80% of the 2.5 mm^2 cable did not meet the NIS criteria for 2.5 mm^2 cable size. The 2.5 mm^2 cable had the poorer diameter, compared to the other cables (1 mm^2 and 1.5 mm^2) diameters. The mean diameter of the 2.5 mm^2 cable sampled from stores 1, 3, 6 and 8 were below 1.0 mm, which is about half value (0.89 mm) of the NIS recommended diameter for 2.5 mm^2 cable (Table 2). The great sharp practice observed in the 2.5mm^2 cable could be attributed to its high demand for household electrical wiring. Similar results were reported by Onyekachi and Nduka (2019) for 1 mm^2, 1.5 mm^2, 2.5 mm^2 and 4 mm^2, when their core diameters fell short of NIS minimum diameter.

Electrical properties of the electric cables

Results obtained from the electrical test and presented in (Figures 4 to 6) showed that most of the cables sampled had very high electrical resistivity. These resistivity values were highly above the NIS recommendation; hence rendering then cable fake, and unsuitable for electrical wiring. As presented in (Figure 4) 60% of the 1 mm^2 cable had resistivity above the NIS recommendation; hence 60% of the 1 mm^2 cable sampled was substandard. The 1.5 mm^{2}showed good standardization, as 50% of the 1.5 mm^2 cable falls within the NIS recommendation. In contrast, it was only 30% of the 2.5 mm^2 cable that meet the NIS recommendation, as 70% of the cable has electrical resistivity higher than the NIS

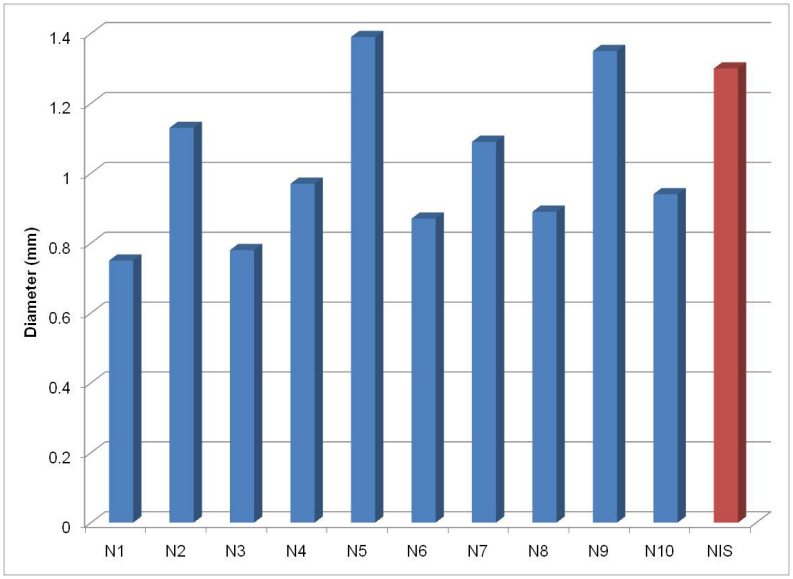

Figure 1: Mean diameter of the sampled 1 mm^2 electric cable.

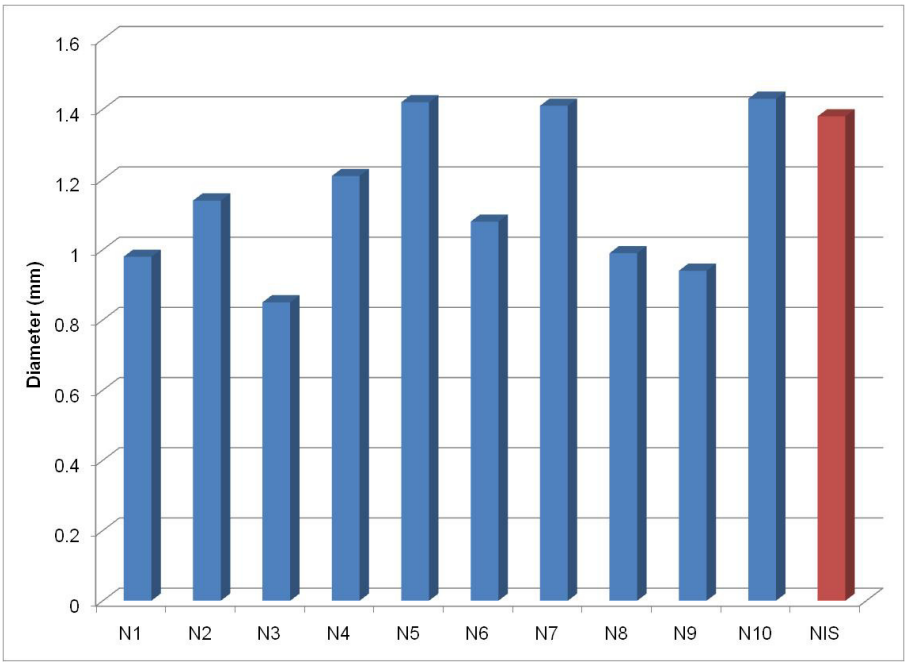

Figure 2: Mean diameter of the sampled 1.5 mm^2 electric cable.

recommendation. It can be seen in the results that even with the smaller core diameter, the electrical resistivity of the cables were very high. This signified that pure copper was not used as the conductor. Due to the high cost of metallic copper, some cable manufacturer usually used recycled copper materials, which is much cheaper as their conductor. Despite the substandard nature of most of the cables sampled, all of the cables bear brand names with manufactures' address. This portrayed that that either the manufacturers purposely downgraded their products for profit maximization, or their products have been counterfeited by a third party. This study results confirmed the earlier SON laboratory reports. According to SON, substandard cables usually have super high resistance of 1,500 Ohms, against the normal maximum resistance of 12 Ohms. Hence, the cable will resist

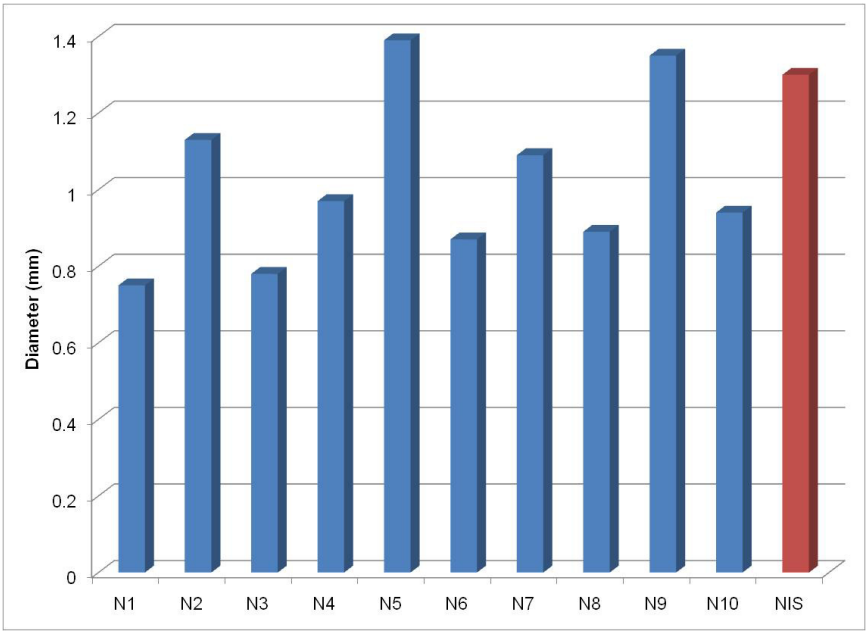

Figure 3: Mean diameter of the sampled 2.5 mm^2 electric cable.

Table 1: Cross sectional area of the sampled cable

Sampled code	Cross sectional area (mm^2)		
	1 mm^2	1.5 mm^2	2.5 mm^2
N1	0.44	0.75	1.19
N2	1.00	1.02	1.84
N3	0.48	0.57	1.29
N4	0.74	1.15	1.70
N5	1.52	1.58	1.84
N6	0.59	0.92	1.47
N7	0.93	1.56	1.99
N8	0.62	0.77	1.43
N9	1.37	0.69	1.65
N10	0.69	1.61	2.57

Table 2: NIS recommendation of electric cables

Cross sectional (mm^2)	Diameter (mm)	Radial thickness of insulation (mm)	Cable resistance at 20ºC (Ωmm)	Resistivity at 20ºC (Ωmm)
1.00	1.30	0.70	18.30	2.15 X $10^{-/}$
1.50	1.38	0.70	13.30	2.0 X $10^{-/}$
2.50	1.78	0.8	7.41	1.85 X $10^{-/}$

electricity flow, a situation that will lead heat buildup within the cable because of friction, and eventually electrical fire outbreak (Adekoya, 2019).

Counterfeiting is another major problem facing international standard regulatory agencies. According to SON, some counterfeiters usually forged SON certification and MANCAP marks, to deceive the public. The Standards Organization of Nigeria continuously issued alert on the presence of substandard and counterfeits electric cables brands in the Nigerian markets (Adekoya, 2019). The Nigerian cable manufacturers had attributed the scourge in the substandard (smaller core diameters) electric cables and wires in the country, to the activities of some importers who shipped in substandard cables from aboard, since electric cables and wires manufactured in Nigeria conformed with SON and NIS standards (Adetoro, 2012). In 2016, Nigerchin cables and wires manufacturing

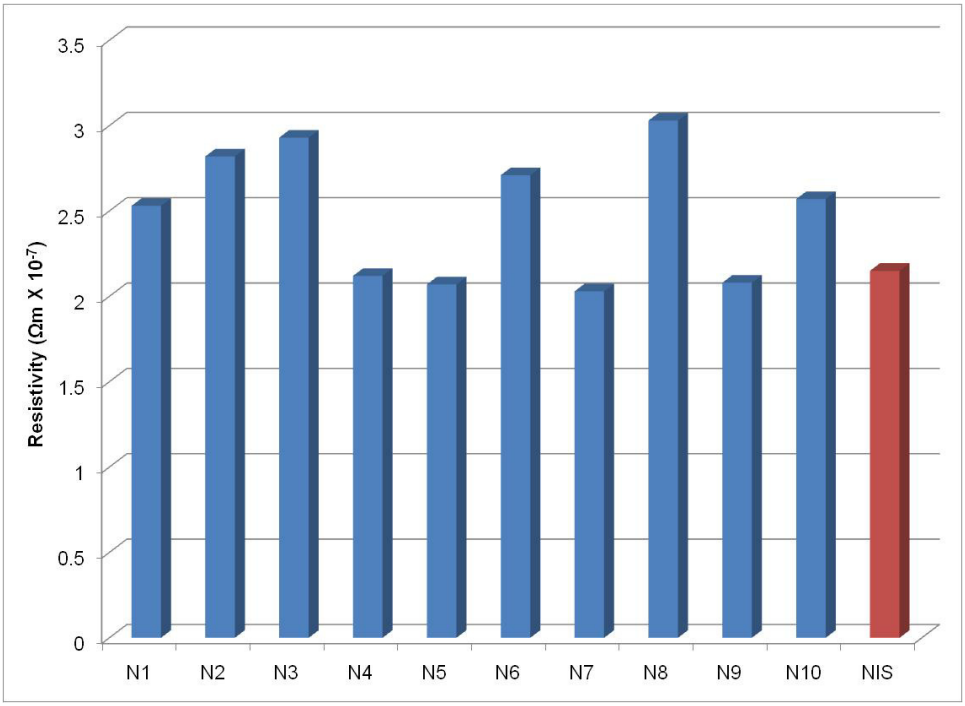

Figure 4: Electrical resistivity of 1 mm^2 copper cable.

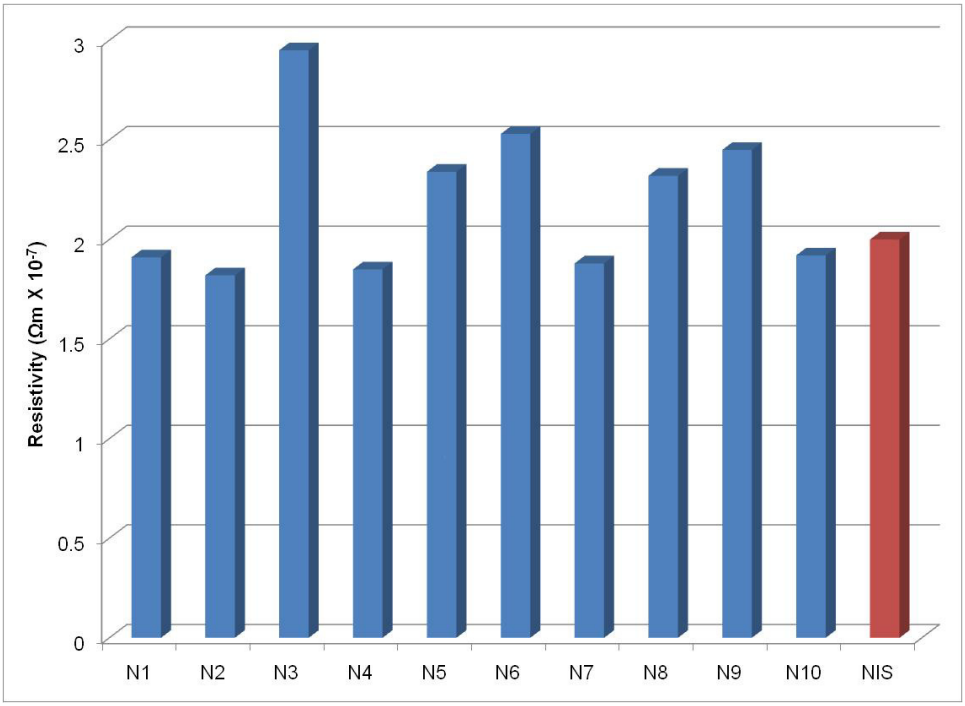

Figure 5: Electrical resistivity of 1.5 mm^2 copper cable.

company raised alarm that some people are counterfeiting their products, for their own personal gains; thereby smearing their credibility and reputation. Although, the Nigeria standard regulatory agencies are trying their best to sanitize the country of counterfeited products, the bodies should put more effort should be focused on the rural areas. This is because it is in the rural area that bulks of these substandard products are being sold. According to SON, counterfeits electric cables have no economic value and constitute serious threat to

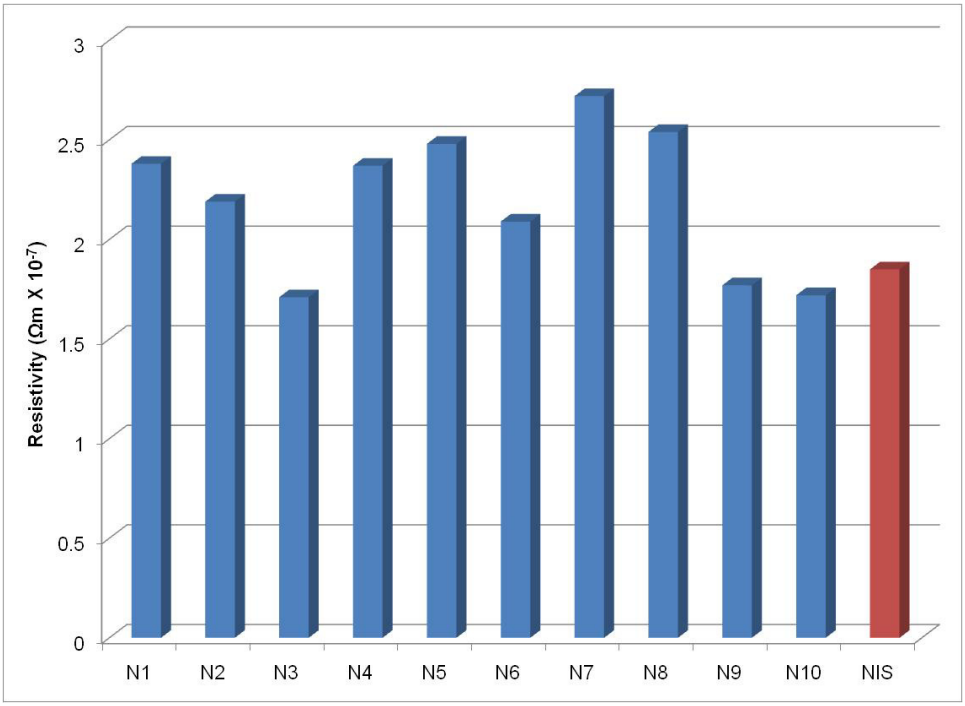

Figure 6: Electrical resistivity of 2.5 mm^2 copper cable.

the power sector, warned Nigeria from patronizing these products (Adekoya, 2019). This will help to minimize the volume of substandard electrical cables in circulation within the country.

Conclusion

This work was carried out to ascertain the compliance of the electric cables sold in Isoko metropolis to International standards. Three electric cables grades (1 mm^2, 1.5 mm^2 and 2.5 mm^2) were sampled from ten major electrical stores within the metropolis. The sampled cables were subjected to physical and electrical properties tests, according to international standards. Results obtained from the tests revealed that most of the cables sold within the metropolis fall short of NIS standards. It was only 20% of the 1 mm^2 cable had diameter recommended by NIS, the remaining 80% cable had diameter between the recommended NIS standard. While 30% of the 1.5 mm^2 cable meets the NIS criteria, and70% of the cable has diameter below NIS criteria. Furthermore, the results revealed that 80% of the 2.5 mm^2 cable did not meet the NIS criteria for 2.5 mm^2 cable size. In terms of the electrical resistivity of the cables, most of the cables had very high resistivity, above NIS recommendations. This high resistivity and smaller diameter can cause overheating of the wired circuit, leading to electrical fire outbreak. Therefore, Nigeria standard regulatory agencies must act fast to avert imminent disasters in the country.

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