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Determination of the Effect of Sand Content on the Resistivity of Kaolin

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ABSTRACT [ENGLISH/ANGLAIS]

This paper seeks to determine the effect of sand content in Kaolin on its resistivity. To this end, different proportions of clay from Oza-nogogo were mixed with different proportion of sand, in different ratios. The mixture - which must be uniform – is then stuffed into cylindrical pvc pipes, 5cm in length, and the values of voltage and current through the sample obtained, from which the resistivity can be determined. Data were obtained and plotted. Results obtained revealed that the sample that contained 80% clay and 20% sand yielded a resistance of 0.317Ω and a resistivity of 0.00199203Ωm. The sample that contained 60% clay and 40% sand yielded a resistance of 0.3Ω and a resistivity of 0.0018846 Ωm, The sample that contained 100% clay yielded a resistance of 0.45455Ω and a resistivity of 0.0028554 Ωm, While the sample that contained 100% sand yielded a resistance of 0.055Ω and a resistivity of 0.00034776 Ωm. However, the sample that contained Equal quantities of both samples ie 50% clay and 50% sand yielded a resistance of 0.26316 Ω and a resistivity of 0.0016537 Ωm.We conclude therefore that the resistivity of clay decreases with increasing sand content. These resistivity values are important variables, informing the use of clay/kaolin as insulators in electrical installations.

Keywords: Sand, kaolin

RÉSUMÉ [FRANÇAIS/FRENCH]

Ce document vise à déterminer l'effet de la teneur en sable dans kaolin sur sa résistivité. À cette fin, différentes proportions d'argile de Oza-nogogo ont été mélangés avec des proportions différentes de sable, dans des proportions différentes. Le mélange - qui doit être homogène - est ensuite remplie dans des tuyaux en PVC cylindriques, 5cm de longueur, et les valeurs de la tension et du courant à travers l'échantillon obtenu, à partir de laquelle la résistivité peut être déterminée. Les données ont été obtenues et tracés. Les résultats obtenus ont révélé que l'échantillon contenant 80% d'argile et de sable de 20% a donné une résistance de 0.317Ω et une résistivité de 0.00199203Ωm. L'échantillon qui contenait 60% d'argile et de sable de 40% a donné une résistance de 0.3Ω et une résistivité de 0,0018846 Ωm, l'échantillon contenant 100% d'argile a abouti à une résistance de 0.45455Ω et une résistivité de 0,0028554 Ωm, si l'échantillon qui contenait 100 % de sable a abouti à une résistance de 0.055Ω et une résistivité de 0,00034776 Ωm. Toutefois, l'échantillon qui contenait des quantités égales des deux échantillons d'argile à-dire 50% et 50% de sable a donné une résistance de 0,26316 Ω et une résistivité de 0,0016537 Ωm.We concluons donc que la résistivité de l'argile diminue avec l'augmentation de la teneur en sable. Ces valeurs de résistivité sont des variables importantes, en informant l'utilisation de l'argile / kaolin comme isolants dans les installations électriques.

Mots-clés: Effet, le sable, le kaolin

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INTRODUCTION

Kaolin belongs to the group of clay mineral's that contain atoms of silicon, aluminium, oxygen, ferrous iron, and hydroxyl groups as the main constituent. It also contains other minerals such as phosphorus, potassium, calcium, sodium, magnesium etc . Members of the Kaolin family include dickite, nacrite, allophone, and hallosite [1]. The iron content in each type of kaolin clay determines its colour, it is usually white to near white in colour. Other colours such as purple, bleach brown, etc and due to impurities in the material.

Kaolin (hydrated aluminium silicate, $Al_2Si_2O_5(O.H)_4$), is an important industrial clay for economic benefits. Properties such as fine particles size, plate-like shape, inertness, non-toxicity and whiteness make it a more versatile mineral, with application in a wide variety of industries. Commercial Kaolin resources are found as sedimentary deposit and as weathering or hydrothermal alteration product of rocks containing a high proportion of alumino-silicate minerals.

In the determination of the resistivity of kaolin, by gradually increasing sand content, certain condition must be considered, such as; soil porosity, grain size, capillary radius and Kaolin content. It was found that the plasticity decreases as Kaolin content increases and so does soil resistivity. wetness of the samples must not be over-looked as it plays an important role in resistivity. Kaolin resistivity depends on other parameters, like ground water, salinity, soil humidity temperature etc. [2-5]. Resistivity is the resistance per unit volume, for current following through the unit cube of material. Resistivity is also defined as the voltage measured flowing across a circuit divided by the current flowing through the unit cube cross sectional area. Its unit is Ohm.

All pottery/ceramics products is made with kaolin and the type of Kaolin used greatly influences the look and quantity of the finished piece. Often potters do not use one type of clay, but may use a mixture of clay to get certain desired results, so that his work will contain certain unique qualities and identity/trademark, for example earth-ware, stone ware and porcelain are all made of different mixtures of clay. Individual potter's often make their own formulae, so that their pottery can have certain desired qualities.

Clay (Kaolin) are broadly divided into two categories primary and secondary. Primary clay have larger grains, and are located close to their original source(in-situ). Secondary clays are sedimentary type of clay that have been carried away from its original source by wind, running water, and other agents, thus making the clay finer than its primary counterpart.

Clay and clay mixtures can fall into any of the following categories:

1. Kaolin: This clay is very pure with a white colour. It does not shrink very much when fired and must be fired at a very high temperature. It is usually not used alone, as it does not have a high degree of "plasticity" that is the ability to be malleable and easy to work with.

2. Fire Clay: Fire clay is easy to work with or not degree of plasticity is variable. It usually has very rough texture and is often added to stone wave.

3. Ball Clay: This clay has a finer grain than fire clay and shrink a great deal during the firing process. For the reasons, it is usually mixed with kaolin, as kaolin clay has a low degree of shrinkage.

4. Earth Ware: This type of clay is very common and generally contain a fair amount of iron. It does not generally need to be fired at a very high temperature.

5. Stone Ware: Stone ware is clay that is generally a mixture of other clay components. It has a high degree of plasticity and requires a fairly high firing temperature.

Generally, two types of clay are recognizable, the silicate clays of temperate regions and the iron and aluminium hydroxide clays found in the tropics and semi tropics. All clay particles are crystalline and not amorphous as was originally supposed.

Oza-nogogo is a town in Ika south Local Government Area of Delta State, located approximately at latitude 6.43°N, in the tropics. The clay used in this research was obtained from this town, as it contains large deposits of clay/kaolin.

MATERIALS AND METHODS

The instrument employed during measurement include the following:

i. Functional generator
ii. Digital multimeter
iii. An analogue Multimeter
iv. Connecting cables
v. Key and
vi. Power supply

1) Functional generator: this served as the source of power supply as it supplied current to the samples. This is capable of coverting A.C current from the source into D.C current and supplies the D.C current in square wave form through an output dc voltage as much as + 12 and - 12 volts.

2) Digital multimeter: the digital multimeter was employed in the measurement of potential difference between two points of the sample. The digital meter was preferred to the analogue type for certain reasons.

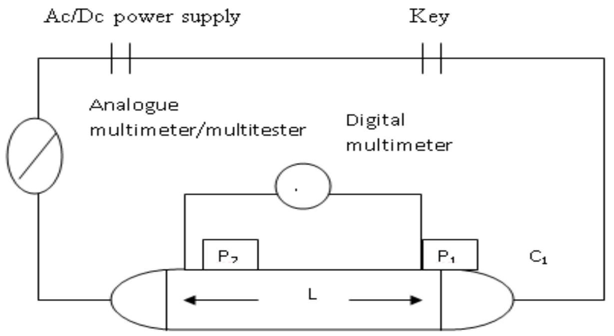
a) The voltage expected is small, as such, it is required that the measuring device must have a high input impedance so that substantial current would flow across it at the time of measurement. The digital multimeter which incorporates an integrated circuit operational amplifier meets this requirement with the rating of input impedance in excess of 10 mega ohms (Technical Data) [3].

b) An operational amplifier (op-amp) also features a very low output impedance typically 5 ohms, so that the output is almost a total reflection of the measurement signal .

c) The digital display of the meters output eliminated human error (error due to parallax)which could occur with an analogue display.

3) An analogue Multimeter: This was used in measuring the quantity of current from the functional generator passing though the samples. It has a very wide range and this serves as an advantages over an Ammeter [2].

4) Cables: cables were used in connecting the instrument together to obtain a circuit as show below



5) Optical Pins: four steel optical pins were used as electrodes (c_1 and c_2) are current electrodes and another set (p_1 and p_2) as potential electrodes (see Fig A).

6) Key: The key is used to control the flow of current through the circuit. This is achieved by either closing or opening the key.

7) Power Supply: A dc power supply was used during measurement to supply pure dc current to the control samples.

The electrical properties of any rock/material is dependent to a large extent on the mineral contituents of such a rock or material [4].

Seven samples were evaluated. The plot of the graph of all seven samples are shown in Figs. 1-7 below. The slope of the graphs gives the resistance, from the slope, the resistivity i.e. specific resistances were calculated using the formula

$$\rho = \frac{RA}{L}$$

where R is the resistance which is also the value gotten from the slope of the graph, L is the length of the PVC pipes used for the experiment which is 8cm it was converted to meters (ie 8cm = 0.08m), A is the area, which is πr^2. Where r is the radius and r = Diameter/2.

RESULTS

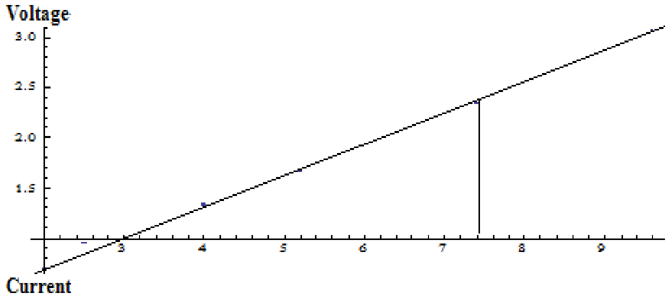
The following readings were obtained and analyzed using the Mathemathica 6 software.

Table 1: This table shows reading for 60% Clay/40% Sand

Voltage(v)	Current(mA)	Current(A)
0.69	2.00	0.004
0.95	2.50	0.0025
1.33	4.00	0.004
1.66	5.20	0.0052
2.34	7.40	0.0074
3.06	9.60	0.0096

ListPlot[{{2.00,0.69},{2.50,0.95},{4.00,1.33},{5.20,1.66},{7.40,2.34},{9.60,3.06}}]

Figure 1: This figure shows graph of voltage vs current (60 % Clay/ 40 % Sand)



Slope= 2.35-1.00/7.4-3.0= 1.35/4.5= 0.3 Ω

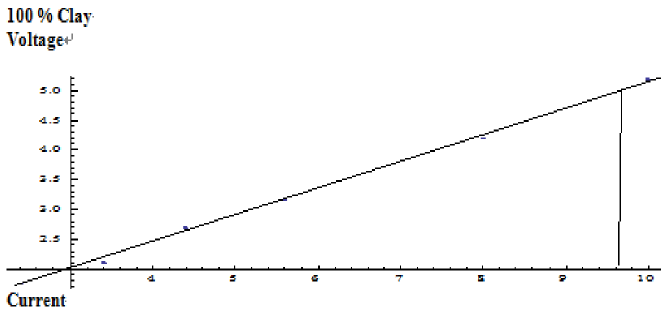
$$Resistivity(\rho) = \frac{RA}{L} = \frac{0.3x0.00031416}{0.05} = \frac{0.00009423}{0.05} = 0.0018846\ \Omega m$$

Table 2: This table shows reading for 100 % Clay

Voltage(v)	Current(mA)	Current(A)
1.74	2.40	0.0024
2.10	4.40	0.0044
2.68	5.60	0.0056
3.16	8.00	0.008
4.18	10.00	0.010
5.18	14.00	0.014

ListPlot[{{2.40,1.74},{3.40,2.10},{4.40,2.68},{5.60,3.16},{8.00,4.18},{10.00,5.18}}]

Figure 2: This figure shows graph of voltage vs current (100 % Clay)



Slope= 5.0-2.00/9.6-3.0= 3/6.6= 0.45455 Ω

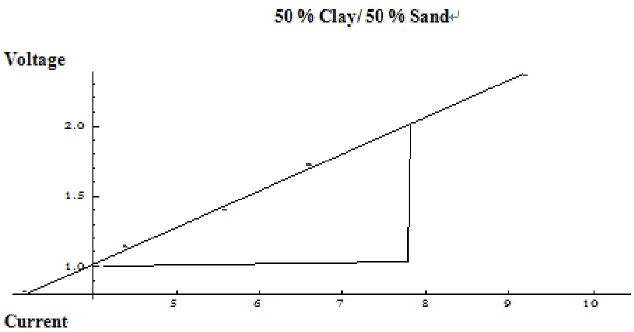
$$Resistivity(\rho) = \frac{RA}{L} = \frac{0.45455\,x0.00031416}{0.05} = \frac{0.00014277}{0.05} = 0.00285548\ \Omega m$$

Table 3: This table shows reading for 50 % Clay/ 50 % Sand

Voltage(v)	Current(mA)	Current(A)
0.82	3.20	0.0032
1.14	4.40	0.0044
1.40	5.60	0.0056
1.72	6.60	0.0066
2.36	9.20	0.0092
0.80	14.00	0.014

ListPlot[{{3.20,0.82},{4.40,1.14},{5.60,1.40},{6.60,1.72},{9.20,2.36},{14.00,0.80`}}]

Figure 3: This figure shows graph of voltage vs current (50 % Clay/ 50 % Sand)



Slope= 2.00-1.00/7.8-4.0= 1.00/3.8= 0.26316 Ω

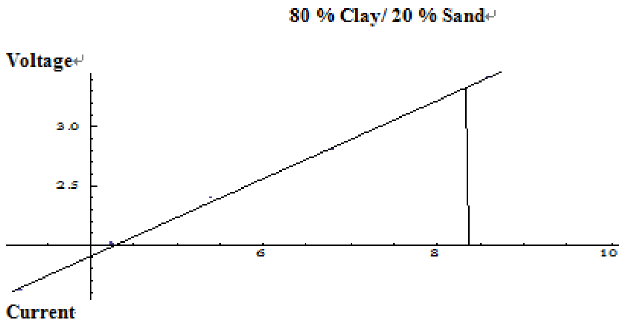
$$Resistivity(\rho)=\frac{RA}{L}=\frac{0.26316x0.00031416}{0.05}=\frac{0.00008268}{0.05}=0.0016537\ \Omega m$$

Table 4: This table shows reading for 80%Clay/20%Sand

Voltage(v)	Current(mA)	Current(A)
1.62	3.20	0.0032
2.02	4.25	0.00425
2.40	5.40	0.0054
2.80	6.80	0.0068
3.42	8.60	0.0086
1.58	14.00	0.014

ListPlot[{{3.20,1.62},{4.25,2.02},{5.40,2.40},{6.80,2.80},{8.60,3.42},{14.00,1.58}}]

Figure 4: This figure shows graph of voltage vs current (80 % Clay/ 20 % Sand)



Slope= 3.3-2.00/8.4-4.3= 1.30/4.1= 0.317 Ω

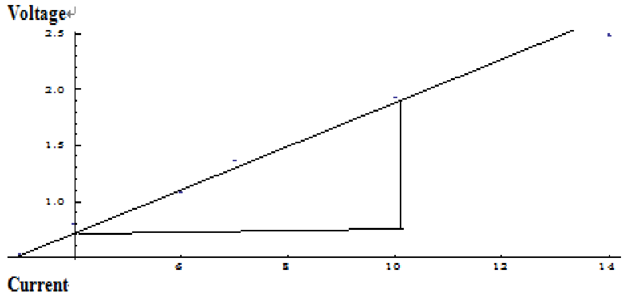
$$Resistivity(\rho)=\frac{RA}{L}=\frac{0.317x0.00031416}{0.05}=\frac{0.0000996}{0.05}=0.00199203\ \Omega m$$

Table 5: This table shows reading for 40%Clay/60% Sand

Voltage(v)	Current(mA)	Current(A)
0.52	3.00	0.003
0.80	4.00	0.004
1.08	6.00	0.006
1.36	7.00	0.007
1.92	10.00	0.010
2.48	14.00	0.014

ListPlot[{{3.00,0.52},{4.00,0.80},{6.00,1.08},{7.00,1.36},{10.00,1.92},{14.00,2.48}}]

Figure 5: This figure shows graph of voltage vs current (40%Clay/60 %Sand)



Slope= 1.9-0.70/10.1-4.0= 1.20/6.1= 0.1967 Ω

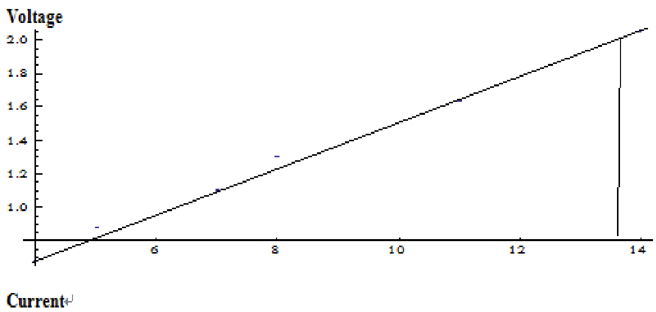
$$Resistivity(\rho)=\frac{RA}{L}=\frac{0.1967x0.00031416}{0.05}=\frac{0.0000618}{0.05}=0.00123606\ \Omega m$$

Table 6: This table shows reading for 20%Clay/80%Sand

Voltage(v)	Current(mA)	Current(A)
0.68	4.00	0.004
0.88	5.00	0.005
1.10	7.00	0.007
1.30	8.00	0.080
1.64	11.00	0.011
2.04	14.00	0.014

ListPlot[{{4.00,0.68},{5.00,0.88},{7.00,1.10},{8.00,1.30},{11.00,1.64},{14.00,2.04}}]

Figure 6: This figure shows graph of voltage vs current (20%Clay/80%Sand)



Slope= 2.0-0.80/13.6-5.0= 1.2/8.6= 0.1395 Ω

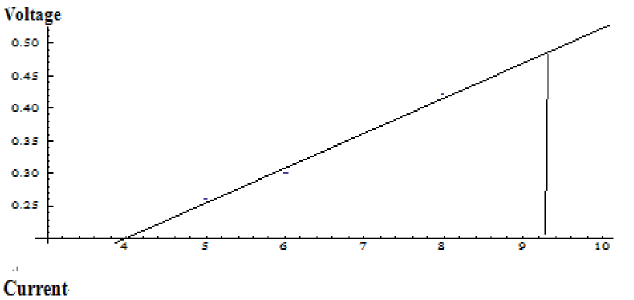
$$Resistivity(\rho)=\frac{RA}{L}=\frac{0.1395x0.00031416}{0.05}=\frac{0.00004383}{0.05}=0.00087662\ \Omega m$$

Table 7: This table shows reading for 100% Sand

Voltage(v)	Current(mA)	Current(A)
0.20	3.00	0.003
0.20	4.00	0.004
0.26	5.00	0.005
0.30	6.00	0.006
0.42	8.00	0.008
0.52	10.00	0.010

ListPlot[{{3.00,0.20},{4.00,0.20},{5.00,0.26},{6.00,0.30},{8.00,0.42},{10.00,0.52}}]

Figure 7: This figure shows graph of voltage vs current (100% Sand)



Slope= 0.49-0.20/9.24-4.0= 0.29/5.24= 0.05534 Ω

$$Resistivity(\rho) = \frac{RA}{L} = \frac{0.05534 \, x 0.00031416}{0.05} = \frac{0.00001739}{0.05} = 0.00034776 \, \Omega m$$

DISCUSSION

From the results obtained ,we see readily that the sample that contained 80% clay and 20% sand yielded a resistance of 0.317 Ω and a resistivity of 0.00199203 Ωm, The sample that contained 60% clay and 40% sand yielded a resistance of 0.3Ω and a resistivity of 0.0018846 Ωm, The sample that contained 100% clay yielded a resistance of 0.45455Ω and a resistivity of 0.0028554 Ωm, While the sample that contained 100% sand yielded a resistance of 0.055Ω and a resistivity of 0.00034776 Ωm. However, the sample that contained equal quantities of both samples ie 50% clay and 50% sand yielded a resistance of 0.26316 Ω and a resistivity of 0.0016537 Ωm.

We conclude therefore that the resistivity of clay decreases with increasing sand content. However, the wetness of the samples must be borne in mind as it plays a very important role in resistivity.

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Nil

CONFLICT OF INTEREST

Nil

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