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# A Study on Grainsize Distribution and Chemical Content and Other Properties of Silica Sand Samples From Selected Sourses

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***ABSTRACT***
*The silica sand samples were obtained from six different locations, Umuchima and Ugwuonyekaba in Okigwe,Ugwuogu and Umuanyi in Uturu, Otamiri River in Federal University of Technology ,Owerri (FUTO) and Nworie River in Owerri all in southeastern Nigeria.*
*The grain size distribution analysis was determined by passing the material through a series of sieves stacked with decreasing mesh sizes from the top to bottom, and weighing the material retained in each sieve.*
*The sieve analysis of the sand samples showed that the grain size ranges from 0.15mm to 0.5mm and more than 95% percentage of the sand samples fall within 100meshsieve, coefficient of uniformity (Cu) is between 1.94 to 2.8 and coefficient of curvature (Cc) is in the range of 0.8 to 1.4.*
*The pH range is from 6.6 to 6.97 and that of silt content is from 0.89 to 2.63 percent. The range of specific gravity is from 2.57 to 2.64.*
*Conductivity of the sand samples is between 613.76 to 989.53 µs/cm.*
*The chemical analyses of the silica sand samples by atomic absorption spectrophotometer (AAS) showed that the percentage silicon oxide content of 95.91 and 96.12 with low iron content of 0.18 and 0.16 for B1 and C respectively is adequate for the manufacture of amber glass, green glass and insulating fiberglass. The rest of the sand samples fall below 95.91 percent of silicon oxide content and A1 had the lowest percentage.*
***KEY WORDS**: Silica Sand, Sieve analysis, Chemical analysis, pH and Conductivity*

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## I. INTRODUCTION

Silica sand is a naturally occurring granular material that is composed of finely divided rock and mineral particles. Sand has various compositions but is defined by its grain size. Sand grains are smaller than gravel and coarser than silt. Sand can also referto as a textural class of soil or soil type; i.e., a soil containing more than 85 percent sand-sized particles by mass.[1].Silica sand has various compositions depending on the local rock sources and conditions but the most common mineral on earth ‘s surface is quartz sand ,it is found in almost every type of rock; igneous , metamorphic and sedimentary [2].

High percentage of silicon oxide content in sand makes glass making possible. Silica sand is the primary component of all types of standard and specialty glass. Silica sand also known as Industrial sand is used to produce flat glass for building and automotive use, container glass for foods and beverages, etc. It provides the silicon oxide ($SiO_2$) component of glass formulation. The requirement falls into two main groups, namely the degree of purity as indicated by its chemical properties and the physical characteristics of the sand [3]. For industrial and manufacturing applications, deposits of silica sand yielding products of at least 95% $SiO_2$ are preferred. Industrial sand’s strength, silicon dioxide contribution and non-reactive properties make it an indispensable ingredient in the production of thousands of everyday products[4][5][6].

**Table 1: General specification of chemical composition of glass sand**

| Glass quality | $SiO_2$% | $Fe_2O_3$% | $Al_2O_3$% | CaO/MgO% | $TiO_2$% |
|---|---|---|---|---|---|
| Optical | 99.80 | 0.005 | 0.10 | 0.100 | - |
| Borosilicate glass | 98.50 | 0.050 | 0.50 | 0.20 | 0.012 |
| Colorless container glass | 98.50 | 0.150 | 0.50 | 0.50 | 0.100 |
| Clear/Float glass | 95.00 | 0.200 | 4.00 | 0.50 | 0.100 |
| Insulating fiber | 95.00 | 0.300 | 0.50 | 0.50 | 0.100 |
| Amber glass | 95.00 | 1.000 | 4.00 | 0.50 | 0.100 |
| Green glass | 95.00 | 1.000 | 4.00 | 0.50 | 0.100 |

Source: [7][8][9]

## II. MATERIALS AND METHODS

### 2.1 Source of Materials

Six locations or sources were selected for this study, four of the sources are pit sand and the remaining two are River sand. The sources and location of selected aggregates are shown in Table 2.

**Table 2: Description of Studied Aggregates**

| S/N | Sample Code | Sample Name/Location | Co-ordinates |
|---|---|---|---|
| 1 | A1 | Umuchima pit sand, Okigwe | 5.8314$^0$N,7.3434$^0$E |
| 2 | A2 | Ugwuonyekaba pit Sand, Okigwe | 5.8351$^0$N,7.3423$^0$E |
| 3 | B1 | Umuanyi pit Sand, Uturu | 5.8308$^0$,7.4191$^0$E |
| 4 | B2 | Ugwuogu pit sand ,Uturu | 5.8225$^0$N,7.3941$^0$E |
| 5 | C | Nworie River, Owerri | 53$^0$N ,7$^0$00E |
| 6 | D | Otamiri River, Owerri | 5.3927$^0$N,6.9861$^0$E |

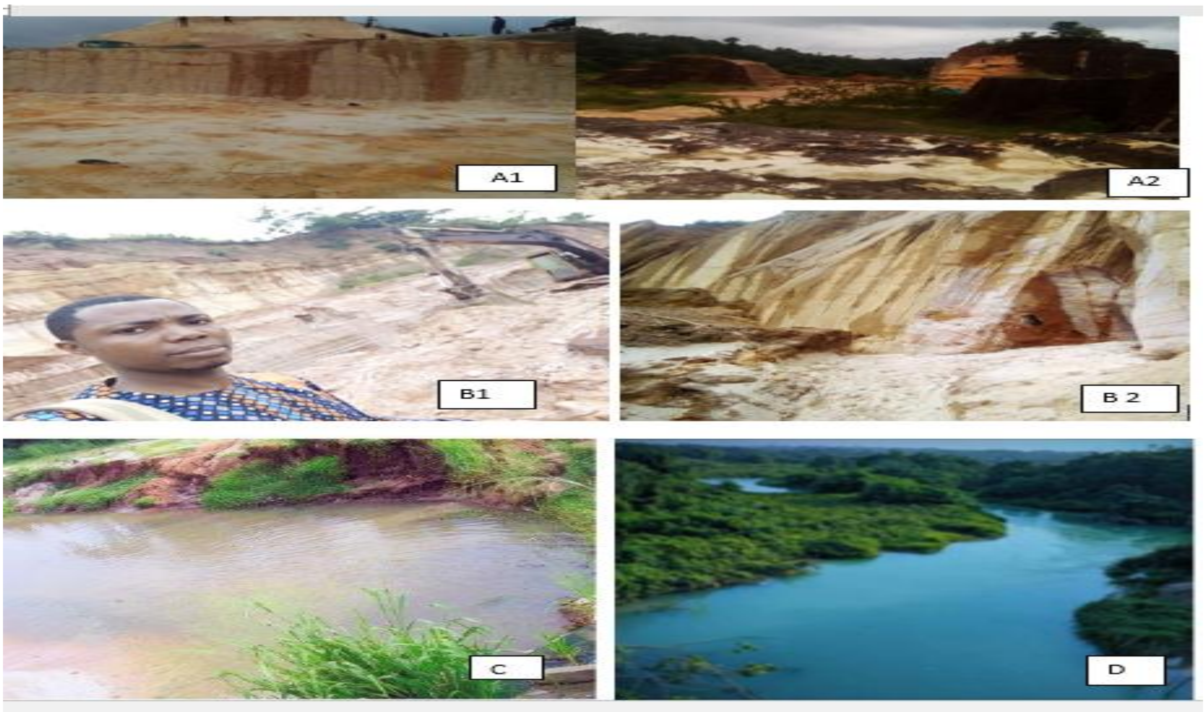


Figure 3.1: Location and collection

### 2.2 Grain size distribution

Grain size distribution was determined by a sieve analysis test and Standard Sieve sizes for fine aggregates according to ASTM E 11[10] were used.

The sand samples were dried in oven and each of the dry samples was weighed to obtain 200g, the mechanical sieveshaker was stacked with decreasing mesh sizes from the top to bottom, the sand sample was poured on the sieve shaker and was operated for 20 minutes. After sieving the samples, they were emptied on a crucible weighed one after the other, and then the cumulative percentage by weight of the particles passing each sieve was calculated and recorded.

Figure 1: Sieve analysis test

**2.3 Determination of pH**

The pH of the samples were determined using a digital pH meter (PH-3C). Five (5) grams of the properly labeled samples were diluted with 10ml of sterile distilled water, and the electrode of the pH meter which has been previously standardized was dipped into the diluted soil sample and swirled gently, allowed to stand until a stable/constant reading was obtained. At each point, two values were obtained and the mean of the values was used.

**2.4 Determination of Conductivity**

Conductivity of the samples was measured with a conductivity meter (DDS 307) during the period of the experiment. Electrical conductivity (EC) of water is a measure of the ability of a solution to conduct an electrical current. The conductivity values were measured in µs/cm, and it gives a surrogate value of level of salinity and total dissolved solids (TDS). Five (5) grams of the soil sample were diluted in 10ml distilled water, and swirled gently for proper distribution. The electrode of a conductivity meter was dipped into the diluted soil, and the noted immediately as a constant value appeared.

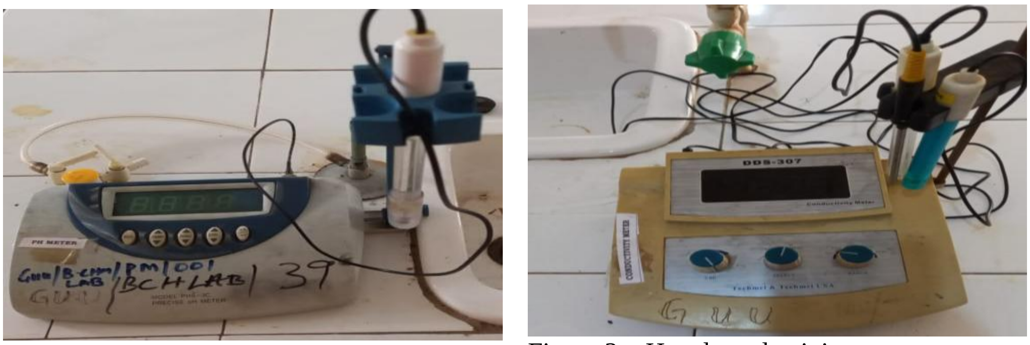


Figure 2: pH and conductivity meter.

**2.5 Determination of Specific Gravity**

The washed aggregate was transferred to the tray and water was added further to ensure that the sample is completely immersed. Soon after immersion, bubbles of trapped air were removed by gentle agitation with a rod. The sample was immersed in water for 24 hours at room temperature.it is then the removed from the water and dried to a saturated surface-dry stateby exposing the aggregates to warm air and stirred to obtain uniform drying. The saturated and surface-dry sample was weighed (mass A), the aggregate was placed in the pyknometer(flat bottom flask) and the pyknometer filled with water. The trapped air was eliminated by rotating the pyknometer on its side, the hole in the apex of the cone being covered with a finger. The pyknometer

Topped up with water to remove any froth from the surface and so that the surface of the water in the hole is flat.Thepycnometer was dry on the outside and weighed (mass B).The contents of the pyknometer was emptied into a tray, taking care to ensure that all the aggregate was transferred. The pyknometer was refilled with water to the same level as before, it was dried on the outside and weighed (mass C).Then the water was drained carefully from the sample by decantation through a 75 µm BS test sieve and any material retained was returned to the sample. Then the sample was placed in the tray, in the oven at a temperature of $105^{o}C \pm 5^{o}C$ for 24 hours. Then it was cooled in the airtight container and weighed (mass D).

Figure 3: specific gravity test

$$\text{Specific Gravity} = \frac{D}{D-(B-C)} \qquad 1$$

Where D = $Mass\ of\ Oven\ dry\ aggregate\ in\ air$

B = $Mass\ of\ oven\ dry\ sand$

C = $mass\ of\ vessel\ with\ water\ only$

A = Mass of saturated Surface- dry aggregate in air

**2.6Chemical analysis**

The materials for this experiment (volumetric flask and digestion flask) were bathed in nitric acid for 12hours, washed with detergent, rinsed in deionized water and dried in oven.

The digestion procedure for soil sand samples were carried out to obtain the various elements present in the samples by weighing and transferring 2g of each soil sample into digestion tubes (50 mL). 20mL of 60% concentration of Nitric acid and 10 ml of 70% perchloric acid were added respectively into each digestion tubes containing the samples and then mixed together and left in fume cupboard for 24 hours, after which a brown red coloured solution was observed due to the fume of $HNO_3$ given off during the reaction of acid with the samples. After this process, the digestion tubes containing the samples including the blank were placed in a digester and heated to a temperature of $120^{o}c$ for 1 hour in which a light coloured clear solution was observed indicating a complete digestion. Care was taken to ensure that the sample did not get dry during digestion to avoid loss of constituent in the soil sample. After that, the digestion tubes were washed with deionized water and filtered throughWhitman filter paper No. 42 [11].The samples were transferred to 100ml volumetric flasks and made up to mark with deionized water and the sample solutions were analyzed for concentrations of $SiO_2$, $Fe_2O_3$, $AL_2O_3$, CaO, $TiO_2$ and $K_2O$ using an atomic absorption spectrophotometer (AAS320N).

**2.7 Metal analysis of soil sand sample**

A method detection limit (MDL) is the minimum concentration of a substance that can be measured. The determinative procedures involve digesting and diluting the blank solutions and then analyzing the concentration of each element of the samples. Then, the standard deviations of the triplicate readings of seven blanks were calculated. The standard deviations were multiplied by three to give MDL.

In the metal analysis procedure, atomic absorption spectroscopic standard solutions containing 1000 mg L-1 (Buck Scientific) was used for preparing intermediate stock solutions and working standards. The intermediate standards were prepared by using dilution method. In addition, the working standard solutions were prepared freshly by appropriately diluting the intermediate standards with deionized water $SiO_2$, $Fe_2O_3$, $AL_2O_2$, CaO, $TiO_2$ and $K_2O$ were analyzed with the AAS using calibration curves, after the parameters (lamp alignment, wave length and slit width adjustment and burner alignment) were optimized for maximum signal intensity and sensitivity of the instrument. The wavelength and slit width were selected and adjusted at the beginning of the analysis and it was constant up to the end of the analysis. This condition was performed in the same way throughout the study period[12].

Figure 4: chemical analysis test

## III. RESULTS AND DISCUSSION

### 3.1 Gradation

Table 3: Result of grain size analysis

| S/N. | Course 4.74-2 (mm) | Medium 2- 0.475 (mm) | Fine 0.475-0.075 (mm) | Silt/Clay < 0.057 | % of Sand | Cu | Cc | USCS | FM |
|---|---|---|---|---|---|---|---|---|---|
| A1 | ------ | 3.75 | 95.04 | 1.21 | 98.68 | 2.32 | 1.86 | SP | 1.7 |
| A2 | ------ | 14.66 | 83.11 | 2.23 | 97.57 | 2.36 | 1.60 | SP | 1.9 |
| B1 | 0.03 | 4.45 | 93.82 | 1.70 | 98.02 | 3.40 | 0.20 | SP | 1.5 |
| B2 | ------ | 14.29 | 83.16 | 2.55 | 97.30 | 5.30 | 1.80 | SP | 1.4 |
| C | 2.30 | 53.85 | 41.22 | 2.63 | 96.90 | 8.3.0 | 3.00 | Well graded | 2.6 |
| D | 1.20 | 55.31 | 42.60 | 0.89 | 99.0 | 7.05 | 2.80 | Well graded | 2.5 |

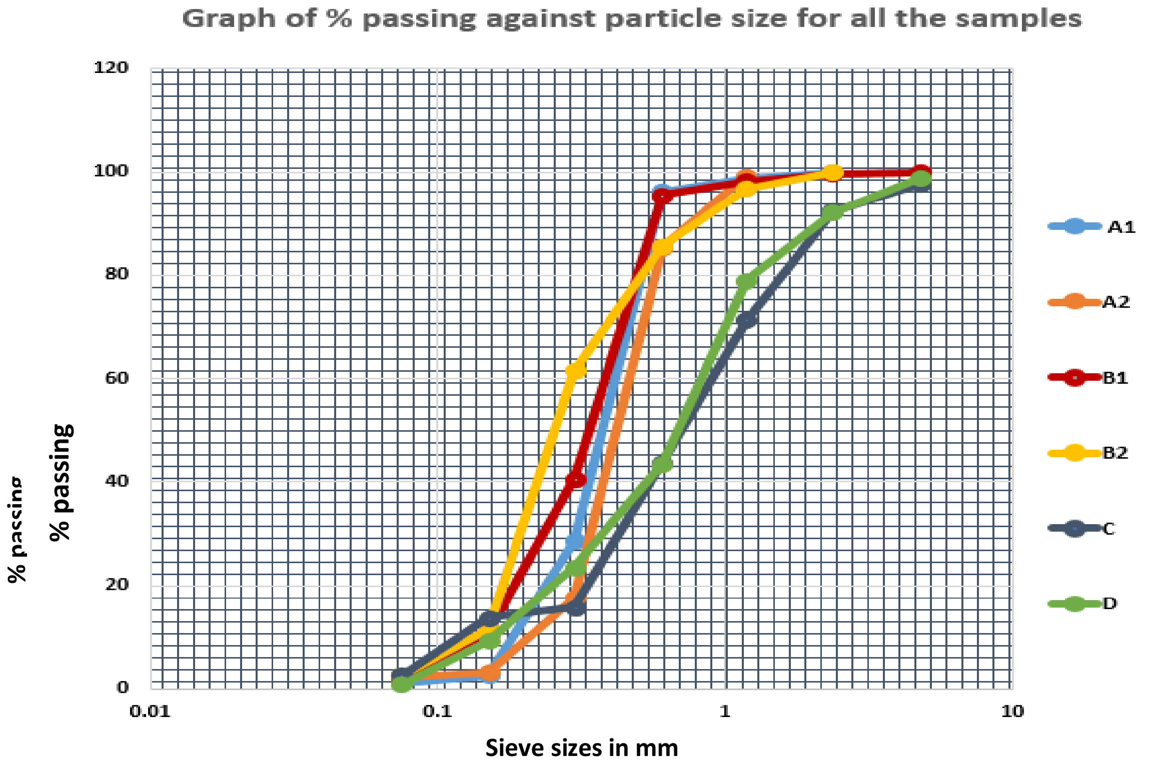


Figure 5 : Graphical illustration of the samples

The result obtained in table 3 shows that Sample C and D are medium sand while the rest of the samples are fine sand. The components of coarse aggregates (4.74-2.0 mm) vary from 0.03% to 2.3%. Medium sand (2.0-0.475mm) range from 3.75% to 55.31%. Fine sand fraction (0.475-0.075 mm) range from 41.22 % to 95.04%. Silt /clay content (<0.075m) are 0.89% to 2.63%. The grain size ranges from 0.15 mm to 0.5 mm and more than 95% percentage of the sand samples fall within 100-mesh sieve.[13]

The values of coefficient of uniformity (Cu) vary from 2.32 to 8.3, while the values of coefficient of curvature (Cc) range from 0.2 to 3.0. All the samples according to the Unified Soil Classification System (USCS) were classified as poorly graded sand (SP) except sample C and D that are well graded. A given sample is well graded when Cu is equal or greater than 6 (Cu >= 6) and Cc is between 1 and 3 (1<=Cc<=3) [14].

Table 4: PH of the Samples

| S/N | Sample Code | pH |
|---|---|---|
| 1 | A1 | 6.88 |
| 2 | A2 | 6.82 |
| 3 | B1 | 6.68 |
| 4 | B2 | 6.69 |
| 5 | C | 6.79 |
| 6 | D | 6.87 |

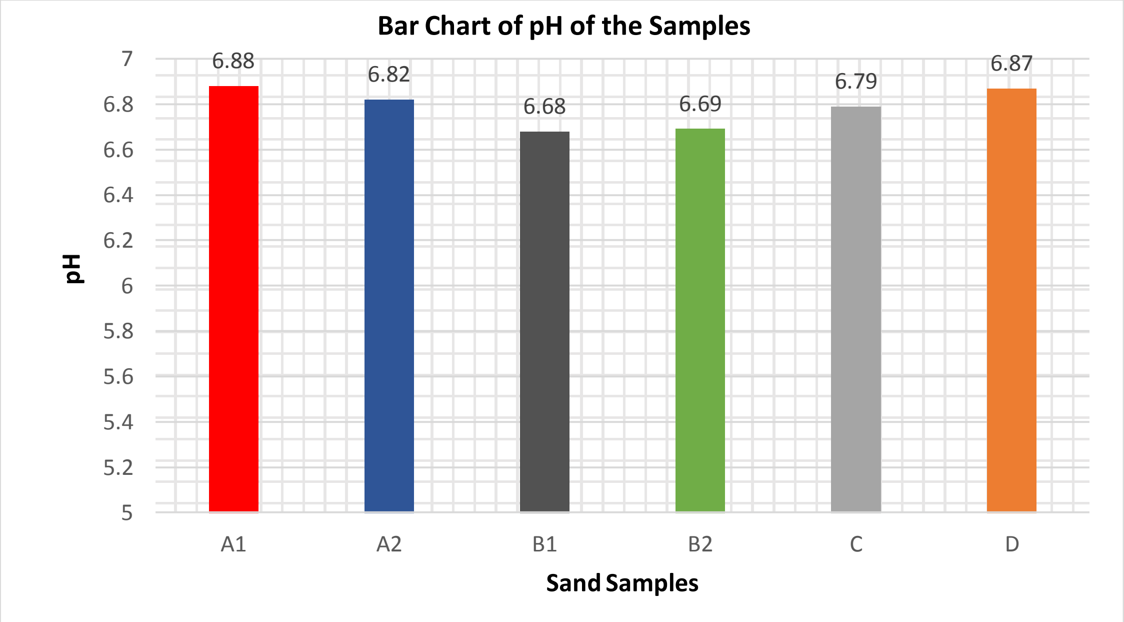


Figure 6: Bar chart of PH the Samples

The pH of the silica sand samples gives alkalinity or acidity of the silica sand [15]. A higher or lower pH values signify the present of acidic or basic oxide in a given silica Sand sample. Sand with a pH close to neutral (7) is best for construction and glass making [16]. The value of the pH of the sand samples ranges from 6.68 to 6.88 and can be classified as slightly weak acid, which has no significant effect.

**Table 5: Specific Gravity of the Samples**

| S/N | Sample Description | Specific gravity |
|---|---|---|
| 1 | A1 | 2.62 |
| 2 | A2 | 2.59 |
| 3 | B1 | 2.57 |
| 4 | B2 | 2.64 |
| 5 | C | 2.63 |
| 6 | D | 2.63 |

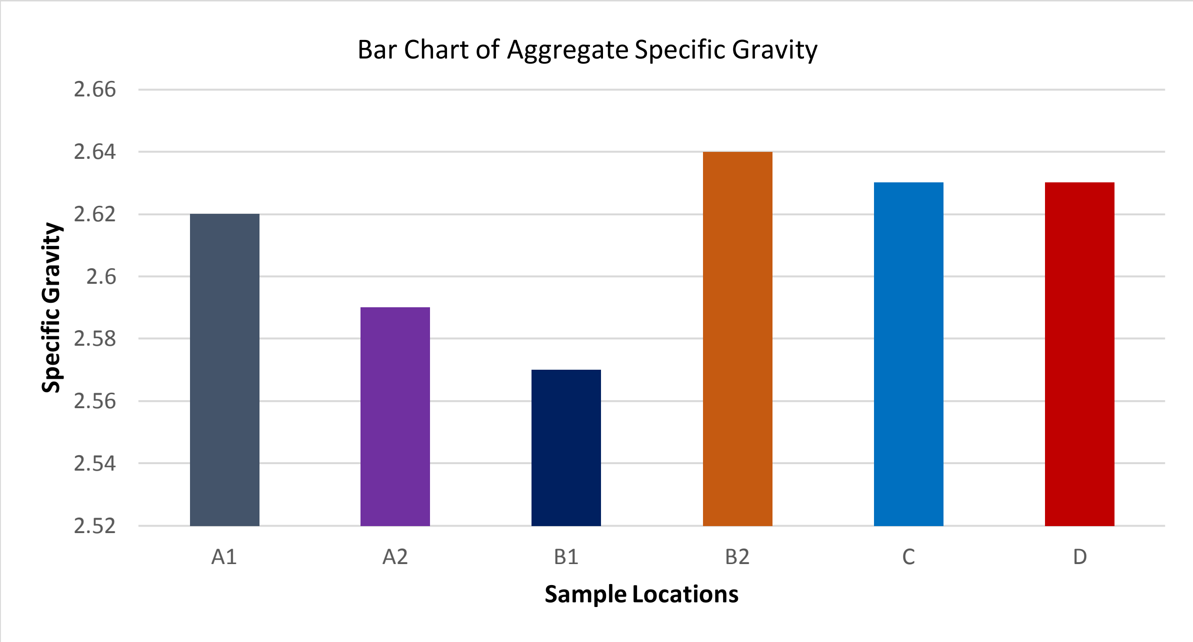


Figure 7: Bar chart of specific gravity of the samples

According to[17], Silica sand with specific gravity greater than 2.65 is not suitable for glass making and all the samples fall below the specified 2.65. Sand samples with specific gravity above 2.65 is said to possess heavy minerals

**Table 6: Conductivity of the samples**

| S/N | Sample Code | Conductivity (µs/cm ) |
|---|---|---|
| **1** | A1 | 804.33 |
| **2** | A2 | 821.88 |
| **3** | B1 | 954.61 |
| **4** | B2 | 989.53 |
| **5** | C | 710.66 |
| **6** | D | 613.76 |

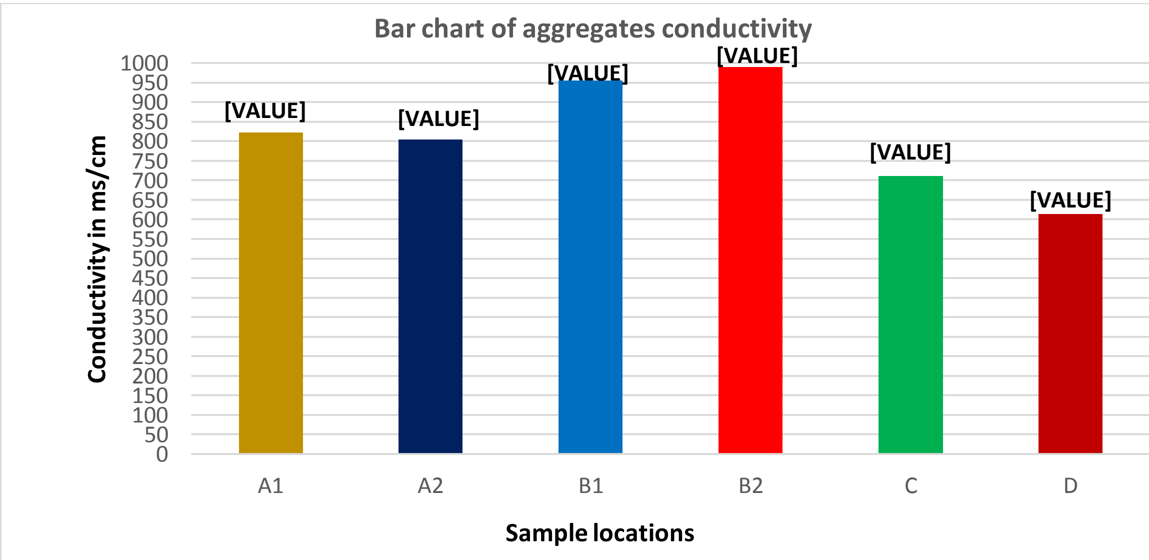


Figure 8: Bar Chart of conductivity of the samples

Electrical conductivity refers to the measure of how electric current moves within a substance. One can simply say that conductivity is the ability of a substance to conduct electricity.
Conductivity is measured in micro or millisiemens per centimeter (µs/cm or ms/cm)
From the bar chart of conductivity, Samples B2, B1, A1 and A2 had the highest conductivity and this could be deducible from the fact that their grain sizes are fine grains and are more compacted (reduced pore space), which have a strong effect on their electrical conductivity. The reverse is the case for C and D, which have low conductivity and could be attributed to the fact their grain sizes are medium/coarse sand and are not compacted (having large pore space).
For fine grain sand, the valence energy band could be lower and little energy is required for conduction compared to medium or coarse sand

### 4.7: Chemical Analysis of the Samples

The chemical analysis of the sand samples after dilation using atomic absorption spectrophotometer (AAS) is as follows:

**Table 7: Chemical analysis result**

| Sand Samples | $SiO_2$% | $Fe_2O_3$% | $Al_2O_3$% | CaO/MgO% | $TiO_2$% | $K_2O$ | Loss on Ignition |
|---|---|---|---|---|---|---|---|
| A1 | 69.01 | 2.13 | 17.19 | 10.5 | ------ | 0.1 | 1.04 |
| A2 | 91.91 | 0.50 | 1.13 | -------- | 0.2 | 0.7 | 5.56 |
| B1 | 95.91 | 0.18 | 2.28 | -------- | ------- | 0.12 | 1.51 |
| B2 | 93.18 | 0.06 | 2.78 | 0.1 | 0.3 | 0.52 | 3.06 |
| C | 96.12 | 0.16 | 0.06 | ------- | 0.9 | 0.5 | 2.26 |
| D | 78.16 | 2.70 | 7.40 | 2.66 | ----- | 2.08 | 7.0 |

The chemical analyses of the silica sand samples by atomic absorption spectrophotometer (AAS) showed that the percentage silicon oxide content of 95.91 and 96.12 for B1 and C respectively is adequate for the manufacture of amber glass, green glass and insulating fiberglass. If B1 and C are subjected to sand processing technique such as washing, attrition scrubbing and acid leaching, their percentage silica content can be increased to more than 98 percent for the production of colorless container glass [18].The rest of the sand samples fall below 95.91 percent of silicon oxide content and A1 had the lowest percentage. The percentage silica content of B2 can easily be enhanced for glass production by sand processing technique than the rest of the sand samples that fall below 95.91 percent of silicon oxide content.

## IV. CONCLUTION

The physical properties of the sand samples show that the size of the grains ranges from 0.15 mm to 0.5 mm, the sand samples are more of fine sand and few are medium sand and more than 95% percentage of the sand samples fall within 100-mesh sieve.The chemical analyses of the silica sand samples showed that the percentage silicon oxide content of 95.91 and 96.12 for B1 (Umuanyi Pit sand) and C (Nworie River sand) respectively is adequate for the manufacture of amber glass, green glass and insulating fiberglass according to general specification of chemical composition of glass sand [7][8][9].

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## REFERENCE

[1]. Wikipedia, "https://en.m.wikipedia.org/wiki/Sand,accessed July 2,2021," 2021. .
[2]. K. B. Ketner, "Silica sand. In D. A. Brobst and W. P. Pratt (Eds.), United States mineral resources professional paper 820. Washinton, DC: U.S. Geological Survey, 577-580," 1973.
[3]. RMRDC., "Raw Materials Research and Development Council , Federal Ministry of Science and Technology, Multi – Disciplinary Task Force – report of the Techno- Economy Survey on Non-Metallic Mineral Products Sector" 3rd Update Abuja, Nigeria.Pp 14-15 and 49,2001," 2001.
[4]. H. R. Samtur, "Glass recycling and reuse. Madison: Wisconsin Institute for Environmental Studies," no. 1–26, 1979.
[5]. W. P. Bolen, "Sand and gravel, industrial. In 1995 Minerals year book. Reston, VA: U.S. Geological Survey," pp. 715–730, 1996.

[6]. L. L. Y. Chang, “Industrial mineralogy, materials, processes, and uses. Upper Saddle River, NJ: Prentice Hall,” no. 54–67, 2002.
[7]. M. B. B. Crockford, “Geology of the Peace River glass sand deposit. Research Council of Alberta, Mimeographed Circular, 7, 1-20.,” 1949.
[8]. N. Sell, “Industrial pollution, control issues and techniques. New York: Van Nostrand Reinhold, 118-143.,” 1981.
[9]. E. Stocchi, “Industrial chemistry. New York: Wiley, 117-125,” 1975.
[10]. ASTM E11, “Standard Specification for woven wire test Sieve Cloth and Test Sieves,” 2020.
[11]. G. R. Sinex, S. A., Cantillo, A. Y., Helz, “Accuracy of acid extraction methods for trace metals in sediments. Analytical Chemistry,” vol. 54, no. 14, pp. 2342–2346, 1980.
[12]. R. A. Underwood, A. L., Day, *Quantitative analysis. New Delhi Prentice Hill*. 1988.
[13]. T. D. Murphy, “Silica sand and pebble , in industrial minerals and Rocks: Am. Inst. Min. and Metal Eng., New York,P.763-72,” 1960.
[14]. F. W. Thomas, “Soil Relationships and Classification. In W. F. Chan and J. Y. Richard (Eds.), the civil engineering handbook,” no. 776–794, 2003.
[15]. R. H. Doremus, “Glass science. New York: John Wiley, pp. 78-90,” 1973.
[16]. A. Paul, “Chemistry of glass ,Oxford:Chapman and Hall,” pp. 56–65, 1982.
[17]. F. V. Tooley, *Hand Book of Glass Manufacturing*, 2nd ed. New York: Ogben Press, 1989.
[18]. M. C. Ofulume, A.B., Amadi, “Investigating The Otamiri River (Ihiagwa, Imo State, Nigeria) Sands As A Possible Raw Material Source For The Glass Industry,” *Aust. J. Basic Appl. Sci.*, vol. 5, no. 9, pp. 492–500, 2011.


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