International Journal of Engineering & Technology
CENTRE OF PROFESSIONAL RESEARCH PUBLICATIONS
ISSN 2049-3444

International Journal of Engineering and Technology Volume 5 No. 8, August, 2015

# Suitability of Selected Sand Mine In Akure, Nigeria for Use as Foundry Sands in Aluminium Alloy Casting

[1]JIMOH Braimoh Olanrewaju, [2]AJIBOLA Olawale Olarewaju, and [2]BORISADE Sunday Gbenga.

[1] Department of Mineral and Petroleum Resources Engineering Technology, Federal Polytechnic, Ado Ekiti, Nigeria

[2] Department of Materials and Metallurgical Engineering, Federal University Oye Ekiti, Oye Ekiti, Nigeria

## ABSTRACT

The research work is carried out to provide an insight to the vast availability of quality and quantity of quarry sands which can be mined for use as foundry sand by the numerous cottage aluminium industries in Nigeria. Four sand deposits (Ado road, Abo road, Owo road and Oda road) were mapped out from Akure in Ondo states, South-western Nigeria. The physical and chemical properties were determined as the bases for evaluation. Abo and Ado roads sand samples have well sorted grain sizes while Oda and Owo road have coarse grains size. The four selected sand samples have positive liquid limit that ranged from 3.0- 17 while only Ado road sand samples have positive values of liquid limit 5.4%; plastic limit 5.86%; plasticity index of 0.46% and shrinkage limit of 2.14%. The pH of the subsoil varies from 5.0 to 7.0 indicating that the subsoil is acidic. While the pH of the topsoil ranges from slightly acidic pH = 5.7 to highly basic pH = 8.1. The presence of macronutrients such as Ca, Na, Mg, and K in most of the sand samples falls within acceptable limits. Three of the selected sand deposits (Abo, Ado road, and Oda road) will be found suitable for aluminium casting, though all the four sand can be used for ferrous materials (steel and cast iron). Oda and Owo road have coarse grain sizes making them very useful in moulding sands in the metal foundries and cement block making.

**Key Words:** *Sand Mine, South-Western Nigeria, Foundry Industry, Moulding Sands, Aluminium Alloy Casting.*

## 1. INTRODUCTION

Industrial quality foundry sand must meet certain prescribed chemical and physical properties. It must be located near its market, and must be mined, processed and shipped economically. The more expensive the extraction process, the greater the cost that must be passed on to the consumer of the final product. The final product (industrial foundry sand), must be nearly free from deleterious or undesirable minerals. Additional treatment costs of removing unwanted bio-material such as roots, and rock minerals increases the market price accordingly. Both the foundry and glassmaking industries adhere to stringent physical and chemical sands specifications. Changes in processing techniques utilizing less desirable types of sand would require changes in technology with an attendant increase in cost.

Metal foundries make use large quantities of green sand, refractory clays (Fasuba et al, 2000, Aye and Oyetunji, 2013) and generate by products such as used foundry sand in the metal casting process after the successfully recycling and reuse of the sand many times. (Pitroda et al, 2013).

Although sand mining has been going on in the south-western Nigeria, the physical and chemical properties of Akure sands have not been properly studied in order to determine the limitation to their metallurgical and foundry usage. Hence, the present work determines the physical and chemical properties of the sands in the selected mine sites specifically for use in aluminium casting industries and estimates the tonnage of sand removed from the selected sand quarries. The quantities of the mine deposits have been estimated (Jimoh et al., 2007).

Akure is by nature blessed with vast deposit of industrial minerals, like gem stones, mica, clay and sands. Concrete sand is found almost everywhere in Ondo state, but the quality sand needed for foundry applications is very scarce. In this paper, the metallurgical qualities are examined to assess their suitability in the development of the growing aluminium industries. The moulding sand after it is prepared should be properly tested to see that require properties are achieved. Tests are conducted on a sample of the standard sand. The moulding sand should be prepared exactly as it is done in the shop on the standard equipment and then carefully enclosed in a container to safeguard its moisture content. Sand tests indicate the moulding sand performance and help the foundry men in controlling the properties of moulding sands. Sand testing controls the moulding sand properties through the control of its composition.

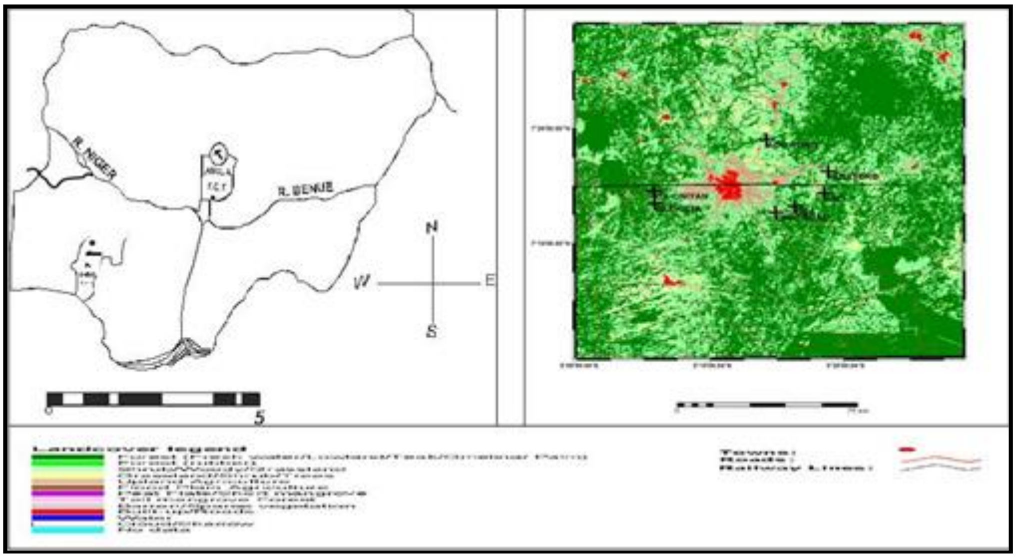


**Figure: 1a. Map of Nigeria indicating Akure in Ondo state and The Study Areas (Source: Area photography, ground control and compilation)**

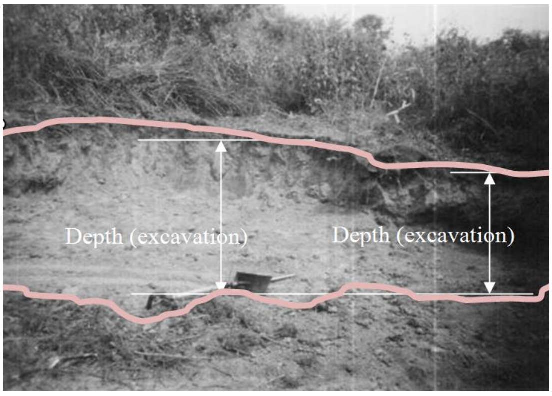


**Figure 1b: The quarry and depth of excavation**

## 2. MATERIALS AND METHODS

### 2.1. Materials

Figures 1a & 1b show the map of Nigeria indicating topography and location maps of sand mines. The study areas include Igoba along Akure-Ado-Ekiti road, Owo road, Abo road, and Oda road which are located on the south-western part of the Akure metropolis (Figures 1a). Twelve sand samples were taken from the four study locations while a control sample was taken at an average distance of about 200m away from the quarry sites.

**Method 1: Determination of the physical and chemical properties of sand samples**

**(a) Sieve Analysis Experiment**

The % weight retained $W_R$ and % weight pass $W_P$ are determined from (1) and (2)

% weight retained $W_R = \frac{w_2 - w_1}{w_T} \times 100\%$ (1)

% weight pass $W_P = (100 - W_R)\%$ (2)

Where $W_T$ = Total weight of sample, $W_1$ = weight of empty sieve, $W_2$ = weight of sieve + sand

**(b) Determination of Specific Gravity**

The Specific Gravity S.G is determined from (3)

$$S.G = \frac{w_2 - w_1}{(w_4 - w_1) - (w_3 - w_2)} \quad (3)$$

where $W_1$ = weight of density bottle, $W_2$ = weight of bottle + sand,
$W_3$ = weight of bottle + sand + water, $W_4$ = weight of bottle + distilled water

**(c) Determination of Permeability of moulding sand**

The sand was compacted in a standard mould. A wire mesh and gravel filter were provided at the top and bottom of the sand in the mould and arranged to form permeameter. Permeability (K) is determined from (4)

$$\text{Permeability (K)} = \frac{al}{At} \times 2.83 \log \frac{H_1}{H_2} \text{ . (cm)} \quad (4)$$

$H_1$ =1760 cm and $H_2$ =755 cm, L = length of the sand sample (cm), A = cross section area of the sand sample ($m^2$), a = small cross section area of the pipe ($m^2$), t = average time interval for $H_1$ and $H_2$ (sec), $H_1$ = the water level in pipe corresponding to $t_1$ (cm), $H_2$ = the water level in the pipe corresponding to $t_2$

**(d) Determination of Moisture Content**

$$\text{Moisture Content, Mc} = \frac{w_w}{w_d} \times 100\% \quad (5)$$

$W_C$ = weight of can, $W_{C+W}$ = weight of can + wet sample, $W_{C+D}$ = weight of can + dry sample, $W_W$ = weight of water sample, $W_d$ = weight of dry sample

(e) **Determination of Atterberg Limit**

Three essential parameters are determined from (6)

$$PI = LL - PL \quad (6)$$

where PI = Plastic index, LL = Liquid limit, PL= plastic limit

(f) **Determination of Shrinkage Limit**

$$\text{\% Shrinkage Limit (L.S)} = \frac{1 - L_2}{L_1} 100\ \% \quad (7)$$

$L_1$ is Initial length and $L_2$ is final length.

**(g) Determination of Exchangeable Cations in the sand samples**

Na, K, Ca, Mg, Fe, Zn, Cu were extracted using Acetic acid, ammonium hydroxide and ammonium acetate. Amount of Na, K, Ca were determined using flame photometer while Mg, Fe, Zn, Cu were determined using an atomic absorption spectrometer.

**(h) Determination of sand pH**

About 20g of sand sample was measured into 20 ml of distilled water was allowed to stand for 30 minutes and occasionally stirred with a glass rod. The electrodes of the pH meter were inserted and the pH measured using the LIDA Electronic digital pH-mV-Temp meter (PHS-3BW model).

**(i) Determination of Total Organic Carbon TOC**

This is a measure of organic matter in sand sample. It is a function of percentage of carbon content.

% organic carbon C in sand is thus calculated from (8).

$$\%C = \frac{(Meq_{K_2Cr_2O_7} - Meq_{FeSO_4}) \times 0.3 \times f}{weight\ of\ dried\ sand} \quad (8)$$

where $f$ = correction factor = 1.33, $M_{eq}$ = Normality of solution x volume of solution used in ml.

**(j) Determination of Total Nitrogen in** sand

Total nitrogen was determined by the macro-Kjeldahl digestion- distillation.
% Nitrogen content in the sample is calculated as in (9):

$$\%N = \frac{T \times M \times 14 \times 100}{W} \quad (9)$$

Where T = titre value, M = Molarity of HCl, W = weight of sand used

(k) **Determination of Total Phosphorus (Bray No 1 Method)**

1 gm of air-dried -2 mm size sample was poured into a 15ml flask and transmittance on electro photometer to determine total phosphorous.

(l) **Determination of Total Chloride (Mohr's Method)**
Sand was first extracted by the use of extractant ratio 1:5 and $H_2SO_4$ respectively. It was then filtered and the titre value was recorded.

**Method 2: Determination of mechanical properties of the moulding sand samples**

**i. Green sand cold crushing strength**

Carried out by placing a suitable moulded sand sample specimen on a flat surface followed by application of a uniform load to it through a bearing block in a standard mechanical or hydraulic compression testing machine. The load F (N) at which cracks appears in the material specimen represents the CCS of the green sand specimen. Test results for the green and dry sand are shown in Table 1.

$$CCS = \frac{F}{A^2} \quad (10)$$

where F = load (KN) and A = sectional area ($m^2$)

**Figure 2: showing the green sand mould specimens.**

**ii. Mould hardness number**

The spherical indenter is penetrates into the mould surface at the time of testing and the depth of penetration is measured with respect to the flat reference surface of the tester.

$$\text{Mould hardness number} = \frac{F}{D-(D^2-d^2)} \quad (11)$$

where, F is applied force (N), D is diameter of the indenter (mm), d is diameter of the indentation (mm). Test results are shown in Table 1.

## 3. RESULTS AND DISCUSSION

### 3.1. Sieve Analyses

Figures 3-4 show the sieve analyses for both top and sub soil samples respectively. Ado road sand is small in the proportion of coarse, medium and fines (7, 40 and 53% respectively) in the topsoil while it is 25.7, 56.5% and 17.8% in the subsoil. Abo sand has coarse 14.5%, medium 40.4%, fines 45.1% in the topsoil and coarse 6%, medium 71.3%, fines 22.7% subsoil. Owo sand presents samples with coarse 24.2% medium 47%, fines 28.8% topsoil and coarse 21.8%, medium 57.5%, fines 20.7%. Oda sand has coarse 20%, medium 41%, fines 38.5% topsoil and coarse 30.8%, medium 33.5%, fines 35.7% subsoil

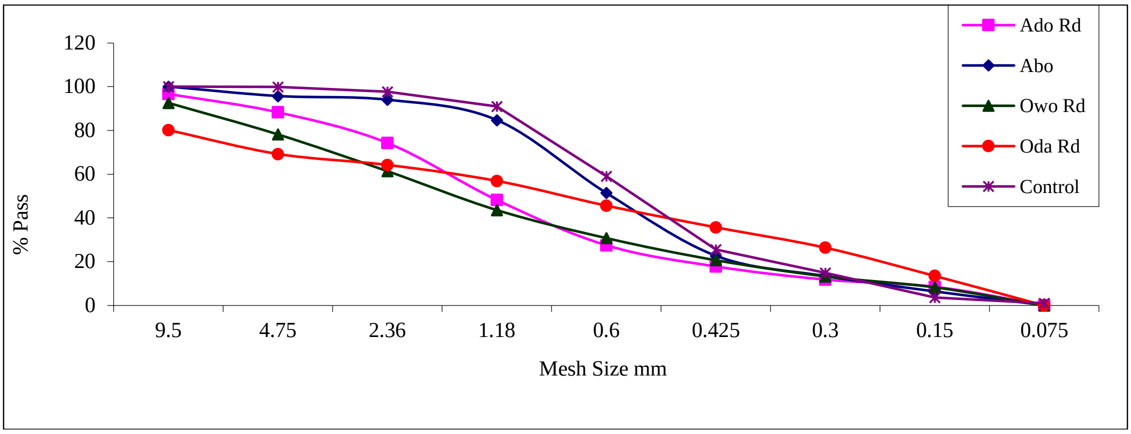


**Figure 3: Sieve Analysis for subsoil samples**

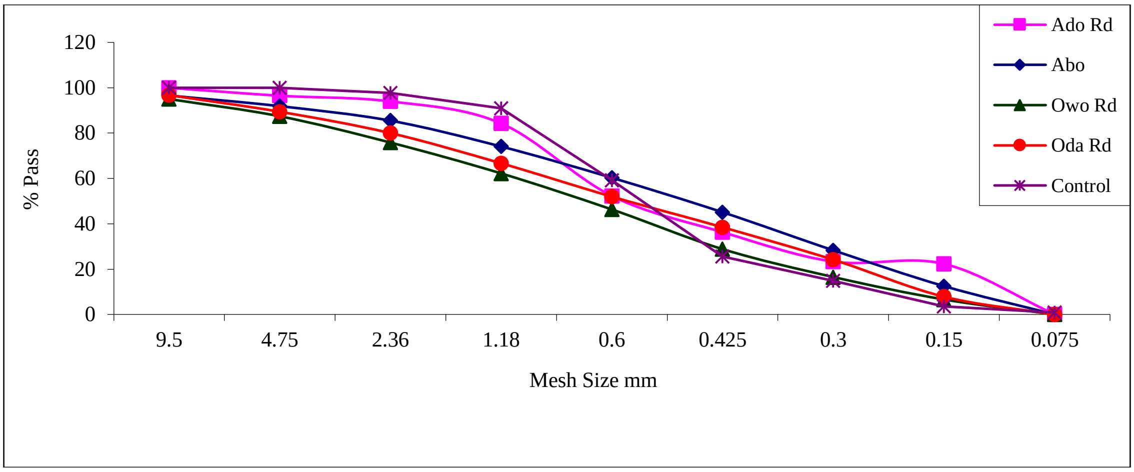


**Figure 4: Sieve Analysis for top soil samples**

.

Oda sand has well sorted grain sizes in both samples, Ado, Abo, (topsoils) and Abo, (subsoil) have more of medium and fine grains than the coarse. However, the medium covers about 50% in both samples from Owo. Ado, Abo samples could be useful for plastering of walls owing to larger percentage of medium and fines in the sand. Owo and Oda have more of coarse and medium sand particles than the fine particles.

### 3.2. Specific Gravity (S.G)

Specific gravity is one of the engineering properties for identifying industrial minerals. Figure 5 shows the specific gravities for the top and sub soil samples. Ado road has the highest specific gravity of 2.88 followed by Oda sample which is 2.86. Both samples exhibit higher specific gravity than the expected range of 2.6-2.7. Abo topsoil has the least specific gravity of 2.13. However, the sub soil samples have low to moderate specific gravity of 2.41-2.58 which may be due to mineral constituent of parent materials and presence of minimal impurities.

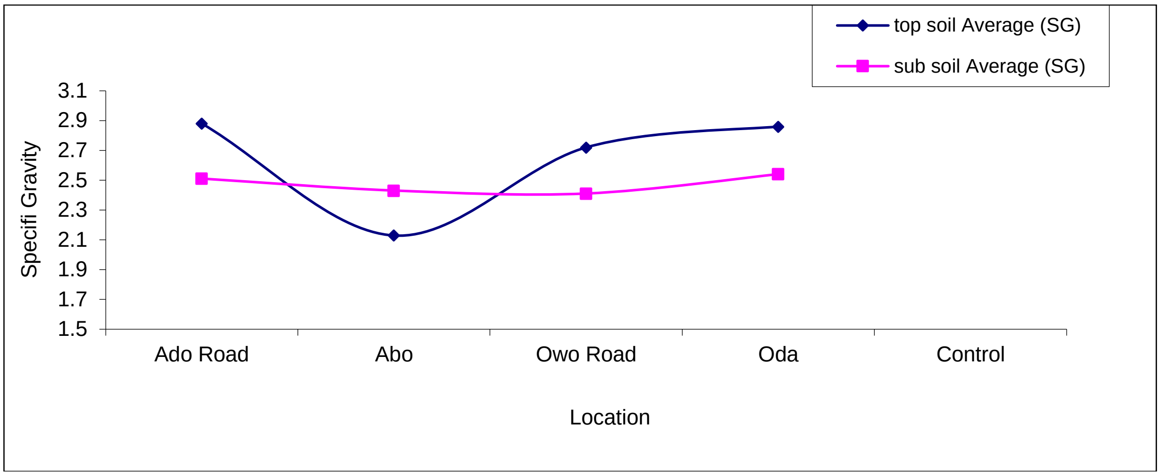


**Figure 5: Specific gravity for topsoil and sub soil samples**

### 3.3. Moisture Content

Figure 6 shows the % moisture content for both topsoil and subsoil samples. Ado road has the highest percentage of moisture content.

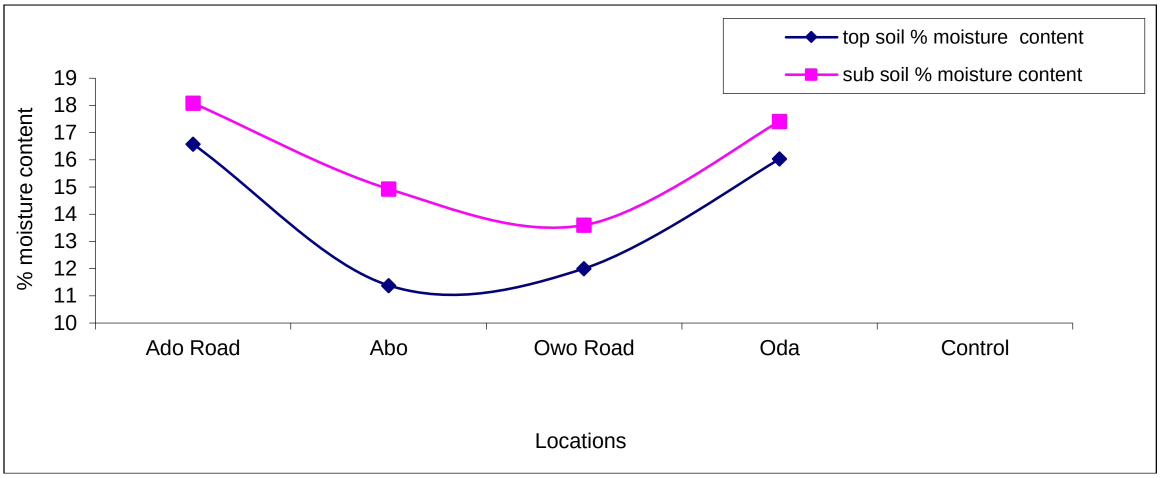


**Figure 6: Moisture content of topsoil and sub soil samples**

### 3.4. Permeability (K)

Abo topsoil has the highest value of permeability 0.0235 contents while Ado road sample has the least value of 0.0122 contents (Figure 7). The gradation in the grain size affected by the porosity of the samples, which favour high level of permeability in Abo sub soil sample, has the highest value of K (0.0211 cm/s) while Oda has the least value as 0.0132 cm/s. The effect of pouring temperature and permeability of sand on the mechanical (hardness and impact strength) and metallurgical properties of Al-4%Si aluminium alloy part produced through sand casting was investigated by Mahipal et al., (2013). Three pouring temperatures and permeability range of moulding sand 30 and 60 Darcy was considered. The result showed that the selected parameters significantly influence the properties of aluminium alloy casting.

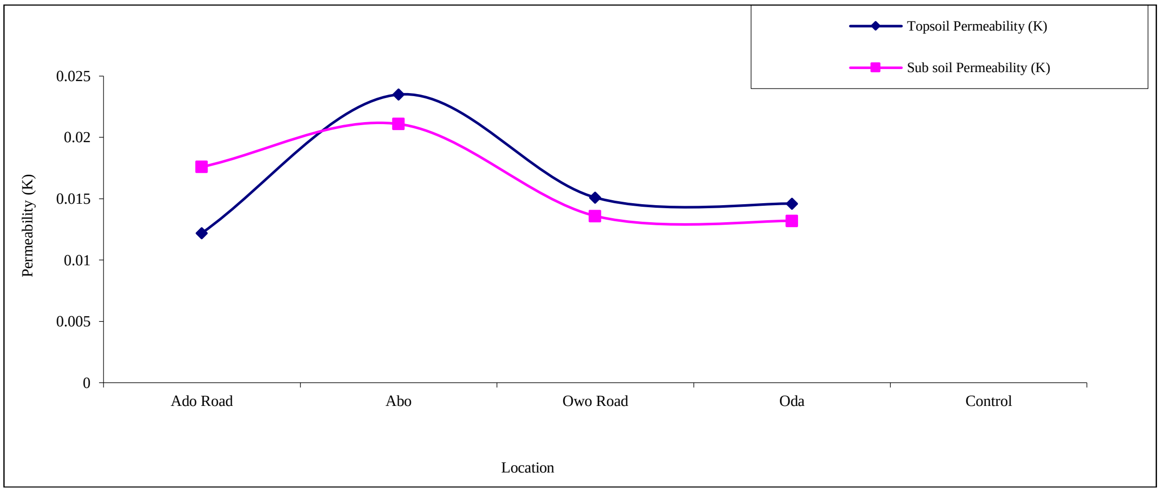


**Figure 7: Permeability values for topsoil and sub soil samples**

## Atterberg Limit

Figures 8 and 9 show the Atterberg limit experiment for the top and sub soil samples. Owo road and Abo have the highest value of 17% of liquid limit while Oda has the least value of 3% liquid limit. Ado road sample was observed to have positive plastic index of 0.46% with 5.86% and 2.14%. Others have nil values for the plastic and shrinkage limit. It is important for the sand core to expand as little as possible and yet not melt when heated or in contact with the molten metal. This property minimizes the risk of the occurrence of veining defects during casting, which in turn lessens the need for polishing and cassation at foundries. All the subsoil samples have negative plastic index except for Ado road, which has considerable values of plastic limit and shrinkage limit of 14.8 and 5.71% respectively. This can be attributed to the fact that Ado samples have considerable amount of clay content and in negligible quantities for other samples.

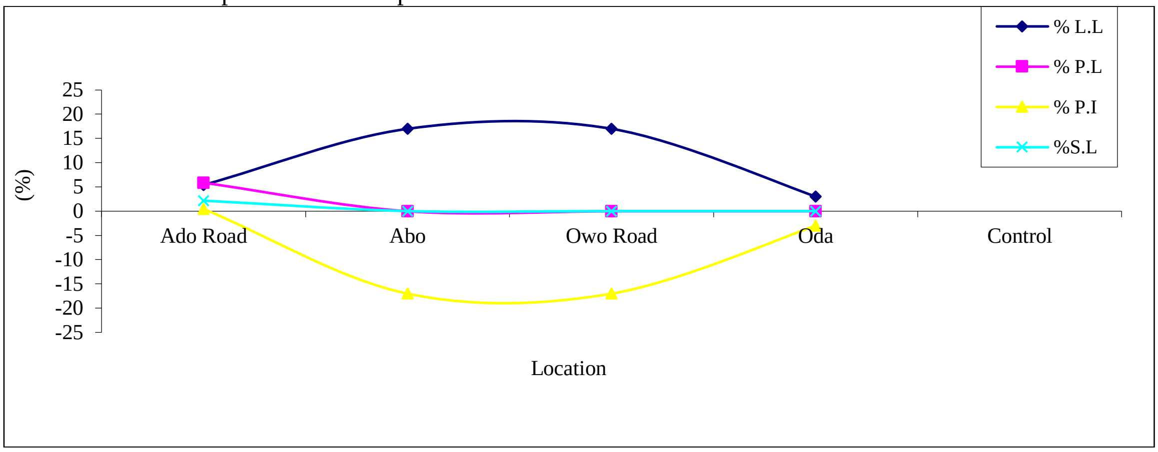


**Figure 8: Atterberg limit for Topsoil samples**

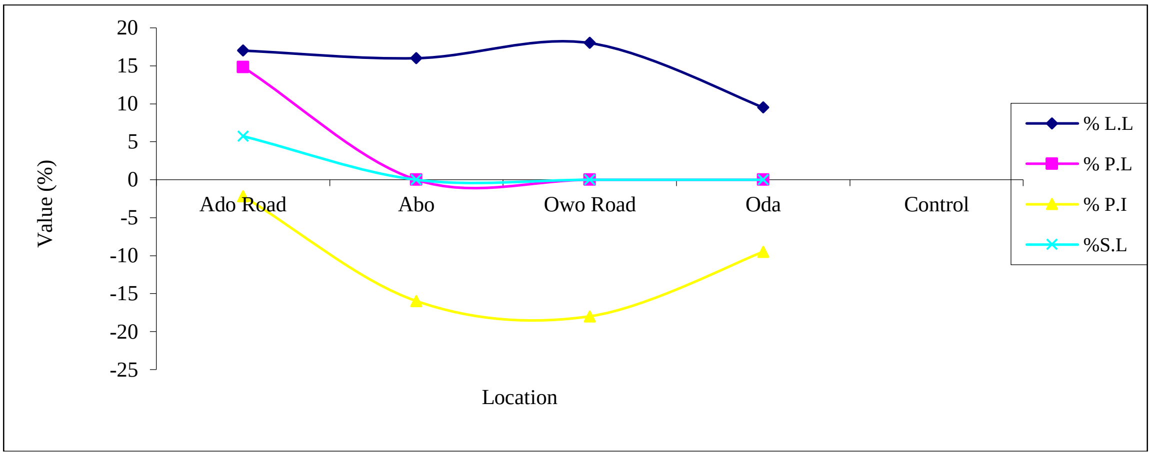


**Figure 9: Atterberg limit for sub soil samples**

**The results of analyses on chemical properties of sand**
**Magnesium, Iron and Manganese in sand**

Magnesium is mainly found as a component in Ferro-magnesium minerals in rocks, which are generally stable under high temperature conditions. In sand, they are unstable and quickly weather to produce magnesium ions (Lombin and Fayemi, 1976).

However, the presence of Mg in Ado road and Owo road are adequate; unlike samples from Abo, Oda, which have less value. It is however noticed that there is concentration of the Mg mineral in the topsoil. The high Fe solubility in soil will result in acidic sand. It can be oxidized by manganese and copper, which are not noticeable in the soil samples hence, the acidic nature of the subsoil samples. Its acceptable limit is about 30-150 ppm (Jimoh et al., 2007). Figures 10 - 11 show that, all the selected samples fall within the required limit of Fe except that of Abo topsoil. However, there is evidence of leaching of the nutrient comparing the topsoil to the subsoil samples. The high content of iron (Fe) may be responsible for the acidic nature of the subsoil samples. More so, there is absence of manganese and copper that might oxidize it to a less soluble form of it. In another view, the sand cannot be considered as appropriate in aluminium casting. Higher content of Fe is detrimental to aluminium casting because Fe is very much soluble in aluminium at high temperature (Adewuyi, 2002; Ajibola and Jimoh 2011; Ajibola et al., 2014a,b,c,d). This will reduce the purity of the melt and increase the density, and affect corrosion resistance of the finished cast product (Ajibola et al., 2014a,b,c,d). For this reason, purification may be necessary to extract the Fe to the minimum acceptable level which may bring additional processing cost. The result did not indicate the presence of manganese in any of the samples.

**Potassium and Sodium in sand**

Potassium K is an important component of the rock forming minerals found in basement complex rock. It is principally found in the flesh coloured K-feldspars (Awojobi, 2002). Sobolu and Osiname (1981) postulated that the minimum acceptable K content in sand is about 58.5 ppm. The results show that there are higher values of K in the topsoil except for in Ado road (15 and 36 mg/Kg) and Owo road (38 and 48 mg/Kg) that show leaching of the K as seen on the result of the subsoil samples (Figures 10-11). Sodium in sand is present in small quantity and restricted to acid and semi acid regions. It is one of the most loosely held of metallic ions and readily lost during leaching. According to Tisdale and Werner (1985) a soil with about 80 ppm of solution is adequate. Figures 10 and 11 show that Ado road topsoil samples have 12 mg/Kg of $Na^{+}$ while Owo road has 4 mg/Kg. The subsoil samples have less values of the $Na^{+}$ than the topsoil except those of Oda road and Owo road. All the samples fall bellow the required $Na^{+}$ level. The potassium availability could be a substitute element.

**Lead, Copper and Zinc in sand**

Figures 10-11 shows that the topsoil values range from 60 - 330 mg/Kg Pb, while that of the subsoil is between 60 - 310 mg/Kg Pb. Copper is also a micronutrient in soils usually required in small quantity by plants. The result does not indicate the presence of copper. The recommended level of zinc in soil is about 25-150 ppm (Jimoh et al., 2007). Clay and sandy soil usually suffer its deficiency. The result indicates that zinc is absent in both the control and subsoil samples of Oda. There is more $Zn^{+}$ in the Ado road and Owo road topsoil than in the subsoil. However Owo road subsoil samples fall within acceptable limit of $Zn^{+}$ requirement for sand.

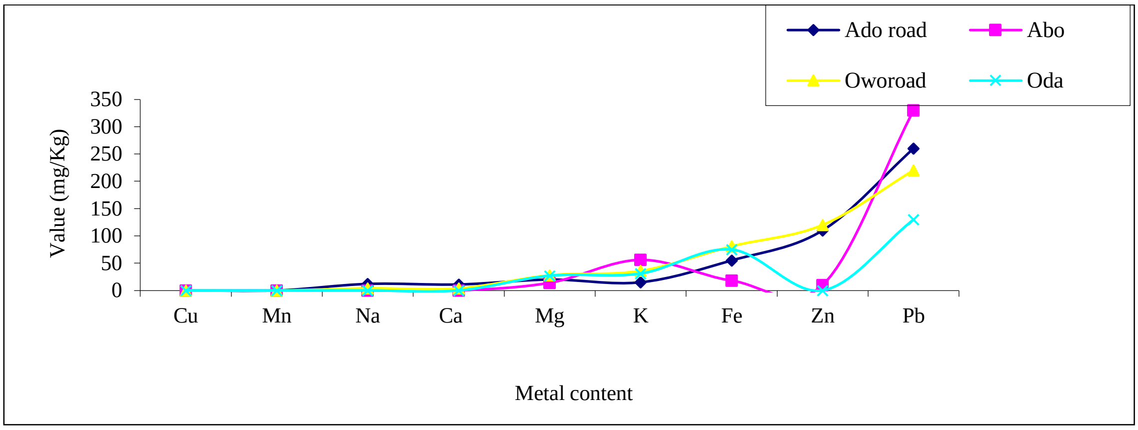


**Figure 10: Metal content in control soil samples**

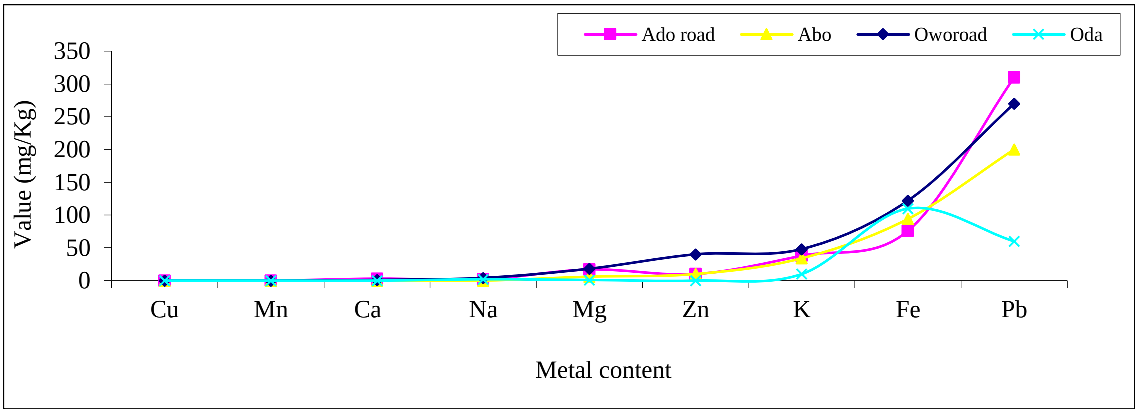


**Figure 11: Metal content in sub soil samples**

### Chloride in sand

Chloride through rainfall is the major source of chlorine in sand. There are higher values of 380 and 270 mg/Kg for Ado, Abo respectively while other topsoil samples are slightly below the acceptable limit, rainfall season favour its balance on the soil (Figures 12-13). However, Owo road has 100 mg/Kg for the subsoil while others fall below this line.

### Sulphur in sand

Sulphur is another macronutrient in soil. All the samples have required level of sulphur. It is however noticed that Owo road top and subsoil samples are reach in sulphate nutrient (300 and 170 mg/Kg respectively). All the samples show a good representation of sulphate that could support plant growth.

### Nitrogen in sand

The ultimate source of nitrogen is the inert $N_2$ gas, which constitutes about 78% of the atmosphere, which is inexhaustible. Higher $N_2$ content is beneficial to aluminium casting. This will reduce the gassing of the melt during pouring and solidification, and hence, will positively affect the porosity and density of the finished cast product (Fruehan and Anyalebechi, 2008).

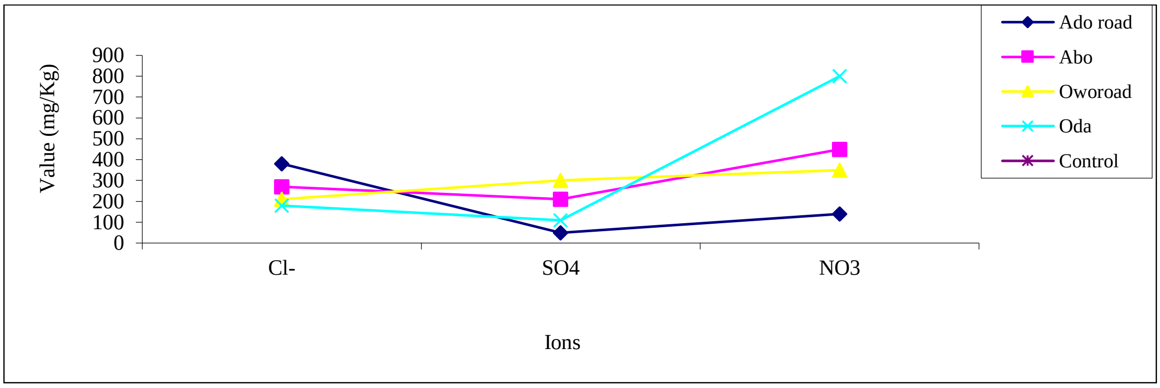


**Figure 12: $Cl^-$, $SO^-_4$, and $NO^-_3$ analyses for control soil samples**

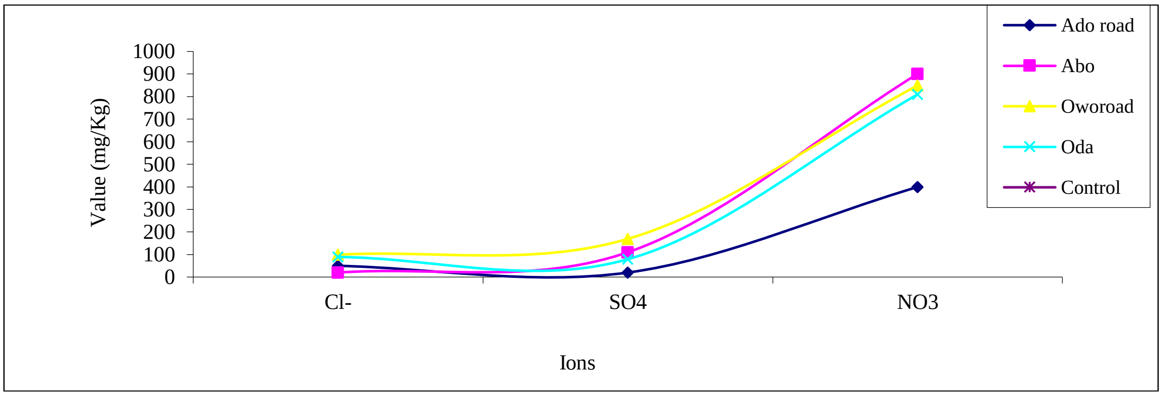


**Figure 13: $Cl^-$, $SO^-_4$, and $NO^-_3$ analyses for sub soil samples**

**pH of sand**

Sand reaction denotes the degree of acidity or alkalinity in a soil. Rowel, 1993, posited that the pH range in soil is within 3 to 10. When it is lower or higher than 5.6 it is acting either as an acid or base. Figures 14 and 15 show that all the control samples have pH values range between 5.7-8.1 falling within normal pH of soil. In comparison, the subsoil samples pH range from 5.0-7.0, being slightly acidic except for samples from Ado road and Owo road. This may also be an evidence of Fe that is present in large quantity and the absence of Mn or Cu that can oxidize it to form less soluble form of it.

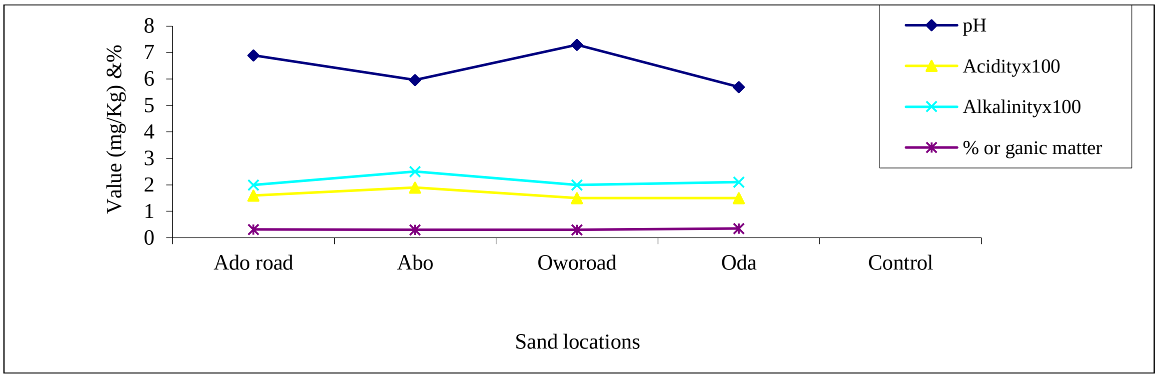


**Figure 14: pH, acidity, alkalinity and organic matter analysis for control soil samples**

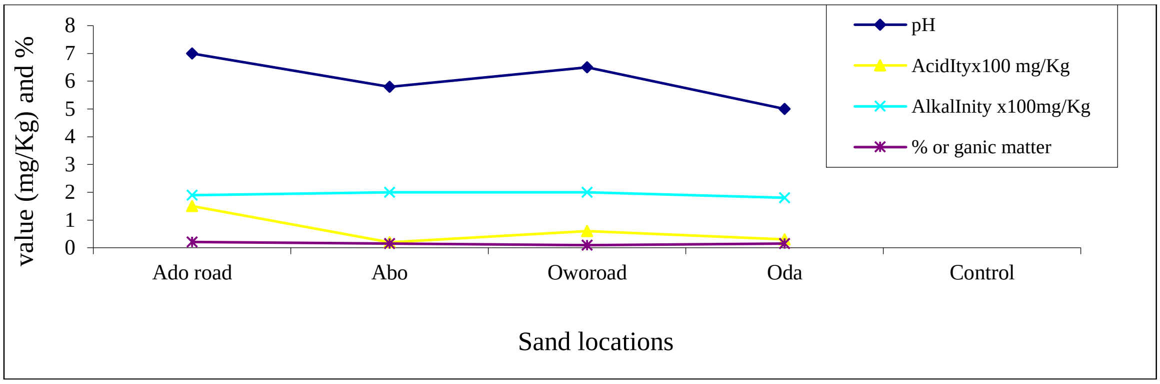


**Figure 15: pH, acidity, alkalinity and organic matter analyses for sub soil samples**

**Total Organic Matter**

Soil organic matter is a very complex substance. It contains depending on the type of plant and animal residue and their stages at decomposition the following carbohydrates including sugars, starches and cellulose, lignin, resin, fats and oils and waxed, proteins, pigments, metal minerals such as Ca, Fe, Mg, k, Zn and the likes. It is the nitrogen reservoir (a very relevant gas in degassing aluminium alloy melt). It supplies the bulk of soil phosphorous and sulphur, because of chemical breakdown, affects the soil physical, chemical and biological properties. Figures 14-15 show that all the pit subsoil samples are deficient of the organic matter in comparison with the control samples. The value ranges from 0.25- 0.85 in the topsoil, and 0.10-0.35 in the subsoil samples.

The results of mechanical properties of the moulding sand samples including the average sand cold crushing strengths (green strength and dry strength) and the Mould hardness number are presented in Table 1. The comparison with the standard (in Table 1) shows that the obtained test values fall with the acceptable limits and hence they are all suitable for aluminium alloy cast in foundry applications

**Table 1: Foundry sand moulding properties of test samples.**

| Samples | Average mould BHN N/mm | Average Mould Strength (Green) (KN/m$^2$) | Average Mould Strength (Dry) (KN/m$^2$) |
|---|---|---|---|
| *Standard | | *50-70 | *200-550 |
| Ado Rd. | 53 | 43-67 | 190-530 |
| Abo | 49 | 40-60 | 180-500 |
| Owo Rd. | 47 | 55-60 | 200-490 |
| Oda Rd. | 52 | 40-65 | 185-520 |

*source: Ademoh and Abdullahi, 2013

## 4. CONCLUSION

Abo and Ado roads sand samples have well sorted grain size range of 0.25-0.5 mm while Oda and Owo road have coarse grains size range of 0.5-1.0 mm. The four selected sand samples have positive liquid limit that ranged from 3.0-17 while only Ado road samples have positive values of liquid limit 5.4%; plastic limit 5.86%; plasticity index of 0.46% and shrinkage limit of 2.14%. The pH of the subsoil varies from 5.0 to 7.0 indicating that the subsoil is acidic while the pH of

the topsoil ranges from slightly acidic to highly basic (pH = 5.7 - 8.1). The quantities of most of metallic minerals in three the of the sand samples (Abo, Ado road, and Oda road) are within acceptable limits of foundry sand, while Owo road sample may still be of suitable foundry use by blending with others.
Sand is a vital material in the metallurgical foundries and construction industries; hence it has a great role it plays in national development. High potential for economic development, particularly foundry and industrial expansion exists in the mined out areas.

## REFERENCES


Ademoh N. A. and Abdullahi A.T. (2013): Foundry properties of moulding sand bonded with grades 3 and 4 Nigerian gum Arabic admixed with bentonite clay. International Journal of Chemical and Biochemical Sciences. IJCBS, 4(2013):101-111

Adewuyi B.O. (2002). The influence of Fe variation on the corrosion behaviour of heat treated aluminium alloys in tomato juice. Nigerian Journal of Technology, 21(1) 72-78.

Ajibola, O.O. and Jimoh, B.O. (2011) Aluminium recycling industries in Nigeria: entrepreneurship challenges and opportunities. Proceedings of the 7th Engineering Forum, Ado Ekiti, Nigeria, 7(1): 238-47.

Ajibola, O.O. Adewuyi, B.O. and Oloruntoba, D.T. (2014a) Design and performance evaluation of wear test jig for aluminium alloy substrate in hydraulic fluid. Poster Presentation at Inaugural African Corrosion Congress (AfriCorr 2014) and Exhibition., Jul 28-30, 2014, Pretoria, South Africa.

Ajibola, O.O.; Adewuyi, B.O.; and Oloruntoba D.T. (2014b). Wear behaviour of sand cast eutectic Al-Si alloy in hydraulic brake fluid. International Journal of Innovation and Applied Studies, 6(3): 420-30.

Ajibola, O.O. Oloruntoba D.T.; and Adewuyi, B.O. (2014c). Metallurgical study of cast aluminium alloy used in hydraulic brake calliper. International Journal of Innovation and Scientific Research 2014, 8(2): 324-333.

Ajibola, O.O., Adewuyi, B.O., and Oloruntoba D.T. (2014d). Effects of hard surface grinding and activation on electroless-nickel plating on cast aluminium alloy substrates. Journal of Coatings, Volume 2014, Article ID 841619, 10 pages. http://dx.doi.org/10.1155/2014/841619

Aye, A.E and Oyetunji, A (2013): Metallurgical Analysis of Ugunoda Clay Deposit, Nigeria for Use as a Refractory. International Journal of Science and Advanced Technology 3(3):25-29. http://www.ijsat.com.

Awojobi, D.A. (2002): Environmental impact assessment of exploitation of granite deposits in Ilorin, M.Eng Thesis, Federal University of Technology, Akure.

Fasuba O.A., Egunlae O.O. and Jimoh B.O. (2000): Metallurgical Analysis of Orin Ekiti clay deposit for use as a refractory. Journal of Engineering Technology and Industrial Applications. 1(2): 72-75

Fruehan R. J. and Anyalebechi P.N, (2008): Gases in Metals, ASM Handbook, Volume 15: Casting. ASM International, p 64-73. DOI: 10.1361/asmhba0005192

Jimoh B.O. Obisesan P.O. and Azzez L.A., (2007): Chemical analysis of sand from some selected deposit in Akure. Journal of Engineering and Earth Sciences. 2(1): 67-72

Lombin, A and Fayemi A.A. (1976); Evaluation of various soil tests for magnesium in Nigeria. Soil Science Journal, No. 122. pp. 59-64. In Jimoh et al, (2007): Journal of Engineering and Earth Sciences, 2(1): 67 – 72.

Mahipal S., Manjinder B., Rohit S., Hitesh A. (2013): Behaviour of Aluminium Alloy Casting with the variation of Pouring Temperature and Permeability of Sand, International Journal of Scientific & Engineering Research, 4(1):1497-1502

Pitroda J, Bhimani D.R, Bhavsar J.J (2013): Used foundry sand: Opportunities for development of eco-friendly low cost concrete. International Journal of Advanced Engineering Technology, IJAET 4(1): 63-66.

Rowel D.L. (1993): Soil Science. Methods and Applications pp 232-249.

Tisdale S. and Werner N. (2000): Soil Fertility and Fertilizers. Macmillan Books: New York, 4th Edition Pp 64 – 69.

Sobolu A.R. and Osiname B. (1981): Sales of Fertilizer in Nigeria I.A.R.T. Res. Bulletin No. 11, pp. 42.