



Physico-Chemical Characterization of Oil Sands at Imeri in Ogun state of South West, Nigeria

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Abstract

The Nigerian tar sand has an immense potential as an additional hydrocarbon based energy resource in Nigeria. Tar sand produces synthetic crude oil which if combined with Nigeria conventional crude oil will prolong the life span of the latter. There is a vast extensive deposit of tar sands in Ondo, Ogun, Edo and parts of Lagos States of Nigeria, stretching across the belt of 120km with consistently high oil saturation. ICP-ES technique was employed for the determination of the major oxides and trace elements concentration in the tar sands samples collected at Imeri, Ogun State. Physical properties such as porosity, bulk density and electrical resistivity were also determined using simple Experimental approach. The results of the porosity ranges from 0.10 – 0.50, bulk density ranges from 1.13 – 1.46 and electrical resistivity ranges from 00.00 – 78.43. Results were also compared with those of previous works who used PIXE-PIGME techniques at Agbabu area and adequate comments were made on the comparison. The results had been able to confirm that Nigerian tar sands could be rich in silica (SiO₂), which are great assets because of their various industrial applications and utilization. Sulfur and carbon were absent in the tar sand samples collected at Imeri which also make the tar sands differs with that of Ondo State. It was recommended that, Deeper depths could be drilled to ascertain the presence of other potential / economical elements in the study area and water analysis should be carried out on the water at the tar sand deposit.

Keywords: Oil sands, ICP-MS, Imeri, South West Nigeria, Agbabu, Resistivity, Porosity, Bulk Density.

Introduction

Tar sand is composed of a mixture of bitumen, which makes up about 10-20% bitumen and about 80-85% mineral matter including sands, clays and 4-6% water. Tar sand has similar composition as the light crude. They are believed to have being formed from biodegradation and water-washing of light crude due to lack of cap rock. The Nigerian Tar sand is believed to have been formed in a similar process. Tar sands are impregnated sands that yield mixtures of liquid hydrocarbons, which require further processing other than mechanical blending before becoming finished petroleum products. Until recently, Nigerian bitumen deposits were called tar sands, but are now known as oil sands. Oil sands are deposits of bitumen; viscous oil that must be vigorously treated in order to convert it into upgraded oil before it can be used in refineries to produce gasoline, kerosene and other fuels. Bitumen is about 20% of the actual oil sands found in Nigeria while 76% is for mineral matter that include clay and sand and 4% water. Oil sands must be mined or recovered In situ. The recovery process includes extraction and separation systems to remove the bitumen from the sand and water. The oil sand history started with the development of oil sand separation in the 1920s by Dr. Karl Clark and in 1936 Max Ball developed a way to produce diesel oil from oil sand¹.

It was also reported that the actual commercial production started in 1963 when the Sun oil company – later Suncor –

started the construction of the first commercial oil sand production plant¹. It was in the 1967 that the first barrel of commercial production by open pit mining was produced². Various countries of the world have embraced the exploration of oil sands as an alternate source of energy. The oil sands of Northeast Alberta, Canada, represent one of the largest petroleum resources in the world. With over 200 billion barrels of oil in the form of bitumen, total recoverable reserves, using current technology, are second only to those of Venezuela and are greater than those of Saudi Arabia³, (figure 1). In Nigeria, the oil sands belt stretches from east of Ijebu-Ode (Ogun State) to Siluko and Akotogbo areas in Okitipupa (Ondo State) and to Edo state. It covers a distance of approximately 110km⁴ as depicted in figure 2. Nigeria's reserve is estimated to be about 30-40 billion barrels with potential recovery of 3654×10^6 bbls⁵. Of the estimated 30-40 billion barrels of oil sands, Ogun state probably has more than 40% of Nigeria's reserve⁶. However, this enormous reserve of oil sands in Nigeria is yet to be exploited as can be seen in figure 1 which indicates that only about 30 billion barrels of conventional oil reserves have been exploited, while the unconventional resources have not been exploited at all. Seepages and outcrops play an important role in the exploration of sedimentary basin or area. A look at exploration history of most important oil fields of the world prove conclusively that oil seeps gives the first clue to the presence of oil reservoir in the subsurface. Seeps occur whenever a permeable pathway leads to the surface from leaking petroleum reservoir. Oil Sands seepages discovered in

the village of Imeri, Ijebu-Imushin (figure 3) Ogun State served as an indication that they are from a reservoir in the subsurface. At these areas, outcrops were observed and representative samples were systematically collected.

The aim of this research work is to analyse the major oxides (heavy minerals), trace elements and physical properties of oil sands samples collected in the study area.

The above aim were achieved through the following objectives: i. Site location and collection of oil samples, ii. Evaluation of the presence and concentration of major oxides and trace elements. iii. Determination of physical properties of sand samples, iv. Comparative analysis of oil sand quality.

In order to achieve the above listed objective, the work span include: i. Laboratory analysis of the concentrations of major oxides and trace elements of tar sands samples collected at Imeri using ICP-ES, ii. Determination of the physical properties of oil sand samples collected at Imeri using simple experimental methodology.

The study area, Imeri falls within the Eastern part of the Dahomey basin. Imeri is a village in Ijebu Mushin which is Ijebu East Local Government of Ogun State. It can be accessed through the Sagamu- Benin Express way when coming from Lagos. The Study area lies between latitudes 06° 46'N and 06° 47'N and longitudes 003° 58'E and 003° 59'E (figure 4). Accessibility was not quite easy as a result of thick forest and had to make use of cutlass to make foot paths.

Material and Methods

The materials and methods for the research work can be classified under two headings namely the field techniques and the laboratory measurements. The field techniques used in this research is divided into two phases.

Field work: The investigation involved both field and experimental work. The field work aspect involved extensive bush trekking in order to collect samples and the exercise was carried out with the aid of global positioning system (GPS), sledge hammer, chisel, pen, marker, field note, sample bags and paper tape. Oral interview was conducted in order to gather information from the villagers and farmers around the study area. The rocks were sighted and the position of the outcrop was marked on the topographical map. Description and identification of the outcrop were noted, and all observations and sketches were made in the field note.

Sample collection: Samples were collected across the tar belt of the Dahomey basin. Fresh samples serving as representative fraction of the whole outcrops were collected using digger and hand trowel. The exact locations of the samples were recorded in order to tie the various deductions with geographical locations. The samples were then kept in a well-labelled sample bags to avoid mix-up and contaminations. The tar sand samples

were collected for ICP-ES (Inductively Coupled Plasma-Electron Spectrometry) analysis and to determine their physical properties. Ten samples were collected from six various locations on which the GPS readings were recorded. Samples 1 and 2 were collected at location 1, sample 3 was collected at location 2, samples 4 and 5 were collected at location 3, Sample 6 was collected at Location 4, Samples 7, 8 and 9 were collected at Location 5, and Sample 10 was collected at Location 6. Samples 1, 2, 4, 5, 7 and 8 are the samples collected at the oil sand deposit while samples 3, 6, 9 and 10 are collected randomly at a far distance around the oil sand deposits at different location. The map of the studyarea is as depicted in figures 3 and 4.

Geochemical Analysis: The analysis was carried out on the prepared samples at Acme Analytical Laboratory (Vancouver) Limited, 1020 Cordova St. East Vancouver BC V64 4A3 Canada. The analysis was done using the Inductively Coupled Plasma- Emission Spectrometry (ICP-ES) technique to determine the concentration of Major Oxides and Trace elements in the oil sand samples collected. Samples 7 and 8 could not be analysed for its granular texture.

Porosity Test: The porosity test was carried out on the samples except for samples 7 and 8 that could not be grounded into powdered form because of its viscous nature. Its experimental work is as follows,

A 500ml measuring cylinder was half filled with water and the volume was noted and also the soil sample was poured into another 500ml measuring cylinder and the volume was also noted. It must be noted that at this point that the water must never be poured unto the sand but the sand to be poured into the water. This precaution was very necessary; so as to avoid trapping air in the water and so air will be completely expelled. Then, the porosity can be obtained as in equation 1:

$$\text{Porosity, } \varphi = \frac{A-(C-B)}{A} \quad (1)$$
$$\varphi = \frac{A+B-C}{A}$$

where: A = Volume of sand (bulk volume), B = Volume of water, C= The mixture of A and B.

Bulk Density: The bulk density was carried out on the samples except for samples 7 and 8 that could also not be grounded into powdered form because of its viscous nature. The experiment was as follow:

A 500ml measuring cylinder was half filled with the sample and the volume was noted. The weight of the sample and the measuring cylinder was also measured on weighing balance and their weight was also recorded. The measuring cylinder has mass of 199.6g and hence used to obtain results of the bulk densities of the samples as in equation 2.

$$\text{Bulk density} = \frac{D(g)}{A (cm^3)} \quad (2)$$

where: A = volume of sand, B = weight of soil sample + measuring cylinder, C = weight of measuring cylinder, D = weight of the soil sample obtained by B-C.

Electrical Resistivity: Resistivities of the samples collected from the study area were analyzed using a simple laboratory experimental setup (see figure 5). The samples collected were

ground and packed into a cylindrical shaped PVC pipe and were shaped into regular forms so as to make good contact with the metal cap (Mercury) inserted into the sample. Direct current source was used to supply voltage across the two ends of the cylindrical pipe. Voltage was supplied at between 12 and 24 V and the corresponding currents were recorded.

Table-1
Concentration of major oxides and trace elements of the tar sand samples collected at Imeri

Analyte MDL	SiO ₂ 0.01	Al ₂ O ₃ 0.01	Fe ₂ O ₃ 0.04	MgO 0.01	CaO 0.01	Na ₂ O 0.01	K ₂ O 0.01	TiO ₂ 0.01	P ₂ O ₅ 0.01	MnO 0.01	Cr ₂ O ₃ 0.002	Ba 5	Ni 20	Sr 2	Zr 5	Y 3	Nb 5	Sc 1
Unit	%	%	%	%	%	%	%	%	%	%	%	ppm	ppm	ppm	ppm	ppm	ppm	ppm
Sample 1	76.75	10.47	3.65	0.03	0.01	0.02	0.13	0.9	0.05	0.01	0.009	52	23	26	597	28	22	9
Sample 2	74.04	8.81	4.14	0.03	0.01	0.02	0.12	0.98	0.07	0.01	0.018	47	20	16	1227	62	20	11
Sample 3	84.47	7.23	2.17	0.04	0.01	0.01	0.07	0.75	0.07	0.01	0.016	56	20	74	505	22	20	7
Sample 4	51.44	24.9	6.26	0.03	0.15	0.01	0.11	0.84	0.68	0.01	0.063	395	82	960	177	213	16	51
Sample 5	57.39	19.2	1.36	0.04	0.02	0.02	0.19	1.66	0.09	0.01	0.046	116	38	91	912	81	33	31
Sample 6	76.96	9.26	5.72	0.06	0.05	0.01	0.09	0.83	0.25	0.01	0.041	137	20	258	516	31	22	12
Sample 7	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Sample 8	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Sample 9	76.95	9.47	5.03	0.08	0.07	0.02	0.13	0.84	0.35	0.01	0.043	181	20	321	605	38	19	10
Sample 10	77.1	10.82	3.68	0.12	0.16	0.02	0.08	0.92	0.3	0.03	0.022	61	21	91	1515	19	19	9

Note: MDL means Minimum Determining Limit.

Table-2
Results of the Physical properties carried out on the samples

Physical properties	Sample1	Sample2	Sample3	Sample4	Sample5	Sample6	Sample7	Sample8	Sample9	Sample 10
Porosity	0.10	0.02	0.46	0.26	0.40	0.42	N.A	N.A	0.50	0.43
Bulk density(g/cc)	1.45	1.32	1.46	1.25	1.13	1.46	N.A	N.A	1.46	1.44
Average Electrical Resistivity(Ωm)	1.84	2.75	78.43	0.04	1.53	20.64	00.00	00.00	0.60	0.42

Table-3
The comparison of oil sand samples at different locations

Trace element/Major Oxides	Sample 1 Imeri	Sample 2 Imeri	Sample 3 Imeri	Sample 4 Imeri	Sample 5 Imeri	Sample 6 Imeri	Sample 9 Imeri	Sample 10 Imeri	Ref. 7	Ref. 8
SiO ₂	76.75	74.04	84.47	51.44	57.39	76.96	76.95	77.10	14.13	16.0
Al ₂ O ₃	10.47	8.81	7.23	24.90	19.20	9.26	9.47	10.82	10.68	
Fe ₂ O ₃	3.65	4.14	2.17	6.26	1.36	5.72	5.03	3.68	4.83	3.95
CaO	0.01	<0.01	<0.01	0.15	0.02	0.05	0.07	0.16	0.37	0.18
TiO ₂	0.90	0.98	0.75	0.84	1.66	0.83	0.84	0.92		
K ₂ O	0.13	0.12	0.07	0.11	0.19	0.09	0.13	0.08	0.66	0.37
MnO	<0.01	<0.01	<0.01	0.01	<0.01	<0.01	<0.01	0.03		
Zr	597	1227	505	177	912	516	605	1515	70	
Ni	23	<20	<20	82	38	<20	<20	21		53
S	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A		1.76
C	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A		16.89

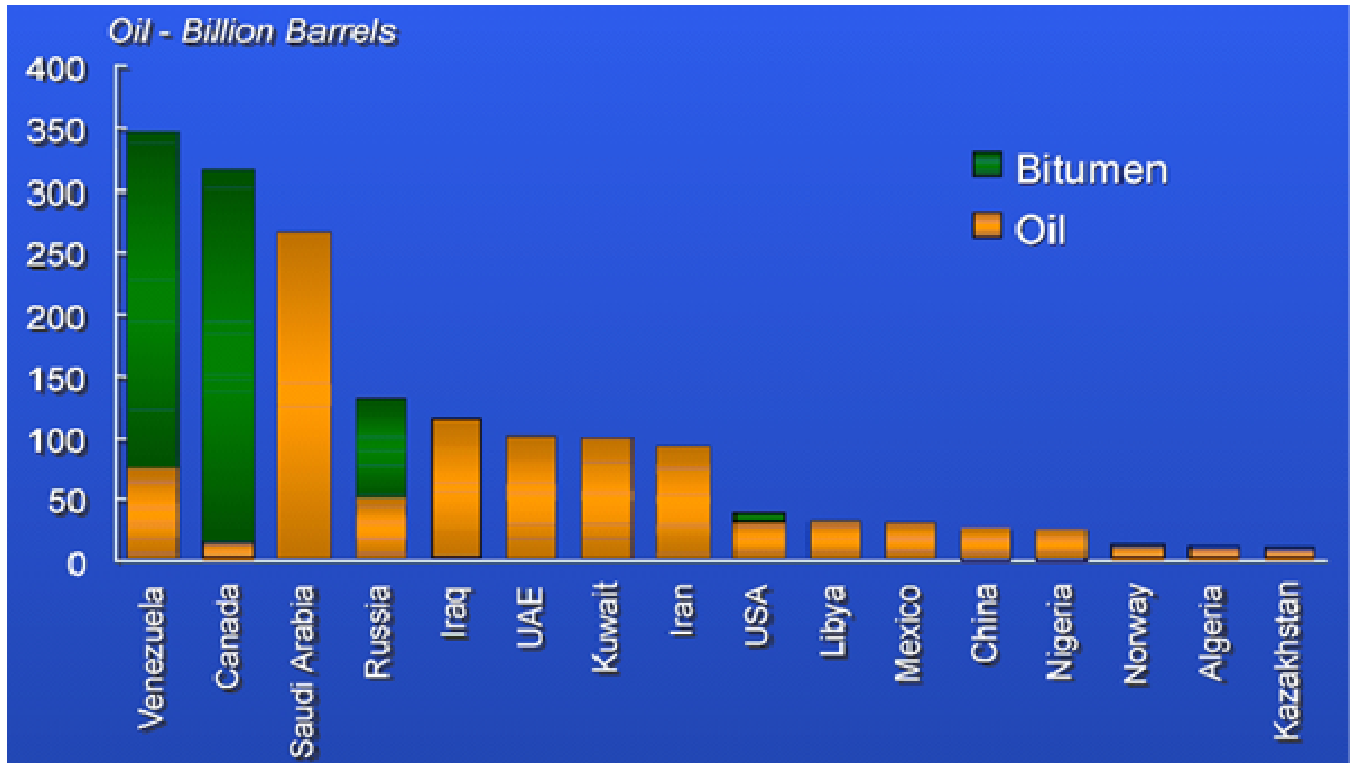


Figure-1
World Petroleum Reserves Recoverable by Current Technology
 (Source: Brant Sangster, 2002 "World Petroleum Reserves Recoverable by Current Technology,")

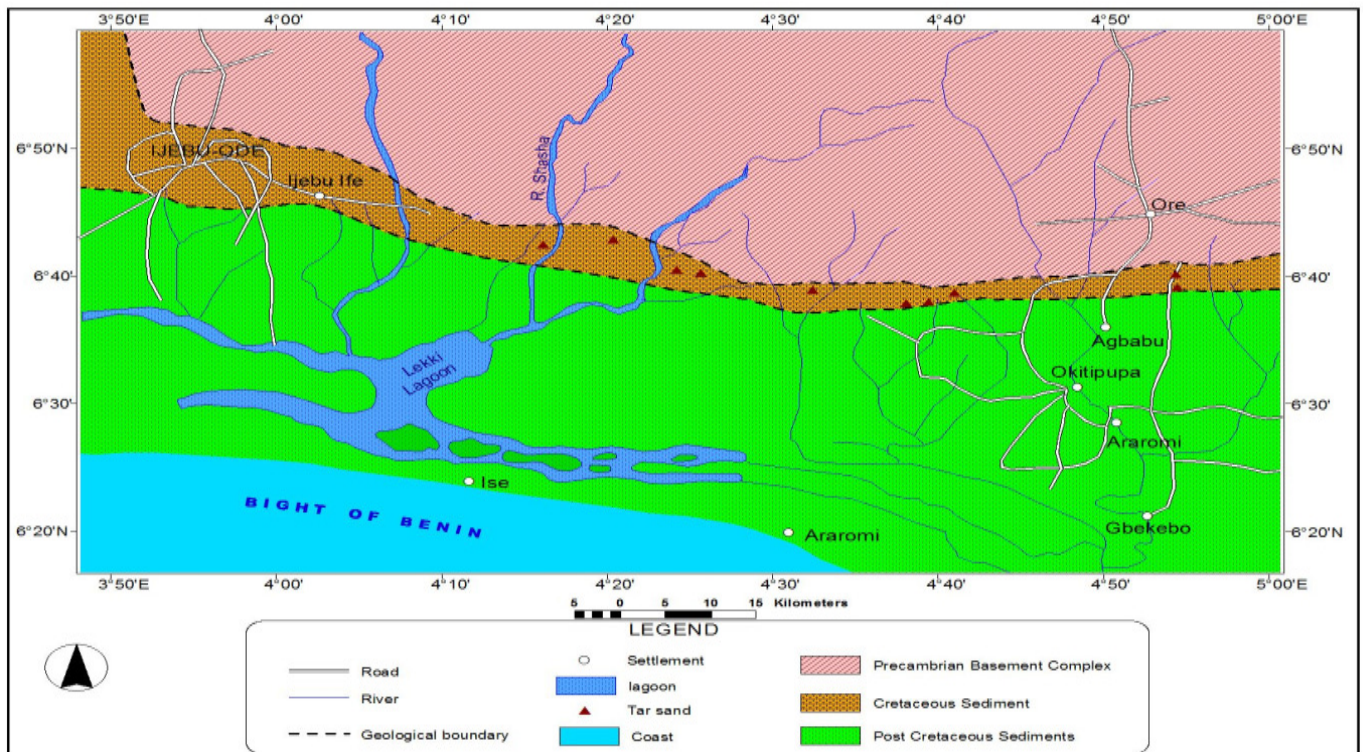


Figure-2
Geology of the Oil Sands belt showing the outcrops (Adapted from Ako, 2003)



Figure-3
 Oil Sands Outcrop at Imeri, Ijebu-Imushin, Ogun State

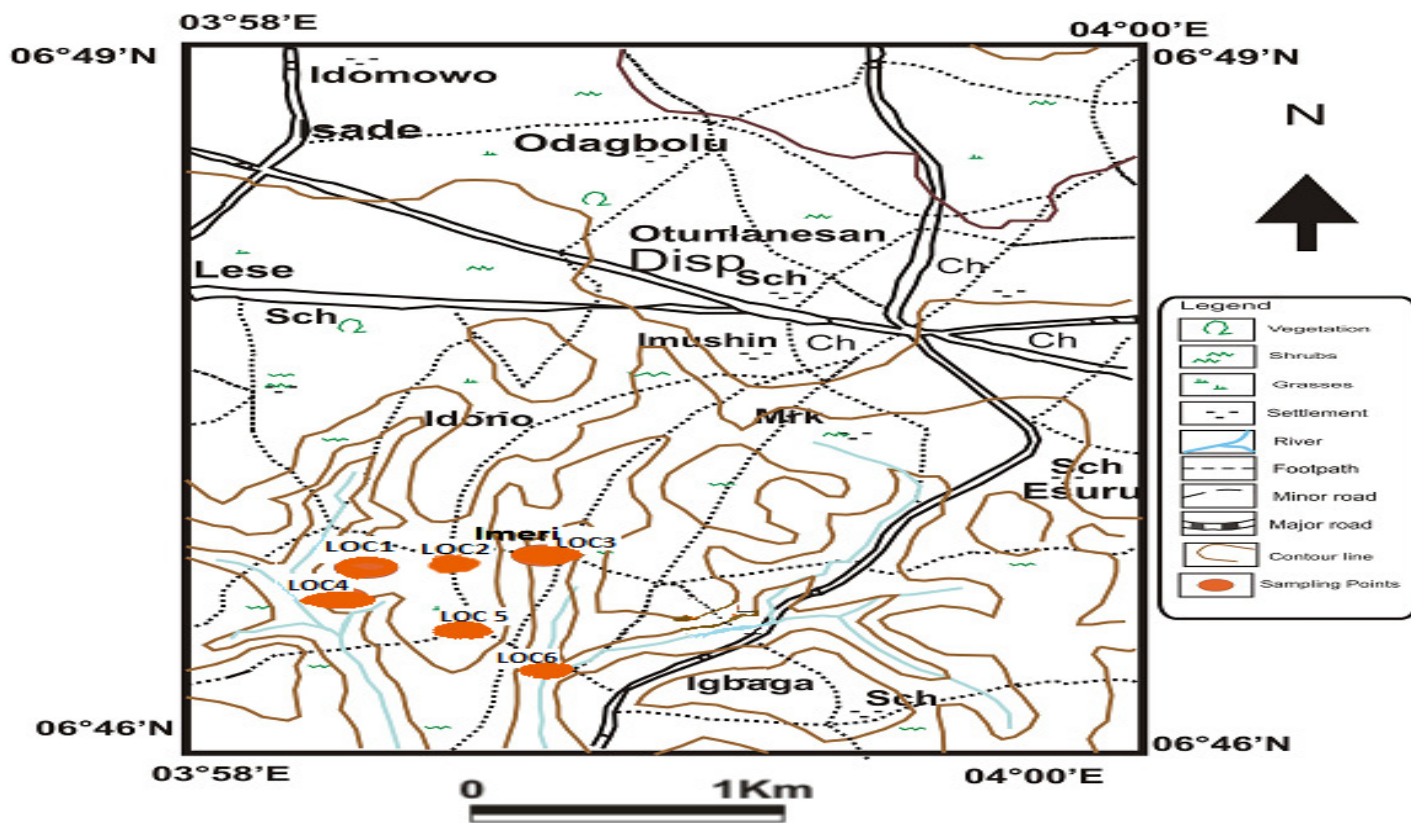


Figure-4
 Location map of the study area showing sampling points

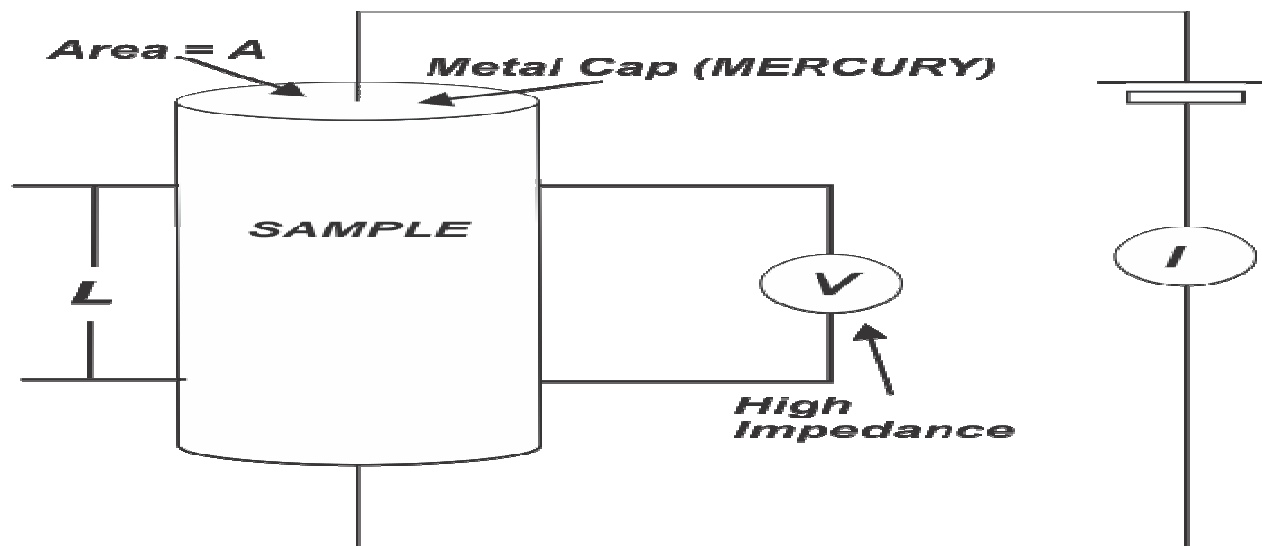


Figure-5
 Experimental setup for the determination of Resistivity

Results and Discussion

The Geochemical analysis was achieved using the Inductively Coupled Plasma- Emission Spectrometry (ICP-ES) technique; the major oxides and trace elements results obtained are as shown in table 1 while the results of the physical properties of the samples are depicted in table 2. Obianjuwa and Nwachukwu determined the major and trace elements concentrations for Nigeria tar sand sample from a deep borehole in Agbabu area of Ondo State using simultaneous PIXE and PIGME analysis and reported their values⁷. Similarly, Olabanji and other researchers, determined the major, minor and trace elemental concentrations of Nigerian tar sands using PIGE and PIXE techniques and also reported their values⁸. Since oil sands are equivalent to tar sands, hence the relevant data from the three respective data are listed in table 3 for comparison. It can be observed from table 1 that, highest concentrations of the oxides and trace elements occurred mostly at all the location except for samples 1, 2 and 3 that has value less than the minimum determining limit for CaO. All the samples have value less than the minimum determining limit for MnO except sample 10 while samples 2, 3, 6 and 9 have values less than the minimum determining limit (MDL) for Ni. It was observed that, there was absence of Sulfur in all the samples which shows that the samples collected at location 1 and 3 does have the properties of oil sands while samples 7 and 8 that could not be analyzed using the ICP-ES technique could probably contain Sulfur concentration in it, if another technique is used.

Observations in the table 3, confirms that samples collected at Imeri are rich in silica (SiO_2) than the Tar sand in Agbabu area of Ondo State^{7,8} Obianjuwa *et. al* (2008) and Olabanji *et. al* (1994). The concentrations of TiO_2 , Fe_2O_3 , Al_2O_3 , Zr are also greater than that of Agbabu area, but the CaO values obtained for the samples at Imeri shows a reasonable agreement with that

of Agbabu area. The values of K_2O and MnO in Agbabu area have high concentrations when compared with that of Imeri. Absence of Sulfur was observed in the analysis of samples collected at Imeri unlike the tar sands in Ondo State which has concentration of Sulfur⁸. The difference of data in some elements may be due to the different geographical locations from which tar sand samples were collected. The porosity of the samples collected at Imeri, ranges from 0.02 to 0.50. The porosity of soil between 0.36 and 0.43 is said to be sandy soil⁹, therefore, samples 5, 6, and 10 are in reasonable agreement, and are said to be more of sand. The porosity of soil samples between 0.51 and 0.68 are said to be clay, therefore, only sample 9 is considered to be clay.

The bulk densities of the samples analysed range from 1.13 to 1.46g/cm^3 . Observation made from Table 5.2 shows that, samples 3, 6 and 9 has almost the same value which shows that they are sandy soil¹¹ while samples 2 and 5 are in reasonable agreement with that of clay, since the bulk density of clay material ranges from 1.1 to 1.3g/cm^3 .

The results of the Electrical Resistivity of the samples show low resistivity values except for samples 7 and 8 collected at location 5 which does not allow current to pass through them at 12 and 24V. The low resistivity value may be due to the Iron rich mineral content of the deposit, high salinity and high porosity.

Conclusion

The ICP-ES technique has proved to be efficient in the analysis of the concentrations of the major oxides and trace elements in the samples collected at Imeri. Results were compared with those of previous works who used PIXE-PIGME techniques at Agbabu area and seem to be in agreement with major oxides

and trace elements. The results also confirm that the samples collected are rich in silica (SiO_2), which are great assets because of their various industrial applications and utilization. Sulfur and carbon that were absent in the samples collected also make the samples differs with that of Ondo State. It should be stated that this is a follow up of the work of Ijeoma dissertation¹⁰ as my samples however, may not contain enough concentrations of oil sand properties because of the heterogeneous nature of the study area.

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