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Soil Corrosivity Determination for the Engineering Design of Burried Pipes Using Geophysical Investigation Along Jos – Bukuru Metropolis

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ABSTRACT

The study area is around Jos – Bukuru metropolis. Areas 1, 2, 3, 4, 6, 7, 8, 11, 13, 14, 16 and the Main Line were investigated where their resistivity's in Ωm (Ohm – metres) were determined. The geophysical investigation method used for this investigation was the electrical resistivity method employing the Schlumberger technique with current electrode spreading from 1.5 to 18m with the depth penetration capacity of 6m. The spread was so chosen because the investigation seek to determine the soil corrosivity from the surface to a depth of 5m underground. Resistivity results revealed that Areas 1, 8, 11 and 16 are mildly corrosive with resistivity range of 126.20 – 193.51 Ωm while Areas 2, 3, 4, 6, 7, 13, 14 and the Main Line were essentially non corrosive with resistivity range of 211.24 – 515.56 Ωm. From the geophysical investigation carried out and the results obtained from data analysis and interpretations, the area under investigation is mostly non-corrosive. However, the average resistivities of some VES points shows that the soil in those points are highly corrosive to moderately corrosive. The average resistivity of the entire project area infers that the soils in the area is essentially non corrosive and the metallic pipes can be conveniently laid since close to 70 % of the area under investigation are non corrosive.

Keywords – Corrosivity, Resistivity, Schlumberger and Electrodes

INTRODUCTION

Corrosivity is a purely an electrochemical reaction where by complex chemical reactions takes place between the soil and the contacting metal. This results in the formation of corrosion products and rust of the metal. Generally, metals and steel structures buried underground such as utility piping, pipeline, tanks and pilings placed in direct contact with soil environment reacts with the metal and as a result are prone to electrochemical reactions. "Tuck et al (2010)". Previously, wall thickness of pipelines is increased as corrosion protection practice to elongate the lifespan of the metal when undergoing corrosion attack in the soil. Electrical resistivity, soluble ion content, oxidation – reduction (redox) reaction potential, pH, moisture content availability e.t.c, are the factors that speedens up corrosion process in the soil. Most of these corrosion factors can be measured empirically to ascertain soil corrosivity. Hence, this study was carried out in the area under investigation to determine the electrical resistivity of the soils with a view to establish their corrosivities. "Peabody (2001)" opined that corrosion damages can be very disastrous and could lead to pollution and even death of humans. Corrosivity generally can be avoided by galvanizing the metals before burying them. "Della (2021)"

Location, Accessibility and General Geology

The areas under investigation is located along Jos – Bukuru metropolis, Plateau State, North Central Nigeria, covering the two metropolitan Local Governments areas of the state capital. The study area is located on Latitudes N 9^0. 84'. 72" to 8^0. 89'. 36" and Longitudes E 9^0. 86'. 78" to 8^0. 90'. 44". The Local Governments are Jos North and Jos

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South respectively. The areas are accessible through tarred and untarred roads. The Topography of the areas is characterized by rugged and rocky terrains in some places and flat land in some other places.

In terms of geology, the area under study is within the Jos-Bukuru granite Complex. This complex is made up of biotite granite rocks. “Falconer (1911)” , “Falconer (1921)” and “MacLeod et al (1971)”. The study area lies within the Jos-Bukuru granite complex. This complex is made up of six (6) lithologic units. These units are differentiated on the basis of mode of formation, mineralogy and the texture of the rocks. There different rock types include Jos biotite granite and N’gellbiotite granite. Others are Delimibiotite granite, Rayfield Gona – biotite granite, biotite micro-grantie and laterite covering the Older Basalt. “Wright (1971)”.

The Jos biotite-granite rock occupies the northern, north-western, central and south-eastern parts of the area under investigation. This rock type has a regular joint system with two equally developed vertical sets. The only pronounced textural variations in this rock type are observed near the margins of the granite against the Basement Complex and the earlier Younger Granite intrusion. There is little compositional variation in the Jos biotite-granite over the greater part of its extent. The exceptionally coarse grain size of the minerals renders it easily recognizable in the field, “Wright (1971)”.

The N’gell biotite granite rock is an intrusion into the Jos biotite-granitic rock and occupies an area of about 160.5 km^2 in the central and southern parts of the rock complex. It shows a very large textural variation compared the Jos biotite-granite rock and medium grained in texture. “Wright (1971)”.

The Delimi biotite-granite rock is best exposed in the deeply dissected headwater region of the Delimi River. Its texture is fine-grained and greisens are common in the granite, which has probably made substantial contributions to the alluvial tin deposits in the Delimi valley.

The Rayfield Gona Biotite Granite occupies part of the western, central and south-eastern parts of the Jos Plateau. This granite is best viewed in the the northern arc in the more dissected drainage system of the upper N’gell group. The Rayfield-Gona granite is characterized by its low resistance to erosion. The joints are close and irregular and the granite weathers to low outcrops. Rounded white boulders appears as hills only where they are buttressed by the more resistant earlier granites. The texture of the Rayfield-Gona granite is fine to medium grained. It is characterized by a wealth of accessory minerals assemblages. It is mainly distinguished as the richest granite that has a lot of columbite, thorite and cassiterite, “Mc Curry (1989)”.

The biotite microgranite lies below the extreme south-western part of the Jos Plateau. The microgranite is composed of almost equal amounts of quartz, orthoclase and albite, with evenly dispersed flakes of biotite.

Laterite occurs as patches within the study area, and they abound more in the central, western and eastern parts of the Jos Plateau. Lateralized Older Basalts represent lavas which have been decomposed to clays and usually overlain by a thick cap of laterite ironstone. The lateralized basalts occur as erosion ruminants in watershed areas and the associated fluvial sediments include sands, gravels and clays. “Mc Curry (1989)”.

The geology of the Jos Plateau comprises of the Precambrian Basement, Migmatie-Gneise-Quartzite complex (which underlies about half of the entire State and in some places has been intruded by Precambrian to the late Paleozoic Pan-African granite Older Granite), diorite, Charnockite etc. Intrusions in the Basement Complex rocks are the Jurassic androgenic alkali Younger Granites. We equally have the Younger Granites which are volcanic rocks (such as basalts and rhyolites) that overly or cross-cut this formation as well as the Basement rocks. The volcanic rocks originated during the early Cenozoic (Tertiary) “Older Basalts” and Quaternary “Newer Basalts”, “MacLeod et al (1971)”. The description of MacLeod actually confirmed the presence of minerals of economic importance like tin and columbite that were extensively mined between 1902 and 1978 on the Jos - Plateau.

MATERIALS AND METHODS

Materials used for this study includes : Terrameter, Cables, GPS, Electrodes, Battery and a Field Vehicle.

Electrical resistivity method involved the generation of artificial electric currents which are sent into the ground and resulting potential differences are measured at the surface, “Tharwat, H, et al, (2018)”. Anomalies from the pattern of potential differences expected from homogenous ground give key information on the form and electrical properties of subsurface of the earth in homogeneities “Keary et al (2002)”.

Geophysical investigation method used for the survey is the electrical resistivity method employing the Schlumberger technique with current electrode spreading from 1.5 to 18m with the depth penetration capacity of 6m. The spread was so chosen because the investigation seek to determine the soil corrosivity from the surface to a depth of 5m underground. The field data was acquired using the Ohmega Allied Resistivity meter. The data was subjected to manual and computer interpretation. The software used was the Surfer11 and Microsoft Excel for data analysis.

RESULTS AND DISCUSSION

The measured data from the site of investigation was converted to apparent resistivity values by multiplying them with their corresponding Schlumberger geometric factor. Using Microsoft Excel, the average resistivities of each VES were thus calculated as one geo-electric resistivity layer with a thickness of 6m from the surface. The averages obtained in Ohm-m were further converted to Ohm-cm which is the standard unit for determining corrosivity using resistivity. The area under investigation was divided into sub areas where a minimum of two (2) VES were carried out. The average resistivity of each sub area was also calculated to be the resistivity of the general sub area.

A preliminary interpretation was carried out using the standard soil resistivity and corrosivity ratings using the Tables, where Table 1 is the Resistivity Data and Soil Corrosivity of the VES Points, Table 2 is the Standard Soil Resistivity and Corrosivity Ratings and Table 3 is the Average Resistivity Data and Soil Corrosivity of the Sub Areas with their Inferred Corrosivities.

Table 1: Resistivity Data and Soil Corrosivity of VES Points

VES	Coordinates	Average Resistivity (OHM-M)	Average Resistivity (OHM-CM)	Inferred Corrosivity
1	N9.84722222, E8.89361111	49.8449	4984.49	Corrosive
2	N9.84861111, E8.90333333	120.3245833	12032.46	Mildly corrosive
3	N9.85055556, E8.88138889	280.45175	28045.18	Essentially non-corrosive
4	N9.84833333, E8.88750000	83.73466667	8373.47	Moderately corrosive
5	N9.86000000, E8.87361111	106.0215833	10602.16	Mildly corrosive
6	N9.83888889, E8.86277778	654.4514167	65445.14	Essentially non-corrosive
7	N9.85250000, E8.85722222	383.42175	38342.18	Essentially non-corrosive
8	N9.83666667, E8.86000000	599.2353667	59923.56	Essentially non-corrosive
9	N9.85527778, E8.84638889	425.1206667	42512.07	Essentially non-corrosive
10	N9.88861111, E8.83416667	419.4274167	41942.74	Essentially non-corrosive

11	N9.89888889, E8.82583333	507.7919167	50779.19	Essentially non-corrosive
12	N9.88861111, E8.83972222	326.9421667	32694.22	Essentially non-corrosive
13	N9.88861111, E8.83694444	1082.695291	108269.53	Essentially non-corrosive
14	N9.80833333, E8.86472222	135.64875	13564.88	Mildly corrosive
15	N9.80833333, E8.86472223	151.79925	15179.93	Mildly corrosive
16	N9.80444444, E8.86277778	438.2995	43829.95	Essentially non-corrosive
17	N9.85361111, E8.86611111	181.2390833	18123.91	Mildly corrosive
18	N9.85361111, E8.86611112	160.22825	16022.83	Mildly corrosive
19	N9.85361111, E8.86611113	448.302	44830.2	Essentially non-corrosive
20	N9.85361111, E8.86611114	276.5814167	27658.14	Essentially non-corrosive
21	N9.87000000, E8.90527778	246.1551667	24615.51	Essentially non-corrosive
22	N9.87000000, E8.90527779	218.3929167	21839.29	Essentially non-corrosive
23	N9.87000000, E8.90527778	1061.0355	106103.55	Essentially non-corrosive
24	N9.87000000, E8.90527779	228.779	22877.9	Essentially non-corrosive
25	N9.83194444, E8.90722222	429.8995	42989.95	Essentially non-corrosive
26	N9.91666667, E8.90722222	798.0944167	79809.44	Essentially non-corrosive
27	N9.83194444, E8.90722222	374.4081667	37440.82	Essentially non-corrosive
28	N9.83194444, E8.90722223	294.6953333	29469.53	Essentially non-corrosive
29	N9.83194444, E8.90722224	101.9844	10198.44	Mildly corrosive
30	N9.83194444, E8.90722225	119.4703	11947.03	Mildly corrosive
31	N9.92916667, E8.92000000	157.1505833	15415.06	Mildly corrosive
32	N9.92916667, E8.91111111	26.30591667	2630.59	Highly corrosive
33	N9.92888889, E8.90944444	315.04675	31504.68	Essentially non-corrosive
34	N9.95805556, E8.87388889	51.21233333	5121.23	Moderately corrosive
35	N9.96583333, E8.86305556	131.0249167	13102.49	Mildly corrosive
36	N9.99333333, E8.87472222	460.6543333	46065.43	Essentially non-corrosive
37	N9.95805556, E8.8605556	131.1645833	13116.46	Mildly corrosive
38	N9.92694444, E8.86166667	98.10016667	9810.02	Moderately corrosive
39	N9.92694444, E8.86166668	393.6386667	39363.87	Essentially non-corrosive
40	N9.92694444, E8.86166669	141.9769091	14197.69	Mildly corrosive
41	N9.8683333, E8.89027778	636.6237917	63662.38	Essentially non-corrosive
42	N9.83555556, E8.92166667	574.2180833	57421.81	Essentially non-corrosive
43	N9.84916667, E8.92194444	170.2946667	17029.47	Mildly corrosive
44	N9.86777778, E8.90444444	112.6511667	11265.12	Mildly corrosive

Table 2: Standard Soil Resistivity and Corrosivity Ratings (Boyawa 2018)

Soil Resistivity (ohm-cm)	Corrosivity Rating
>20,000	Essentially non-corrosive
10,000 to 20,000	Mildly corrosive
5000 to 10,000	Moderately corrosive
3,000 to 5,000	Corrosive
1,000 to 3,000	Highly corrosive
<1000	Extremely corrosive

The average resistivities thus obtained serve as the basis for inferences, conclusion and recommendations.

Table 3: Average Resistivity Data and Soil Corrosivity of Sub Areas with their Inferred Corrosivities

Areas	Average Resistivity (OHM-M)	Average Resistivity (OHM-CM)	Inferred Corrosivity
Area 1	128.08	12807.55	Mildly Corrosive
Area2	515.56	51555.73	Essentially non-corrosive
Area 3	489.07	48906.59	Essentially non-corrosive
Area 4	258.98	25898.11	Essentially non-corrosive
Area 6	211.24	21123.86	Essentially non-corrosive
Area 7	584.21	58421.42	Essentially non-corrosive
Area 8	126.20	12620.18	Mildly Corrosive

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Area 11	170.68	17067.63	Mildly Corrosive
Area 13	436.85	43685.24	Essentially non-corrosive
Area 14	241.92	24191.58	Essentially non-corrosive
Area 16	193.51	19351.40	Mildly Corrosive
Main Line	373.45	37344.69	Essentially non-corrosive

Figure 1 is the statistical analysis of the average resistivities of the VES points, Figure 2 is the statistical analysis of the average resistivities of the Areas, Figure 3a is the corrosivity intensity map of the area and Figure 3b is a 3D representation of corrosivity intensity map.

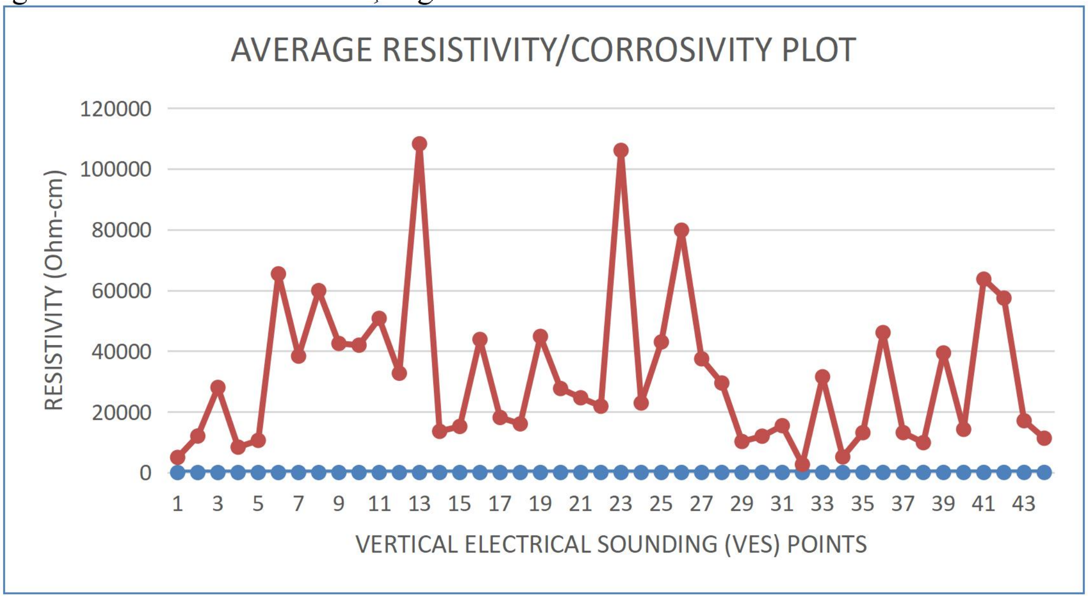

Figure 1: Statistical Analysis of Average Resistivity of VES Points

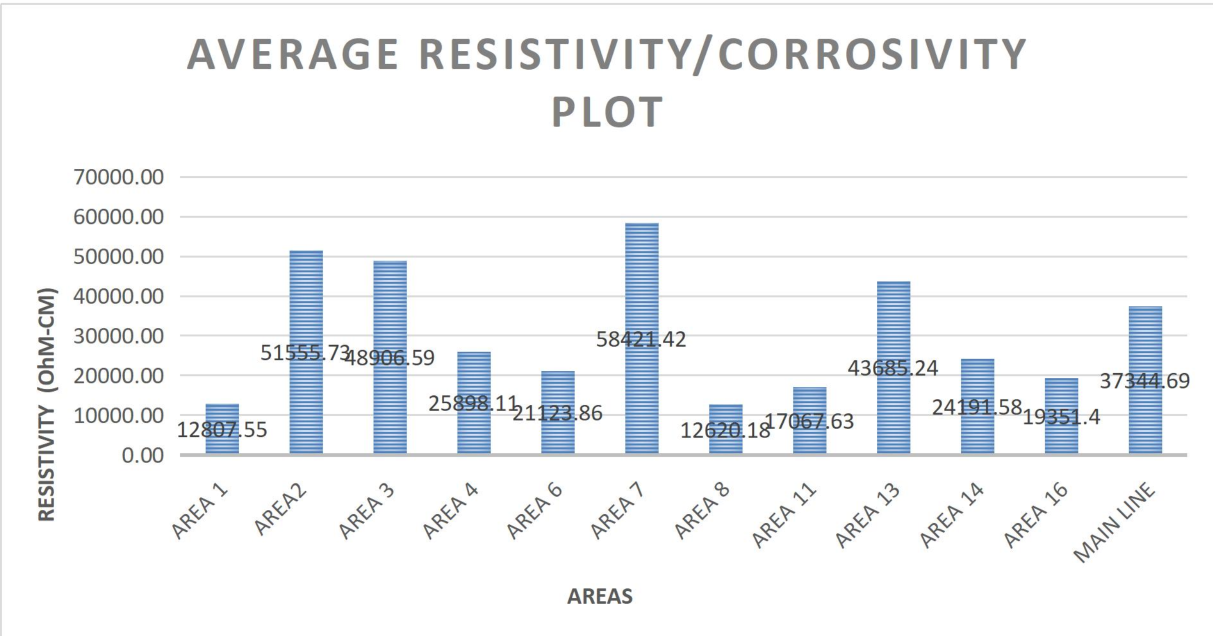

Figure 2: Statistical Analysis of Average Resistivity of the Areas

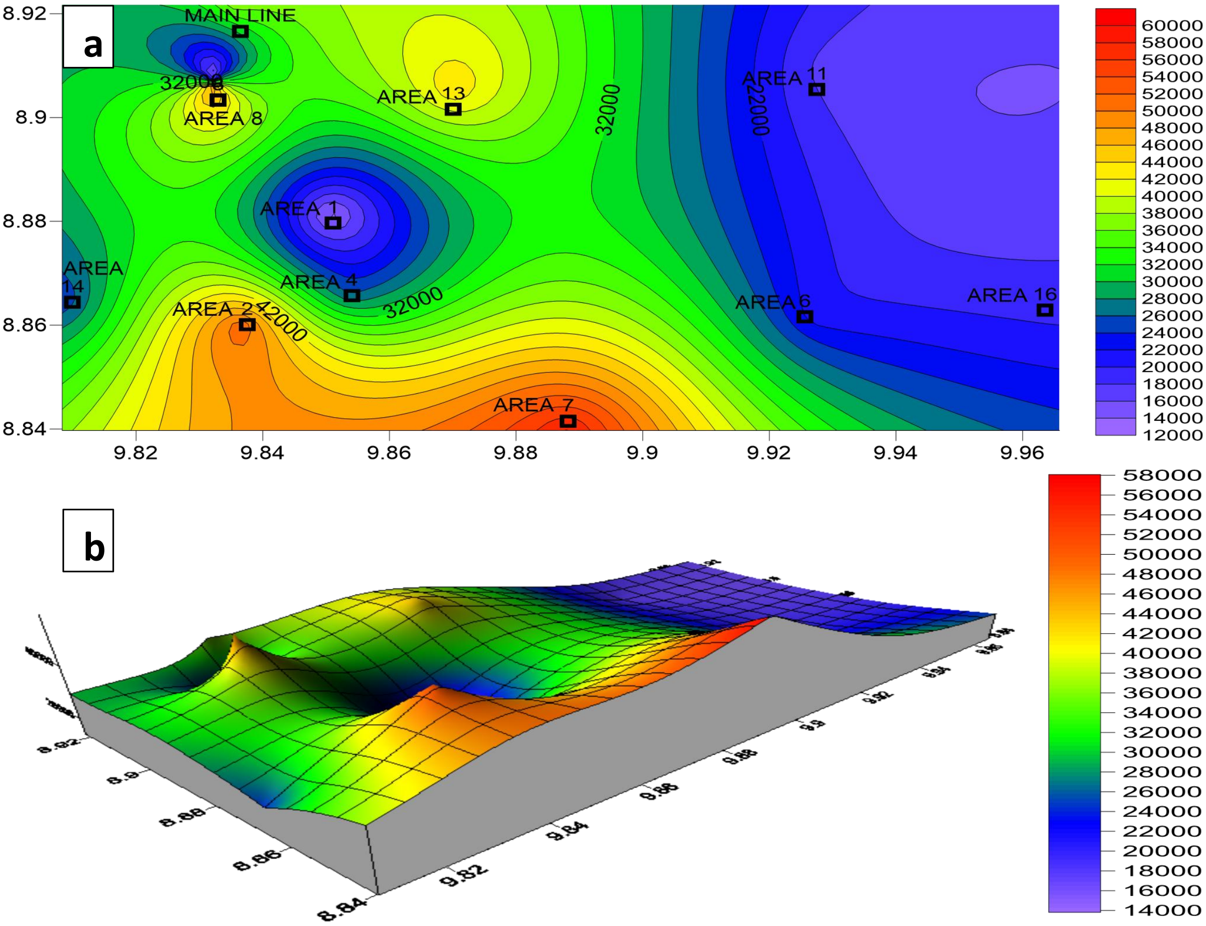

Figure 3: (a) Corrosivity Intensity Map of the Project Area. (b) 3D Representation of Figure 3a.

Areas 1, 2, 3, 4, 6, 7, 8, 11, 13, 14, 16 and the Main Line were investigated where their resistivities in Ωm (Ohm – metres) were determined.

The geophysical investigation method used for this investigation was the electrical resistivity method employing the Schlumberger technique with current electrode spreading from 1.5 to 18m with the depth penetration capacity of 6m. The spread helps to determine the soil corrosivity from the surface to a depth of 5m underground. The resistivity results obtained were compared with the corrosivity rating table in other to infer the nature of the soil corrosivities.

Resistivity results revealed that Areas 1, 8, 11 and 16 are mildly corrosive with resistivity range of 126.20 – 193.51 Ωm while Areas 2, 3, 4, 6, 7, 13, 14 and the Main Line were essentially non corrosive with resistivity range of 211.24 – 515.56 Ωm. From the results, pipes buried in the essentially non corrosive areas will be free from the effects of soil corrosion while those buried in mildly corrosive areas might need to be galvanized in other to reduce the effect of soil corrosion on them.

CONCLUSION

From the geophysical investigation carried out and the results obtained from data analysis and interpretations, the area under investigation is mostly non-corrosive. The average resistivity of the entire project area infers that the soils in the area is essentially non corrosive. From the results, pipes buried in the essentially non corrosive areas will be free from the effects of soil corrosion while

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those buried in mildly corrosive areas might need to be galvanized in other to reduce the effect of soil corrosion on them. By implication, It is recommended that concerted efforts should be made to galvanize any metal work that would be buried in the points where the soil corrosivity is mildly corrosive.

REFERENCES

Boyawa, C. aand Olayiwola, A.U. (2018). Subsoil Corrosivity Rating Using Their Resistivity Values, *Engineering Reports*5-15.

Della, A. (2021). Understanding the Causes and Cure for Corrosion. *Journal of Environmental Science.* 4 (2) 70 -83

Falconer, (1911). The Geology and Geography of Northern Nigeria. *Mac Millan Press*, 135 - 138

Falconer, (1921). The Geology and Geography of Northern Nigeria. *Mac Millan Press*, 165 – 180

Keary et al (2002). Estimation of Hydraulic Parameters From Subsurface Geophysical Methods, Orissa, India. *Engineering Geology Journal* 16 (3) 34 -66

Macleod et al (1971). The Geology of the Jos Plateau. *Journal of Geosciences and Environment.* 7 (2) Feb 2, 1971

McCurry, P. (1989). A General Review of the Geology of the Precambrian to Lower Paleozoic Rocks of Northern Nigeria. *Rock View Nig. Ltd, Jos. 13-37*

Peabody, A.W. (2001). Peabodys Control of Pipeline Corrosion. *2ND Ed. NACE International*

Tharwat, H., et al (2018). Geoelectrical Exploration of Groundwater , Egypt. *Journal of Astronomy and Geophysics* 7 (2) Sept, 2018.

Tuck et al (2010). Corrosion and Degradation of Engineering Materials. *Science Direct Journal*, 4 , 22 - 70

Wright, C. (1971). Ring Complexes in the Younger Granite Province of Northern Nigeria. *Memo No. 1, Geological Society of London, 65-76.*