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Research Paper

Chemical Compostion of the Laterite Deposit in Anyigba and Environs (Northern Anambra Basin) and the Clinker requirements for the manufacture of cement from Obajana and Ekinrin –Adde marble deposits.

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Abstract:
The extensive Laterite horizon capping the Ajali Sandstone Formation in Anyigba and its environs, in the northern part of the Anambra Sedimentary basin, north central Nigeria, was subjected to X-Ray Fluorescence (XRF) analysis to determine its iron-oxide content. The average iron-oxide content obtained from 11 samples analyzed is 14.02%. This concentration value falls below the minimum concentration required for the production iron and steel. However, the laterite provides a very valuable source of iron-oxide (Fe_2O_3) and alumina (Al_2O_3) required in producing a satisfactory cement clinker in the manufacture of cement. TheSilica Ratio (S.R.), Alumina Ratio (A. R.) and Lime Saturation Factor (L.S.F) of the Obajana marbleare 5.37, 2.13 and 940respectively while that of Ekinrin –Adde marble are 2.26, 1.79 and 438respectively.The S.R. and the L.S.F of the Obajana marble do not fall within the recommended ranges (1.9 - 3.2 and98 - 103) for cement production while in the Ekinrin Adde marble, the L.S. F does not fall within the recommended rangefor cement production. To meet the recommended range for Portland cement production, the S.R and the L.S.F of the cement kiln feed for Obajana marble and the L.S.F for Ekinrin – Adde marble respectively will have to be adjusted. The L.S.F value of the marble can be adjusted to fall within the recommended range required for a typical cement kiln by blending the marble with suitable proportions of clay and laterite to supply SiO_2 and Al_2O_3; and Fe_2O_3 respectively. The adjustment is done to obtain the desired ratio of S.R and. L.S.F. for Obajana cement clinker to fall within 2.3 – 2.7 and 98 - 103 respectively and L.S.F for Ekinrin – Adde cement clinker to fall within 98 – 103.

***Keyword**: iron-oxide, laterite, chemical ratio, cement, content*

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I. Introduction

In the manufacture of cement, a very valuable product in the building construction industry, it is very important to produce a satisfactory cement clinker (Biju *et al*, 2023) and this requires a 'raw meal' of the correct chemical composition. Three chemical ratios: Silica Ratio (S.R), Alumina Ratio (A.R) and Lime Saturation Factor (L.S.F) are used to monitor the composition of the raw meal and clinker. These ratios are calculated from the oxides CaO, SiO_2, Al_2O_3, and Fe_2O_3(measured as total iron). While lime (CaO) is obtained from limestone/marble as the principal raw material for the manufacture of cement, silica (SiO_2), iron oxide (Fe_2O_3 – measured as total iron) and Alumina (Al_2O_3) can be obtained from laterite. This study seeks to determine the chemical composition of the extensive laterite horizon capping the Ajali Sandstone Formation in the northern part of the Anambra Sedimentray Basin with a view to using it in producing a satisfactory cement clinker for cement production from the Obajana marble and Ekinrin-Adde marble in the neighborhood of the laterite deposit in Anyigba and environs in Kogi State, north central Nigeria

Location of the Study Area

The study area covers Anyigba town and its neighbouring communities in the northern part of the Anambra Basin, and covers part of the Dekina topographic map sheet 248SW and the Ejule topographic map sheet 268NW, extending from latitudes $07^0 21'0''$N to $07^0 37'30''$N and longitude $07^0 20'0''$E and $07^0 33'0''$E.

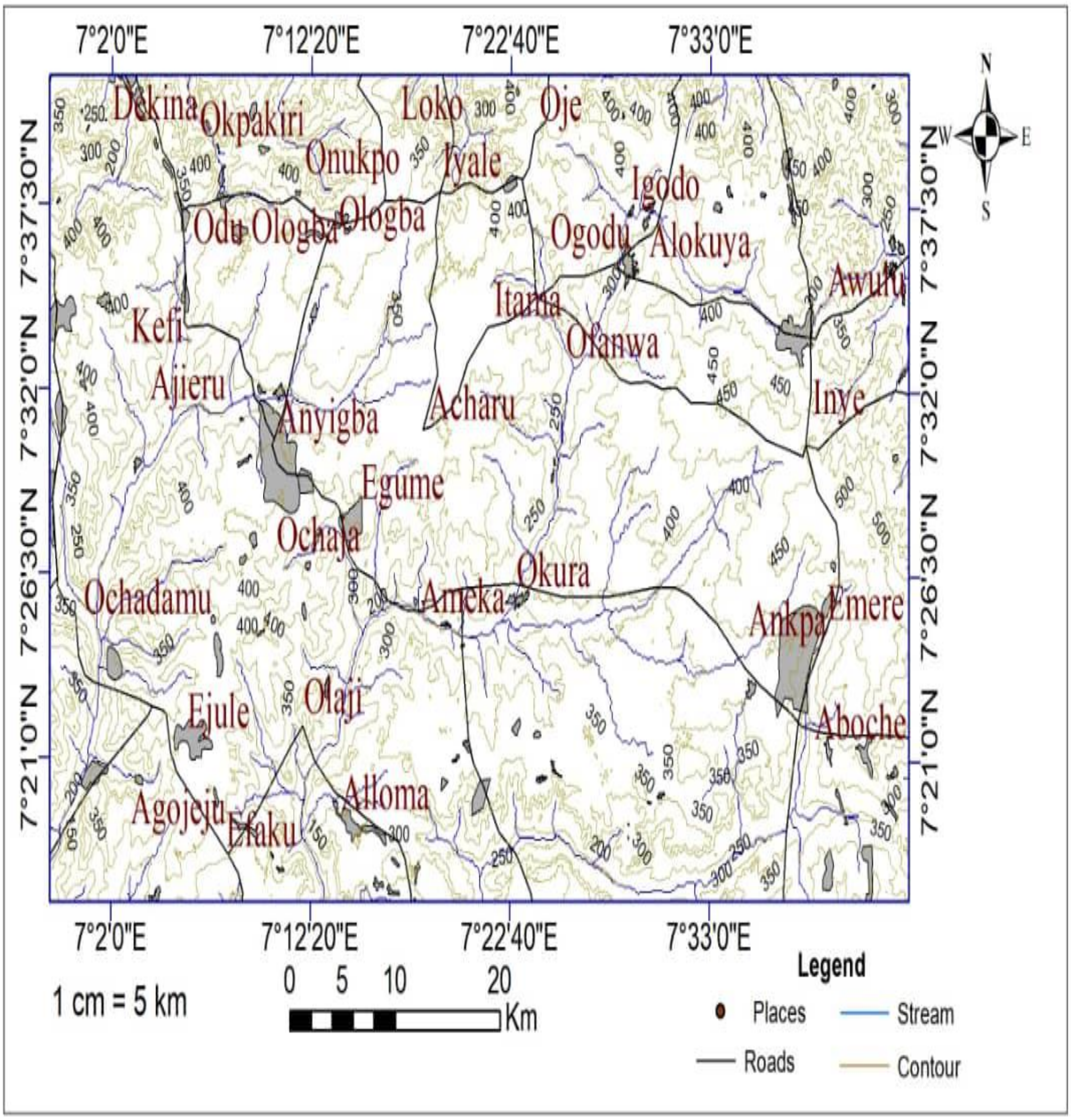

Fig 1. Topographic Map of the Study Area

II. Methodology of Study

Field geologic traversing and sampling of the laterite samples in the study area were carried out along road cuts, river valleys and excavated pits using a topographic base map (Scale of 1: 5000) and a Bruton Compass-Clinometer. Eleven (11) fresh representative samples were obtained from the laterite exposures. Sampling was carried out about 1m from the top of the laterite exposure at every sampling location. After careful examination and description of the samples in terms of colour, texture etc., samples were packaged in sample bags and well labelled with permanent marker ink.

The chemical compostion of the laterite samples was determined using the Neutron Activation Analysis (NAA) at the Centre for Energy Research and Training (Nuclear Science and Technology Laboratory) of the Ahmadu Bello University, Zaria, Nigeria. The samples were prepared by soaking in HNO_3 acid for 3 days and later washed with distilled water in the NAA NIRR-1 laboratory. 0.18g of the sample were packed and sealed in a polyethylene bag for both long and short irradiations. The neutron flux of irradiation of samples was set at 5x1011 n/cm^{2}s which increases the sensitivity of analysis for the activated nuclides. To determine the unknown (blank) concentrations of elements in the samples, two irradiation schemes were adopted, based on the half-life of the product radio-nuclides capability and capacity of NIRR-1. For the short-lived activation, each prepared samples were irradiated with neutron spectrum. Similarly, long activation samples were irradiated with thermal neutron flux. Measurement of the activated samples was carried out by the PC-based gamma-ray spectrometry set-up. Short life irradiated sample was counted using far geometry 'H2' (first count) and near geometry 'H1' after a decay period (2 – 15min). The second count was also carried out for 10 minutes following the short-life irradiation regime after a decay period of 180 min –240 min. The long-life irradiation was counted for 30 min, after a decay time of 4–5 days. After 10-15 days of decay period, second count was carried out for 60 min at detector geometry ''H1''

III. Results and Discussions

The major element oxide content of the laterite samples obtained from the NAA analyses are presented in table 1 below

Table 1: Major Element Oxide Composition of the Laterite in the Study Area

Element (wt. %)	L1	L2	L3	L4	L5	L6	L7	L8	L9	L10	L11	**Mean**
SiO_2	63.9	65.9	57.38	56.24	57.1	54.10	61.87	64.4	52.96	68.72	44.73	**58.85**
MnO	0.03	0.01	0.05	0.07	0.06	0.90	0.07	0.02	0.8	0.03	0.10	**0.19**
Fe_2O_3	8.95	8.30	15.45	16.50	15.76	17.23	12.25	8.65	18.72	8.52	25.79	**14.19**
Al_2O_3	20.3	19.8	21.67	22.20	21.90	20.30	19.90	19.74	21.50	18.32	23.54	**20.83**
CaO	0.3	0.1	0.16	0.18	0.17	0.20	0.39	0.3	0.19	0.21	0.29	**0.23**
MgO	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.00**
TiO_2	3.8	3.6	3.32	3.34	3.30	3.4	3.03	3.7	3.01	1.95	3.72	**3.29**
P_2O_5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.00**
K_2O	0.3	0.1	0.01	0.12	0.1	0.14	0.08	0.3	0.13	0.33	0.15	**0.16**
L.O.I	0.12	0.17	0.32	0.34	0.30	0.28	0.09	0.2	0.7	1.70	0.51	**0.43**
Total	97.8	98.0	98.34	98.99	98.69	96.55	97.69	97.31	98.01	99.77	98.83	**98.17**

The Fe_2O_3, SiO_2 and Al_2O_3 content of the laterite samples have been used in conjunction with the CaO and SiO_2 content of the marble samples from the Obajana marble deposit, Jimoh *et al.,* 2015 and Ekinrin-Adde marble deposit, Onimisi *et al.,* 2017 to calculate the S.R, A.R and L.S.F. required to produce a satisfactory cement clinker for the manufacture of cement from these marble deposits

Table 2. The Mean of the Wt % of the Major Element Oxides of the Obajana Marble

wt. %	OBM 1	OBM 2	OBM 3	OBM4	OBM5	OBM 6	OBM7	OBM8	OBM9	OBM10	Range	**Mean**
SiO_2	4.12	2.12	0.58	1.36	1.12	0.67	2.54	0.67	3.12	2.72	0.58- 4.12	**1.902**
Al_2O_3	0.13	0.62	0.08	0.43	0.34	0.10	0.52	0.11	0.16	0.21	0.08 - 0.52	**0.243**
Fe_2O_3	0.08	0.22	0.06	0.24	0.19	0.09	0.25	0.08	0.07	0.04	0.04 - 0.25	**0.114**
TiO_2	0.08	0.04	0.01	0.03	0.02	0.01	0.03	0.01	0.02	0.04	0.010-0.08	**0.029**
MnO	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.03	0.01	0.03	0.01 - 0.03	**0.015**
MgO	2.11	0.85	0.18	2.89	0.73	0.31	1.06	0.41	1.46	0.98	0.18 - 2.89	**1.098**
CaO	49.90	53.02	55.25	51.66	54.28	55.18	52.29	55.24	53.98	53.32	49.9 - 55.25	**53.31**

Na_2O	0.31	0.15	0.07	0.12	0.01	0.07	0.11	0.07	0.21	0.08	0.01 -0.31	**0.120**
K_2O	0.21	0.14	0.02	0.04	0.06	0.01	0.09	0.02	0.08	0.06	0.01 - 0.21	**0.073**
P_2O_5	0.09	0.06	0.03	0.05	0.05	0.08	0.05	0.12	0.03	0.02	0.02 - 0.12	**0.058**
LOI	42.62	42.71	43.05	42.96	42.40	43.08	42.88	43.18	42.18	41.12	41.12 - 43.18	**42.18**
Total	99.67	99.49	99.34	99.76	99.65	99.69	99.59	99.63	99.64	99.76	99.40 - 99.76	**99.63**

Source: Jimoh *et al (2015)*

Table 3. The Mean of the Wt % of the Major Element Oxides of the Ekinrin Adde Marble

Sample No	SiO_2	Al_2O_3	Fe_2O_3(T)	CaO	MgO	K_2O	Na_2O	LOI	Total
1.	2.15	0.62	0.61	51.73	1.56	0.16	0.17	43.01	100.01
2	2.34	0.33	0.5	50.99	1.62	0.15	0.19	43.52	99.64
3	18.57	3.59	1.18	40.23	1.64	0.23	0.27	33.87	99.58
4	1.02	0.63	0.46	52.72	1.53	0.15	0.21	42.94	99.66
5	0.39	0.43	0.45	53.06	1.51	0.15	0.19	43.61	99.79
6	4.37	1.38	0.57	51.36	1.54	0.15	0.18	40.33	99.88
7	4.67	1.64	0.47	50.36	1.54	0.15	0.19	40.93	99.95
8	0.78	0.30	0.44	53.54	1.53	0.14	0.19	42.69	99.61
9	0.65	0.44	0.46	53.08	1.52	0.15	0.18	43.27	99.75
10	17.37	4.04	1.35	40.17	1.62	0.17	0.23	34.83	99.78
11	3.62	1.14	0.45	52.17	1.56	0.15	0.18	40.27	99.54
12	1.98	0.70	0.45	52.29	1.55	0.15	0.19	42.72	100.03
13	0.37	0.39	0.42	53.77	1.52	0.14	0.19	42.89	99.69
14	0.58	0.29	0.46	53.51	1.5	0.14	0.18	43.36	100.02
15	3.39	0.36	0.59	51.08	1.52	0.13	0.16	42.53	99.76
16	1.31	0.53	0.56	53.01	1.56	0.16	0.19	42.72	100.04
17	2.34	1.25	0.48	51.97	1.61	0.13	0.17	42.01	99.96
18	2.21	1.13	0.54	52.16	1.57	0.13	0.16	42.01	99.91
19	1.68	0.63	0.4	52.57	1.53	0.15	0.18	42.88	100.02
20	2.27	0.59	0.61	51.85	1.58	0.13	0.19	42.76	99.98
Mean	**3.60**	**1.02**	**0.57**	**51.08**	**1.56**	**0.15**	**0.19**	**41.66**	**99.83**

Source: Onimisi *et al.*(2017)

The standard S.R, A.R and L.S.F of a typical cement Kiln feed (Bleuoide) are given as:

$$S.R = \frac{(SiO_2\%)}{(Al_2O_3\%) + (Fe_2O_3\%)}$$

$$A.R = \frac{(Al_2O_3\%)}{(Fe_2O_3\%)}$$

L.S.F =100 (CaO %)
2.8 (SiO_2%) +1.2 (Al_2O_3) +0.65Fe_2O_3

The recommended S.R., A.R. and L.S.F ranges in marble/limestone used in modern cement clinker are (2.3 – 2.7), (1.0 – 2.5) and (92 -98%) respectively (Winter, 2012).

Table 4: A comparison of S.R., A.R and L.S.F ranges for Obajana and Ekinrin Adde with Recommended S.R., A.R and L.S.F ranges for Cement Production

	Obajana Marble	Ekinrin-Adde Marble	Recommended S.R., A.R and L.S.F (Winter, 2012)
S.R.	5.37	2.26	2.3 – 2.7
A.R.	2.13	1.79	1.0 – 2.5
L.S.F	940	438	98 – 103

The table above shows that the S.R. and the L.S.F of the Obajana marble do not fall within the recommended ranges for Portland cement production while in the Ekinrin Adde marble, the L.S. F does not fall within the recommended range for Portland cement production. To meet the recommended range for Portland cement production, the S.R and the L.S.F of the cement kiln feed for Obajana marble and the L.S.F for Ekinrin – Adde marble respectively will have to be adjusted. The L.S.F value of the marble can be adjusted to fall within the recommended range required for a typical cement kiln by blending the marble with suitable proportions of clay and laterite to supply SiO_2 and Al_2O_3; and Fe_2O_3 respectively (Panda, 2016). The adjustment is done to obtain the desired ratio of S.R and. L.S.F.for Obajana cement clinker to fall within 2.3– 2.7 and 98 - 103respectively and L.S.F for Ekinrin – Adde cement clinker to fall within 98 – 103.

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