MINERALOGICAL AND CHEMICAL COMPOSITION EVALUATION OF LIGNITE COAL FROM IHIOMA ORLU, IMO STATE OF NIGERIA.

BY

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Abstract: -

A sample of Ihioma lignite coal in Orlu Local Government Area of Imo Stat, Nigeria, was analyzed to finding its chemical and mineralogical composition using particle size distribution, XRD-EDS, proximate, ultimate, mineral composition analysis. Particle size distribution recorded less than 1% values with mesh size of the sample, the proximate analysis recorded 6.0%,4.0%,38.5%,51.5% of moisture, ash content, volatile matter and fixed carbon, while ultimate analysis recorded 2.0%,4.0%,1.064%,64.6% of oxygen, hydrogen, nitrogen and carbon respectively. The mineral composition indicated 20.5% sodium and 6.6% of silicon as highest composition while 0.3% sulphur and 0.43% aluminum recorded lowest mineral composition of the coal sample. Also 70.81% of FeO_3 and 68.0% of CaO_3 chemical compositions were fully distributed, while 0.01% of TiO_2 and 0.04 of K_2O were relatively less distributed in the coal sample. The mineralogical analysis showed the presence of hematite as the major mineral while quartz, albite and trace metals of metakaolin were noted as minor minerals in the sample. This coal has index evaluation maturity, quality potential, environmental friendliness and ignition characteristics. It can also be useful in many ways such as in ceramics, pottery, and in manufacturing of ornamental stones.

Keywords: *composition, mineralogical, sample, Lignite, chemical, coal.*

INTRODUCTION

Coal is one of the most important non-renewable natural local energy carrier mineral resources .It can contribute significantly to the economic growth of any nation. Coal is the largest and most wide spread fossil fuel resource providing 23% of the world's energy. [8]

It is classified by ranks which is a measure of the amount of alteration it has undergone during formation. Consecutive stages in evolution of rank from the initial peat stage are: brown coal (Lignite), sub-bituminous coal, bituminous coal and anthracite. Sub-bituminous coal, bituminous coal and anthracite are known as black coal. [7]

This research made it possible to have in details, the characterization of Ihioma coal, which is the lowest rank of coal with low energy content and relatively a geologically young coal deposits that were not subjected to extreme heat or pressure [5]. This type of coal is crumbly and has high moisture content which has 25% – 35% carbon and heat value of about 4,000 and 8,300 BTU – per pound. It is a brown coal with lot of moisture content. But unlike other types of coal like sub-bituminous which has carbon value of above 35–45% and has been subjected to extreme heat that gives it lowered sulphur than others. [10]

This research work is to determine the chemical evolution composition of bituminous coal from Ihioma. This scope is limited to the coal deposit of Ihioma Orlu in Imo State. Representative samples of this coal was collected and stored in polythene bags prior to analysis. Proximate, ultimate, particles size distribution methods of analysis was carried out on each coal sample in triplicate order. Mineralogical determination of the coal samples was determined in triplicates and the mean values were being recorded. The aim of this research is to determine the mineralogical composition of the lignite coal sample, to use the information obtained on the mineral composition, proximate and ultimate analysis in understanding , reactivity or dissolution rate which gives high ignition characteristics at temperature as low as 40^{0c} and to recommend possible use of this Ihioma coal.

Materials and Methods

The coal samples used in this study were collected from Ihioma mines in Orlu Imo State and the following materials are useful during the course of the experimental work: Paraffin oil, Bomb calorimeter Set of sieves, Oven driver (model: Mino/50),Cellulose flask binder, Pelletizing machine, Desiccator, Grinding device, Weighing balance, Atomic Absorption Spectrophotometer (AAS), X-Ray Diffraction Machine (XRD)model DY674, Energy-Dispersed X-ray Fluorescence machine (ED-XRFS) Model MINIPAL 4, Volumetric flasks, Fume chamber, Distilled water, Hydrochloric acid, Nitric acid, Heating device, Hydrofluric acid, Sulphuric acid.

Methods

2Kg of Ihioma Coal were obtained from Orlu in Imo state Nigeria and were air dried to remove loose moisture content and was ground to a fine powder. The powder was then sieved through a 600, 300, 250, 212, 180 and 150µm test sieves to obtain the finest size micron for analysis. The powdery coal was then analyzed using ASTM approach for proximate and ultimate analysis. Statistical evaluation was also performed. The chemical composition was determined using XRF and mineral distribution using XRD. All Analyses were based on previously reported procedures for coal analyses [14] [15].

Proximate analysis

The proximate analysis was determined using American Society for testing and Materials; ASTM 3286, ASTM 3175, ASTM 3174, ASTM 3173 for volatile matter, ash content and moisture content. The fixed carbon content was determined by calculating the ash percentage and subtracting it from volatile matter and moisture content from 100 [17] [16]

Ultimate analysis

2g of the sample was passed through the 180um sieve for ultimate analysis in an elemental determining device. The determination of carbon and hydrogen contents was done using Seylers formulae:

$$\% \text{ Hydrogen} = 0.069 \left(^{Q}/2.3 + VM\right)$$

$$\% \text{ Carbon} = 0.59 \left(^{Q}/2.3 - 1.1 \times {}^{VM}/3\right) + 43.4$$

Q and VM are the gross calorific value (MJ/Kg) and percentage of volatile matter respectively. The oxygen and nitrogen contents were calculated on air-dried mass bases using equation below:

% Oxygen = 100 (carbon + hydrogen + nitrogen + sulphur) % [17, 18].

XRD Analysis

The powdered coal obtained from 180µm was fired at 1000^{oC} for 2 hours and the ash obtained was analyzed using XRD at Step 0.020, Cnt Time was 0.600 Seconds, Range at 5.00-60 (degree) and scan rate was 2.00 Deg/Min.

Results and Discussion

The data collection and analysis of results conducted in this research were carried out in a highly scientific research development centre in accordance with all quality control measures kept in place to having results that will be acceptable globally. Pymotech Research Centre and Institute of Materials and Research, University of Michigan, United States of America. These laboratories were equipped to conduct Scientific Research Development and training as Environmental consultants.

Table 1: Particle Size Distribution – Ihioma Coal Sample

MESH SIZE (µM)	WEIGHT FRACTION RETAINED (G)	COMMULATIVE WEIGHT FRACTION RETAINED (G)	CUMULATIVE FRACTION PASSED (G)
600	0.160	0.161	0.839
300	0.402	0.563	0.437
250	0.14	0.70	0.299
212	0.067	0.767	0.233
180	0	0.767	0.233
150	0.065	0.832	0.168

Particle size distribution of Ihioma coal shows that all values used with the mesh size (um) indicates values that are less than 1%.This gives a knowledge of combustion arising from it because oxidation reaction occurs faster inside the grain. The ignition properties of this coal are as a result of its single particles size distribution when exposed to a hot oxidizing environment, ignition occurs. [11]

Table 2 : Proximate Analysis of Ihioma Coal

This result indicates that the moisture content is 6.0% which corroborate the order of maturity of this coal sample. The

PARAMETERS	UNITS	VALUES
MOISTURE	%	6.0
ASH CONTENT	%	4.0
VOLATILE MATTER	%	38.5
FIXED CARBON	%	51.5

moisture content and volatile matter which is 38.5% is the index for evaluating the maturity, quality and potential application of different coal. The ash content is used to determine the slagging potential of coals during thermal conversion [2]. So ash content reportedly affects the composition, volume and performance of blast furnace. With 4.0% result gotten, it shows that Ihioma Coal has better fouling potential. The 51.5% fixed carbon indicates solid residue leftover after devolatization and it's used to estimate the amount of coke obtainable from coal carbonization. It shows that Ihioma Coal has coke potential. [1]

Table 3: Ultimate Analysis of Ihioma Coal

PARAMETERS	UNITS	VALUES
OXYGEN	%	2.0
HYDROGEN	%	4.0
NITROGEN	%	1.064
CARBON	%	64.6

Carbon and hydrogen possess high percentage content while nitrogen and oxygen has low values during this elemental analysis. The values of 64.6% and 4.0% values gotten in carbon and hydrogen respectively are significantly related to the maturity (rank). [3] The 1.064% value of Nitrogen gotten indicates the environmental friendliness of this fuel relative to potential NOx pollutant emissions. Sulphur content is 0.3% showing at reduced percentage. Because of its low value, this helps the use of this coal in future for steel manufacturing and reduction of potential environmental pollutants. [6]

Table 4 : Mineral Composition of Ihioma Coal

This indicates that silicon and sodium has 20.5% and 6.6% values respectively than the other mineral gotten in this coal

PARAMETERS	UNITS	VALUES
CALCIUM	% OXIDE	0.08
SODIUM	% OXIDE	6.6
POTASSIUM	% OXIDE	0.05
IRON	% OXIDE	0.85
SULPHUR	% OXIDE	0.3
ALUMINUM	% OXIDE	0.43
MAGNESIUM	% OXIDE	0.08
SILICON	% OXIDE	20.5
PHOSPHORUS	% OXIDE	0.0007

sample, which shows that this coal is still a young one because other constituents are not evenly distributed. [9]

Table 5: Chemical composition of Ihioma coal ash by ICP (wt%) is stated as follows:

Metals	weight (wt%)
SiO_2	8.23
N_2O_3	14.73
FeO_3	70.81
CaO_3	68.0
MgO	0.06
Na_2O	0.02
K_2O	0.04
TiO_2	0.01

This shows that FeO_3, 70.81%, Al_2O_3, 14.75%, and CaO 3.68%, all in (wt%) are widely distributed minerals found in this coal sample while MgO,N_2O,K_2O and TiO_2 were relatively less significant or are not even distributed.

Plate 1: XRD OF IHIOMA COAL POWDER SHOWN AMORPHICAL FEATURE

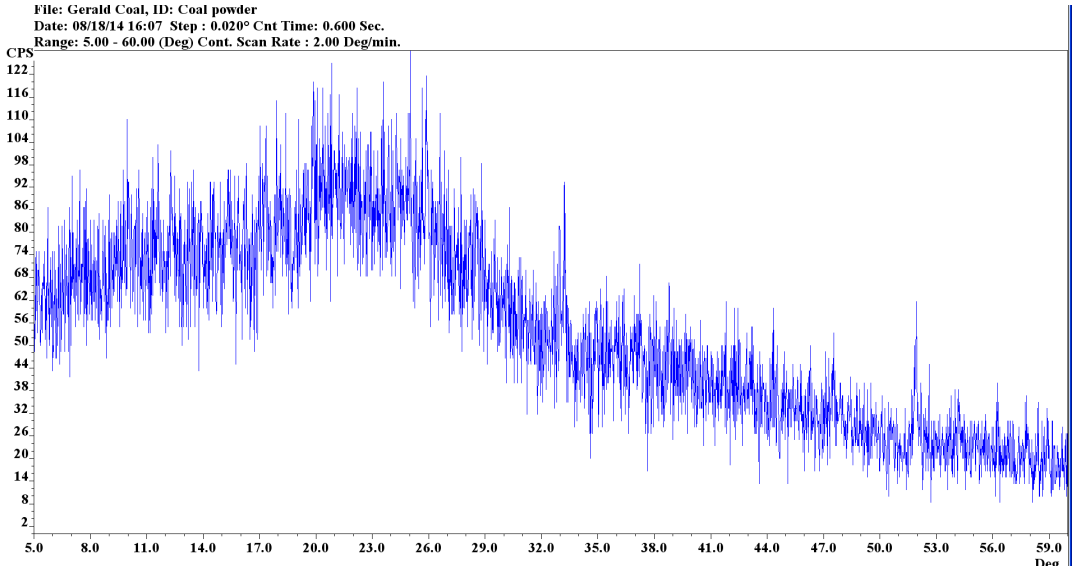
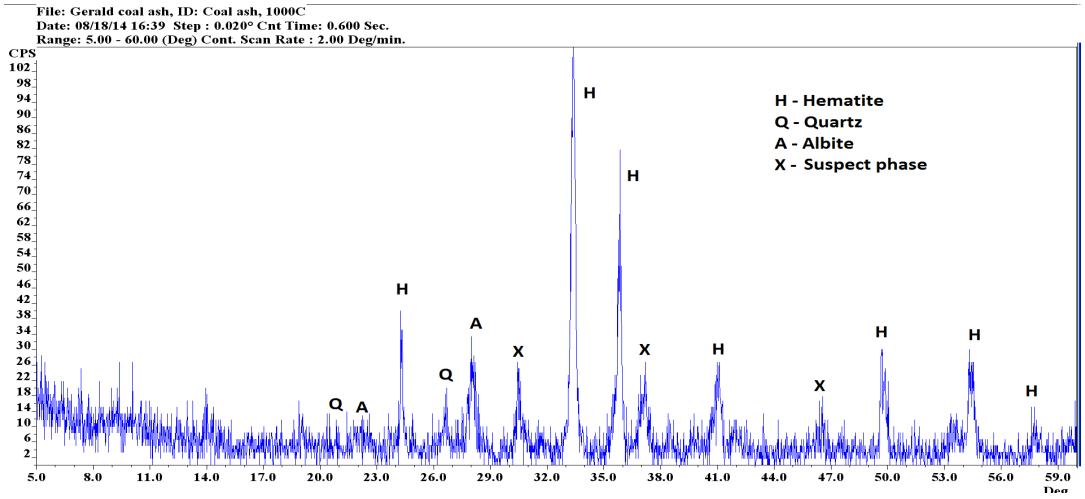
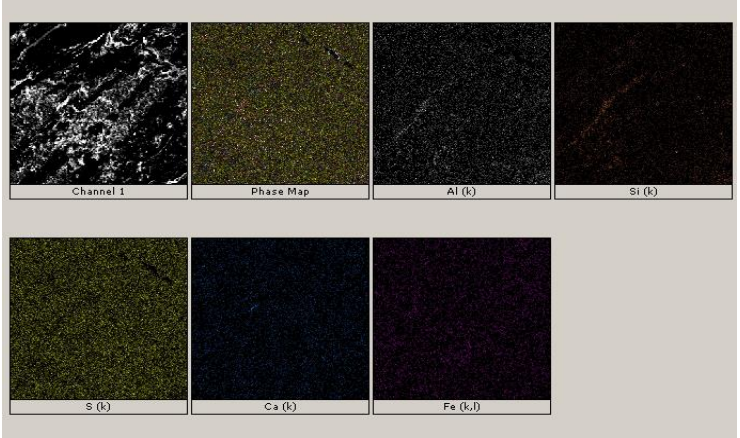


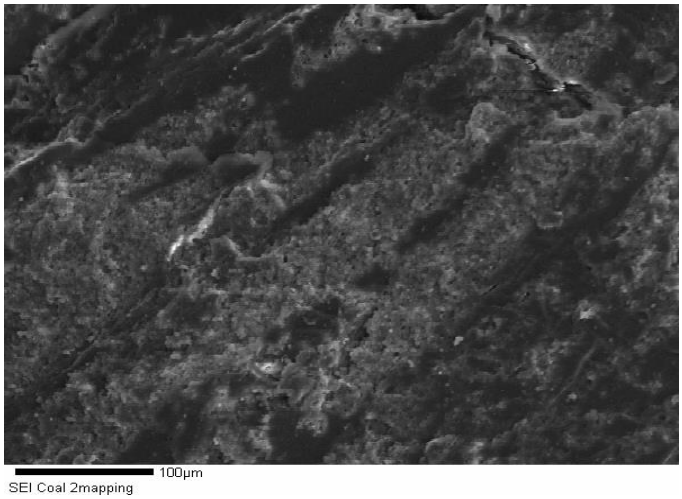
Plate 2 : XRD – IHIOMA COAL ASH



Coal powder was fired at 1000°C for 2 hours; the resulted ash was analyzed by XRD. Major mineral: hematite Minor minerals: albite, quartz, and a suspected phase (may be metakaolin)

Plate 3: X-Ray Mapping Of Ihioma Coal Showing: Al, Si Distributed Along With the Dark Strips, but S, Ca, and Fe Are Not Distributed





CONCLUSION

From the results above (proximate analysis), the moisture content is 6.0% which is disadvantageous because it decreases system capacity and increases operational cost. Corroborate the order of maturity of this coal sample (Ihioma) with 38.5% volatile matter which indicates the index for evaluating the maturity, quality and potential application of this coal. Ihioma coal has Ash content of 4.0% which gives it better fouling potential because it affects the composition, volume and performance of blast furnace Ihioma coal has 51.5% fixed carbon which indicates solid residue left-over after devolatization and it's used to estimate the amount of coke potential exhibited by this coal. [3]

Ultimate analysis of this sample shows that carbon and hydrogen possess high percentage content while Nitrogen and oxygen has low values during this elemental analysis. The values of 64.6% and 4.0% values in carbon and hydrogen respectively are significantly related to the maturity (rank) of this coal from Ihioma. The 1.064% value of Nitrogen indicates the environmental friendliness of this fuel relative to potential NOx pollutant emissions. [12]

Mineral composition of Ihioma coal which has only sodium (6.6%) silicon (20.5%) indicates that their contents are still in its lignite form. Particle size-distribution of Ihioma Coal in mesh size (µM) shows that cumulative fraction passed in grams are all less than 1g, indicating that particle size are well distributed with a result that it's appearance, reactivity or dissolution rate is high resulting to ignition characteristics which ignites at temperature as low as 40^0C. [14]
Ihioma coal as we have known to be in lignite form has features of ignition. This coal has or may have factors which cause spontaneous combustion, such is if the larger the grain, the harder it is for the heat arising on the inside to be dissipated to the outside and the higher the ambient temperature, the faster the oxidation reaction and the greater the heat released inside the grain. [20] It is important to know of this lignite coal so as to prevent spontaneous ignition. Ignition of particles clouds is additionally complicated by antiparticle radiation effects. When a single particle of this lignite coal is exposed, to a hot oxidizing environment, ignition occurs. From the layered coal structure it was noted that coalification of this Ihioma coal was not complete because its development ended at lignite stage; the degree of coalification is known as 'rank of coal' because it progressively increases from lignite low rank coal to high rank coal, also the carbon content increases while the reactivity decreases [19]. This shows that maybe some factors needed to improve this Ihioma coal did not occur. The XRD analysis shows metals identified as Hematite as its major mineral found which is mostly reddish and brown in colour with slight amount of titanium $(FeT_1)_2O_3$. It's about 70% Iron,

which helps as pigment for paints, glazes, facial and body decoration, helps in healing blood-related disorders. It also identified Quartz which is colourless with black brownie part of granite. It has resistance to weathering, enhances absorbing energy, amplifying and transmitting signals while Albite also shown as Sodium aluminum silicate appears white or colourless, cream or light yellow, light brown used in manufacture of ceramics, pottery, and manufacture of ornamental stones. [18]

RECOMMENDATION

Nigerian's goal is to revitalize the coal mining industry and expand power generation by attracting foreign companies to develop these larger coal resources and construct coal – fired generating plants, which can be converted into country's electrical distribution grid. This will generally boost reliable electricity supply, however cost electrical energy and expand industrialization of the economy, increase employment, and also human resources development. These are just but few measures in addition to what we ought to do to revive the coal industry which has collapsed wholly, the abundant coal deposit at various seams of most lands in Nigeria should not be allowed to waste or remain untapped. The time is set to arise and device the energy which is in our coal

Our recommendations at this stage is based on findings from evaluation of quality composition of Ihioma coal, which centers on solving the effective need of brown coal as follows: Brown coal of Ihioma can be used to produce lower quality products such as synthetic crude oil. Further processing may be used to produce fuel oil, motor fuel blends and heating oil. It is also advised that non-fuel products may be produced including solvents, polymers etc. Finally, lignite coal of Ihioma is geologically with highest moisture and mineral content with environmental friendliness as fuel relative to potential NOx pollutant emissions, but although this coal has deposits not in commercial use, there is also need for government and private sectors to utilize this coals improved opportunities because of its characteristics composition and characterization which gives their proven usefulness.

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