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Characterization of Diatomite from Bularafa in Gulani Local Government Area of Yobe State, Nigeria

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***Abstract**:* Diatomite, a distinctive sedimentary rock composed of fossilized diatoms, was systematically investigated in the context of the Bularafa region within Gulani, Yobe State, Nigeria. Employing quantitative elemental and mineral analysis facilitated by X-Ray Fluorescence (XRF) and X –Ray Diffraction, the study delves into the composition and properties of the diatomite, with a specific emphasis on its potential applications in filtration, agriculture, and manufacturing. The mineral analysis revealed a substantial of SiO_2 and the element Si content of 83.597 wt. %, indicative of the predominant silica composition characteristic of diatomaceous earth. This high silica content positions the Bularafa diatomite competitively on a global scale. Concurrently, the study explored the diverse physical properties, encompassing particle size distribution, specific gravity, porosity, and water absorption. These characteristics highlight the material's versatility and suitability for various industrial applications. Comparative analyses were conducted, aligning the Bularafa diatomite's properties with global deposits, revealing a competitive edge in silica content. This research serves as a comprehensive exploration of the Bularafa diatomite, providing an understanding of its elemental composition and physical properties.

Keywords: Diatomite, X-Ray Fluorescence, X-Ray Diffraction, Elemental Analysis, mineral analysis, Physical Properties.

1. INTRODUCTION

Diatomite is a powdery non-metallic mineral composed of the fossilized skeletal remains of microscopic single celled aquatic plants called diatoms. It is chalk-like, soft, friable, earthy, very fine grained, siliceous sedimentary rock, usually light in colour (white if pure, commonly buff to gray in situ, and rarely black). It is very finely porous, very low in density and essentially chemically inert in most liquids and gases. It also has low thermal conductivity and a rather high fusion point. (Dolly, 2000). In commercial applications, the silica content is usually over 86% and may be as high as 94%, and the skeletal structure can contain up to 80% to 90% voids. The honeycomb silica structure gives diatomite useful characteristics such as high absorptive capacity and surface area, chemical stability, and low bulk density (Robert, 2018)

Diatomite, a naturally occurring sedimentary rock, exhibits distinctive chemical and physical properties that make it a valuable resource. In terms of its chemical composition, diatomite comprises approximately 89.7% silicon dioxide (SiO_2), with additional constituents such as 1.09% iron oxide ($Fe2O_3$) and 3.72% aluminium oxide ($Al2O_3$). The Loss on Ignition (LOI) for diatomite is measured at 3.70%. In the realm of physical characteristics, diatomite is available in various granule sizes, ranging from fine-grained powder (0.5mm-2mm) to small-grained (2mm-7mm), medium-grained (7mm-15mm), and large-grained (15mm-25mm). Noteworthy physical constants include a molecular weight of 60.1, a boiling point of 4046ºF (2230ºC), and a surface area of 10-20 sq.m/g. Diatomite possesses a specific gravity of approximately 2.20, a bulk density of around 0.4, and a loose weight of approximately 7.5 lbs./cu.ft. The nominal color of diatomite is buff white, with a pH level of around 5.7 and a moisture content of approximately 6%. These properties collectively contribute to the diverse applications of diatomite across various industries.

Diatomite has several uses due to its porosity, diatomite has been used extensively as a filter for a variety of uses. It is used to filter impurities out of everything from beer and wine to oils and greases. Similarly, diatomite is used to filter impurities from water to produce safe drinking water in public water systems. It is known for removing bacteria and protozoa in water. (Minarals Information Institute, 2011) It is a very mild abrasive as such it has been used for long in toothpaste and metal polishes. It is also applied in paper, paint, brick, tile, ceramics, plastics, soaps, detergents and other products as a filler. A filler is a substance that increases the volume of a product and/or fills in space. It is also used in insecticides and pharmaceutical products. Diatomite is also used in the making of insulating material in high-temperature application like furnaces and boilers. It has also proven effective as a good refractory material.

The exploration and characterization of diatomite deposits in Nigeria, particularly in the Bularafa region of Gulani Local Government Area, Yobe State, remain relatively unexplored. This study aims to fill this research gap by looking into the characterization of diatomite from Bularafa. Bularafa is an administrative subregion in Gulan in Yobe, Nigeria. Characterization of diatomite involves studying its physical, chemical, and mineralogical properties. These properties provide insights into its potential industrial applications, such as in filtration, agriculture, manufacturing, and more. Characterization describes those aspects of composition, structure and the defects that made up a material which are very important for a specific processing, investigating the properties or applications and remaking of the material.

The aim of this study is to carry out the quantitative elemental analysis of the material obtained in the study area and to explore it potential industrial applications. In order to achieve this, an X-Ray Florescence (XRF) was used to quantitatively analyse the elemental composition of diatomaceous earth obtained in the study area. This information is the basic in the characterization of a material in order to determine methods of processing, development and possible areas of application. The paper is very significant due to the fact that the development of a mined material speeds up economic development and create jobs for the teaming population. The paper also involves analysing these properties to understand its quality, suitability, and potential industrial applications. It provides valuable information to researchers, engineers, and industries interested in utilizing diatomite as a raw material

2. 0 Material and Method

Diatomaceous earth samples were excavated from Bularafa in Gulani Local Government Area of Yobe State. Tools deployed in the process include diggers and shovels. Samples were collected from various locations within the study Area. Care was taken to ensure representative sampling from different depths and geological formations. Polythene sack was used to package and transport the materials. The material was having high moisture content as of the time of acquisition and was immediately sun dried to remove the moisture. After drying the material was pulverized using hammer mill.

The pulverized material is now adopted as the valid gross sample and from it the laboratory samples were produced. The research intends to look at the in-situ characteristics of the material before any further processing. The analytical report was based on the dried weight basis. A Nitron 3000 Analyser of Thermoficial scientific make was used for XRF analyse the samples. A Rigaku MiniFlex 600 X-ray Diffractometer was used for the X-Ray Diffraction of the sample.

3.0 RESULTS AND DISCUSSION

3.1 Mineral Compositions of the Diatomite Sample

X-ray diffraction (XRD) was used to determine the presence and amounts of minerals species in the sample, as well as identifying their phases present The X-ray diffraction (XRD) results for diatomite in Gulani reveal a predominant presence of SiO_2 (Silicon Dioxide) at a concentration of 83.597 wt.% as depicted in Table 1, corresponding to a mole percentage of 88.960. This high silicon content aligns with the expected composition of diatomite, a sedimentary rock primarily composed of the fossilized remains of diatoms, which are rich in silica. The substantial concentration of SiO_2 suggests that the diatomite sample in location Y is consistent with the typical mineralogical makeup of diatomaceous earth.

In addition to silicon dioxide, the analysis identifies the presence of various metal oxides and trace elements in the diatomite sample. Notably, iron oxide (Fe_2O_3) is present at 6.027 wt.%, with a mole percentage of 2.413. The significant concentration of iron oxide might indicate the presence of iron-rich minerals or impurities within the diatomite. Understanding the mineralogical composition is crucial, as it can impact the physical and chemical properties of the diatomite, influencing its potential applications in various industries.

The presence of other metal oxides, such as CaO (Calcium Oxide), K_2O (Potassium Oxide), and $Al2O_3$ (Aluminium Oxide), adds complexity to the diatomite composition. These elements can contribute to the overall reactivity, stability, and mechanical properties of the material. The concentration of aluminium oxide (5.588 wt.%) is noteworthy, as aluminium compounds can influence the adsorption and catalytic properties of diatomite, potentially impacting its applicability in water treatment or other industrial processes.

Table 1: Components of Diatomite in Gulani

Component	Concn.	Error	Units	Mole%	Error
SiO_2	83.597	3.244	wt.%	88.960	3.452
V_2O_5	0.114	0.028	wt.%	0.040	0.010
Cr_2O_3	0.019	0.017	wt.%	0.008	0.007
MnO	0.036	0.015	wt.%	0.032	0.014
Fe_2O_3	6.027	0.091	wt.%	2.413	0.036
Co_3O_4	0.014	0.028	wt.%	0.004	0.007
NiO	0.008	0.014	wt.%	0.007	0.012
CuO	0.064	0.012	wt.%	0.051	0.010
Nb_2O_3	0.005	0.025	wt.%	0.001	0.007
MoO_3	0.004	0.032	wt.%	0.002	0.014
WO_3	0.007	0.047	wt.%	0.002	0.013
CaO	1.788	0.128	wt.%	2.039	0.146
K_2O	0.735	0.116	wt.%	0.499	0.078
Al_2O_3	5.588	5.977	wt.%	3.504	3.748
Ta_2O_5	0.020	0.046	wt.%	0.003	0.007
TiO_2	1.034	0.068	wt.%	0.827	0.055
ZnO	0.032	0.010	wt.%	0.025	0.008
Cl	0.864	0.118	wt.%	1.559	0.213
ZrO_2	0.044	0.022	wt.%	0.023	0.012

The detection of trace elements like V_2O_5 (Vanadium Pentoxide), Cr_2O_3 (Chromium (III) Oxide), and others, though present in relatively low concentrations, may have implications for specific applications where these elements play a crucial role. The results provide valuable insights for researchers and industry professionals interested in exploiting the unique properties of diatomite for purposes ranging from filtration and adsorption to catalyst support. It is essential to consider the uncertainties associated with the concentration values, as indicated by the reported errors. These uncertainties highlight the need for caution in drawing definitive conclusions and may guide further investigations to refine the understanding of the diatomite's composition in location Y. In summary, the XRD results contribute significantly to the characterization of diatomite, laying the foundation for informed utilization and further research in diverse industrial and scientific fields.

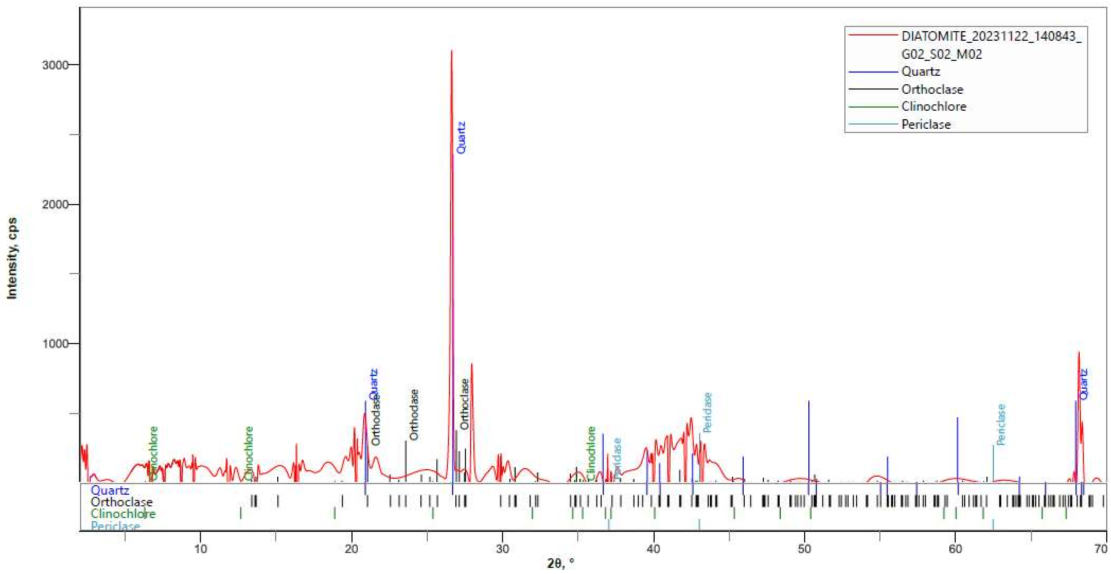

Figure 1.0 Gulani Diatomite profile

Summarily, the XRD peaks indicate the coexistence of different mineral phases in the diatomite, with Quartz and Clinochlore being the major components as shown in Figure 1. The presence of unknown phases underscores the complexity of the sample and may warrant further investigation to identify and characterize these components accurately. The information provided in the table is valuable for understanding the crystalline nature and composition of the diatomite in Gulani.

3.2 Chemical Properties of the Material Sample

An X-Ray Florescence (XRF) was used to reveal the details of the chemical composition of the sample. The result is presented in figure 2.0. Silicon has the highest atomic concentration of 85.08 and weight concentration of 83.38. It is followed by Aluminium with atomic concentration of 6.02 and atomic weight of 5.67. other constituent of the material include Iron, sodium, phosphorus, magnesium ,sculpture, chlorine, titanium, calcium and potassium.

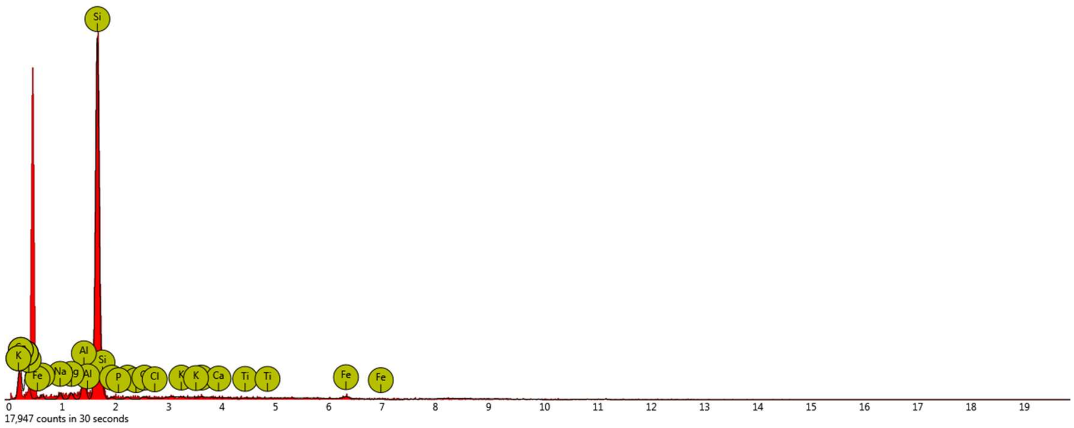

Figure 2.0 Bularafa Diatomite XRF result.

3.3 Microstructure of the Diatomite sample

The microstructure of the sample is presented in figure 2. It shows the white shapes of the diatoms across the surface, the closely packed spheres of silica being arranged in three dimension.

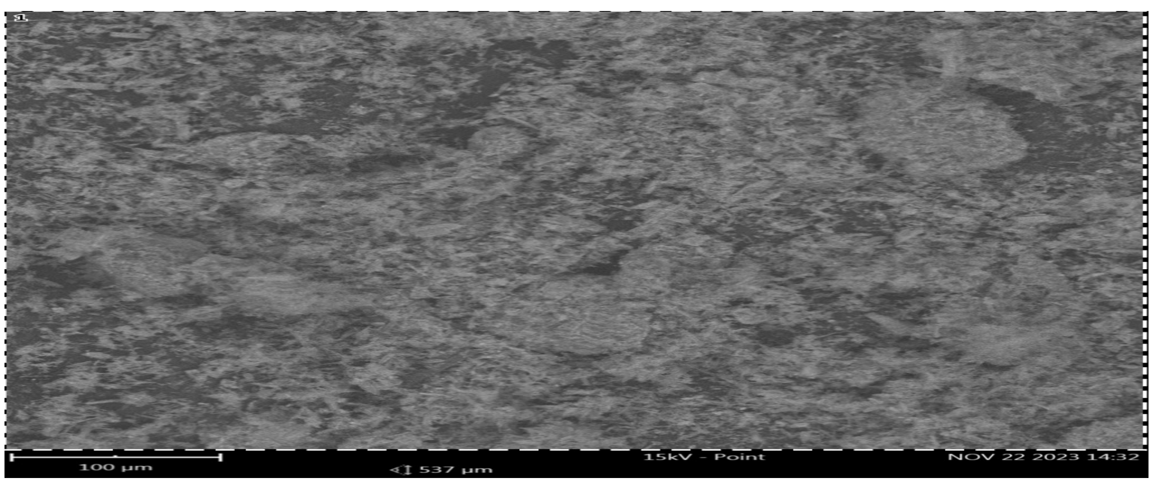

Figure 3.0 Microstructure of the diatomite sample

3.4 Physical Properties

The physical properties of the diatomite samples were assessed through various tests, including particle size distribution, specific gravity, porosity, and water absorption. The particle size distribution analysis indicated that the diatomite particles were predominantly in the range of fine to medium-sized particles, which is desirable for many industrial applications. The specific gravity values ranged from 2.0 to 2.3, indicating a relatively lightweight material. The porosity of the diatomite samples was found to be high, ranging from 50% to 70%, which indicates their ability to hold a significant amount of liquids or gases. The water absorption capacity of the diatomite was also determined, and the results indicated excellent water-holding capabilities.

3.5 Industrial Applications

The characterization results revealed that the diatomite from Bularafa in Gulani Local Government Area of Yobe State possesses favourable properties for various industrial applications. The high silica content makes it suitable for use as a raw material in the production of silica-based products, such as glass, ceramics, and refractories. The fine to medium-sized particle distribution and high porosity make it suitable for use as a filtration medium in water treatment, beverage processing, and pharmaceutical industries. The water absorption capacity suggests potential applications in moisture control, absorbents, and catalyst supports.

3.4 Comparison with Other Diatomite Deposits

The characterization results of the Bularafa diatomite can be compared with diatomite deposits from other regions. Although variations in mineralogical composition and physical properties may exist, the high silica content and unique frustule structures are common features among different diatomite deposits. The Bularafa diatomite can be considered as a valuable resource due to its high-quality silica content (84%) and favourable physical properties.

Table 2: Basis of comparison with samples across the world

Sample	**SiO_2**	**Al_2O_3**	**F_2O_3**	**CaO**
China	82.95	5.75	1.41	0.24
Turkey	76.8	7.25	3.85	-
Egypt	83.6	4.24	1.07	6.17
Algeria	72.1	5.3	3.8	7.2
Jordan	725	11.42	5.8	1.48
Bularafa	83.597	5.588	6.027	1.788

Source: (Angela Danil De Namor, 2012)

3.5 Implications and Future Research

The characterization of diatomite from Bularafa in Gulani Local Government Area of Yobe State provides valuable insights into the properties and potential applications of this specific diatomite deposit. The results highlight the importance of this natural resource in various industries and suggest potential economic benefits for the local community. Further research can focus on exploring the thermal stability, mechanical properties, and specific applications of the Bularafa diatomite, as well as its beneficiation techniques for improving its purity and suitability for specific industrial uses. In conclusion, the characterization results demonstrate the significant potential of the diatomite from Bularafa, Gulani Local Government Area of Yobe State, Nigeria, and warrant further investigation and exploration for its utilization in various industries.

4. CONCLUSION

Chemical Characterization of Diatomite from Bularafa in Gulani Local Government Area of Yobe State, Nigeria. It was found that there is high silica content of about 92% justifying its quality and need for further research. The analysis has also revealed the impurities present in the deposit suggesting ways of beneficiation of the deposit in order to improve the quality of the product. Investment in the exploration of the deposit will bring about job creation and industrial and economic development. Comparison of silica content with other deposits around the world shows that the silica content is highly competitive.

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