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STUDIES ON THE INDUSTRIAL APPLICATIONS OF LIMESTONE SAMPLES FROM THREE GEOGRAPHICAL REGIONS IN NIGERIA: ASHAKA, MFAMOSING, AND NKALAGU

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ABSTRACT

The chemical properties of limestone have been the subject of several studies in recent years, highlighting its importance in various industrial applications. The present study focuses on six limestone samples from three geographical regions in Nigeria (Ashaka, Mfamosing, and Nkalagu). The analyses of their chemical composition using the Loss on Ignition Test and X-Ray Fluorescence Spectrometry was successfully carried out. Results of the study show that CaO is the main component, comprising between 60.054 % and 78.632 % of the samples. Values of Loss of Ignition (LOI) ranged from 30.820 % to 33.280 % while SiO_2 composition ranged between 5.095 % to 12.238 %. Other oxides detected, include Al_2O_3 and Fe_2O_3, which make up less than 1 % of the composition. Obtained values were compared to Limestone standards for various industries and findings indicate that the Ashaka, Mfamosing, and Nkalagu limestone samples are of high purity and suitable for use in various industrial fields, including the steel industry, manufacture of bleaching powder, manufacture of calcium carbide, sugar industry, textile manufacture, cement industry, agricultural practice (soil liming), and flue gas desulphurization. Thus limestone deposits from Ashaka, Mfamosing, and Nkalagu has more potential and application uses beyond cement production which they are currently used for.

Keywords: Limestone, Ashaka, Mfamosing, Nkalagu, Industrial application.

INTRODUCTION

Limestone is a highly abundant mineral widely distributed throughout the earth's crust, constituting approximately 4% of its total composition (Hart, 2018). It is a sedimentary rock that is primarily composed of calcium and magnesium (Ayuba *et al*. 2015) and is mostly made up of calcium carbonate ($CaCO_3$) in crystal forms of calcite and aragonite (Azubuike *et al*. 2011; Popoola, 2015). Due to its versatility, limestone has a wide range of industrial applications, including construction, agriculture, and chemical production, which have led to a significant increase in its demand in recent years (De-Souza *et al*. 2017; Siler *et al*. 2018).

Limestone's color can vary from white to gray or dark hues, with white deposits indicating high purity, and different shades of gray and dark hues indicating the presence of carbonaceous materials and iron sulfide (Oats, 2011). However, the quality of limestone can vary depending on the geological structure of the field from which it is mined. Therefore, it is essential to extract limestone from diverse areas of the field to obtain a good ratio and avoid the production of low-quality limestone due to an excess of alkalis (Oates, 2011; Ofulume *et al*. 2018).

Limestone mining is developed based on the geological structure of the field, which involves identifying the location of limestone deposits, the depth of the deposits, and the overburden (Noureddine *et al*. 2016). Once this has been established, the mining process can begin, which typically involves drilling, blasting, and crushing the limestone to produce various sizes of limestone aggregates that can be used for different purposes.

Limestone is commonly used as a construction material, especially in the form of crushed aggregates, which are used for the production of concrete, asphalt, and road base materials (De-Souza *et al*. 2017). Additionally, it is used in the agricultural industry as a soil conditioner to improve soil quality and crop yields (Siler *et al*. 2018). Limestone is also used in the chemical industry as a raw material for the production of various chemicals, including calcium chloride, calcium hydroxide, and calcium carbonate (De-Souza *et al*. 2017).

Furthermore, limestone is a versatile mineral that has numerous industrial applications due to its abundance and chemical properties. Understanding the geological aspects of limestone fields is essential in ensuring the production of high-quality limestone, which can be used in different industries. The demand for limestone is expected to continue growing due to its diverse applications, making it an important mineral for economic development. Nigeria is a country with large deposits of limestone across the various geographical regions that has been used predominantly for the production of cement. Thus, this research aims to explore the potential of limestone deposits in three geographical regions (south-south, south-east and North-east) of Nigeria for other industrial applications.

Study Area

This study examines the chemical composition of limestone deposits obtained from three geographical regions of Nigeria for industrial applications: Ashaka in Northeast Nigeria's Gombe State, Mfamosing in South-South Nigeria's Cross River State, and Nkalagu in Southeast Nigeria's Ebonyi State (see Figure 1).

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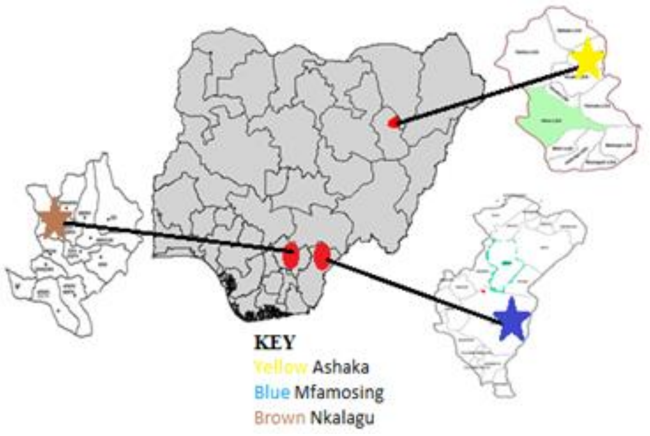

Figure 1: Map of Nigeria showing the three geographical regions limestone deposits were sampled

Ashaka is situated at 10.88°N latitude and 11.52°E longitude in the Funakaye Parish of Gombe state, which falls under the sub-Saharan climatic region with distinct dry and rainy seasons. Gombe receives an average rainfall of 907mm and features Sudan/Guinea savanna vegetation characterized by scattered trees, shrubs, and various grass types (Mbaya *et al*. 2019).

Mfamosing, located at 5°7'N latitude and 8°31'E longitude in the Akamkpa Parish of Cross River state, features diverse vegetation, including lowland forests, freshwater swamps, mangroves, coastal wetland vegetation, mountain forests, and savannah vegetation. Cross River State receives an annual rainfall of 2,600mm (Onojeghuo and Onojeghuo, 2015).

Nkalagu is a town situated at latitudes 6°10'N and 6°40'N and longitudes 7°35'E and 7°50'E in the Ishielu Parish of Ebonyi State. Ebonyi State is known for its large wetlands, and its vegetation is believed to lie within the savanna with a tropical wet and dry climate. The state receives an annual rainfall of 2,000mm (Essien *et al*. 2013: Edewade, 2018)

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Sampling

The sampling procedure for this study adhered to the guidelines provided in ASTM C50/C50M-13, BS 5309: Part 4, BS 812: Part 101, and BS 932: Part 1. Six limestone samples were collected from different locations spanning the northeast, south-south, and southeast regions of Nigeria. The limestone samples were identified as AS1 (Ashaka 1), AS2 (Ashaka 2), MF1 (Mfamosing 1), MF2 (Mfamosing 2), NK1 (Nkalagu 1), and NK2 (Nkalagu 2).

The limestone samples were extracted from quarries situated in the states of Gombe (AshakaCem), Cross River (UniCem), and Ebonyi (NigerCem) in Nigeria. To minimize variations in constituent parts, the sampling points were separated by a distance of approximately 100 meters. Samples were chiseled randomly from ten points at each quarry location, and these samples were mixed to form a representative sample. Labelled ziploc bags were used to contain 1000 grams of the rock samples from each location, and the samples were then shipped to the laboratory for analysis.

Sample Preparation

The limestone samples were analyzed at the Ashaka Cement Laboratory, situated in Funakaye Parish, Gombe State. The preparation of the samples followed the standard procedures outlined in BS 6463: Part 101. The preparation process began with drying the collected limestone sample in an oven at 110 °C for 12 hr to eliminate moisture. Next, 200 grams of the dried sample were finely crushed and ground using a Herzog grinder (model HZ55468) to achieve a fine particle size.

MATERIALS AND METHODS

The study was conducted to evaluate the quality of limestone deposits from Ashaka, Mfamosing, and Nkalagu sites through geochemical analysis. The loss on ignition (LOI) test was conducted using the standard procedure for LOI test analysis (ASTM D7348-13 and BS1744: Part 1). Initially, the muffle furnace (model N534C) was switched on and set to a temperature of 950 °C. Next, a Denver Analytical Balance (Model TP-214) was used to measure ten grams of the limestone sample on a weighing boat. An empty crucible, labeled for sample identity, was then placed on the balance and tared The sample was transferred to the crucible and removed from the balance. The scale was tarred, the crucible with the sample was weighed, and the reading was recorded as M1. The crucible with the limestone sample was placed in the centre of the muffle furnace using the crucible tongs, after which the furnace was closed. After 60 minutes, the sample pan was removed and placed inside a desiccator to cool. Once cooled, the annealed crucible with the limestone sample was weighed again, and the measured value was recorded as M2. The LOI was calculated using the formula $(M1 – M2) * 100$, and the results were recorded.

To further characterize the limestone, the standard procedure outlined in ASTM C1365-18 was employed. The procedure began by weighing 0.4 grams of stearic acid into a steel beaker using a balance. Next, 20 grams of a ground limestone sample were added to the stearic acid, and the mixture was milled together for 60 seconds using a Herzog grinding machine (Model HZ55468). After grinding, the mixture was poured into a steel plate, and 5 grams of the mixture from the steel plate was poured into an aluminum beaker along with one gram of stearic acid. The aluminum beaker was carefully inserted into a pellet-making machine (Herzog Pressing Machine, Model HG58154), and the limestone sample was pelleted, which took four minutes. The limestone sample pellet was then placed in an Axios X-ray Fluorescence Spectrometry (XRF) machine (model A4850) connected to a computer. The analysis took three minutes, and the composition values for the main oxide contained in the limestone were displayed on the screen in terms of weight percentage (%) weight printout.

RESULTS AND DISCUSSION

Table 1 gives the observed shades/color of the limestone samples. The color of limestone deposits comes in different shades (white, gray or dark hue) according to Oates (2011). He elaborated that white deposits signify that the limestone is of higher purity while various shades of gray and dark hue are caused by the presence of carbonaceous materials and iron sulphide in the limestone. Shades of limestone samples obtained from Ashaka, Mfamosing, and Nkalagu revealed that all were hue, gray or dark gray. Hence, they are not of very high purity.

Table 1: Observed shades/color for the limestone samples

Sample ID	Shade/Color
AS1	Hue Gray
AS2	Gray
MF1	Hue Gray
MF2	Gray
NK1	Gray
NK2	Dark Gray

(**Key**: AS1= Ashaka 1, AS2 = Ashaka 2, MF1 = (Mfamosing 1, MF2 = Mfamosing 2, NK1 = Nkalagu 1, NK2 = Nkalagu 2)

Chemical Composition

Chemical composition results of the limestone samples were obtained using XRF instrument and values were presented as percentage weight composition in Table 2. The findings provide valuable insight into the composition and characteristics of the limestone samples, which informs our understanding of their potential industrial applications. The XRF analysis of the limestone samples from Ashaka, Mfamosing, and Nkalagu revealed that the main component of the samples is lime (CaO), which accounts for 60.05 % -78.632 % of the composition. The samples also contain other oxides such as Al_2O_3, FeO_2, SiO_2, MgO, and Na_2O in lower concentrations (≤5 %).

The LOI values as seen in Table 3 for the limestone samples ranged from 30.820 % to 33.280 %, indicating a high volatile component, which suggests a high carbonate content in the samples. The LOI value is important in the analysis of limestone because it provides an indication of the purity of the limestone. The higher the LOI value, the greater the amount of carbonates present in the sample, which means that the limestone is less pure. In contrast, a lower LOI value indicates that the limestone contains fewer carbonates and is therefore purer (Nabavi *et al.* 2011). The LOI value is also used to calculate the chemical composition of the limestone, as the amount of carbonates present is directly related to the amount of calcium oxide (CaO) and other oxides that are present in the sample. This information is important for determining the suitability of the limestone for various industrial applications, such as in cement production, steelmaking, and soil conditioning (Nabavi *et al.* 2011). The presence of Al_2O_3 in the samples confirms the presence of clay minerals in the limestone. The FeO_2 and SiO_2 values of the samples ranged from 0.879 % to 2.271 % and 5.095 % to 12.238%, respectively. These results provide important information on the chemical composition of the limestone samples, which is essential for their industrial applications.

Table 2: Percentage (%) weight compositions results observed from XRF analysis of the limestone samples

Compounds	AS1 (wt%)	AS2 (wt%)	MF1 (wt%)	MF2 (wt%)	NK1 (wt%)	NK2 (wt%)
SiO_2	12.238	7.722	7.806	5.095	10.319	5.333
Al_2O_3	4.798	3.294	2.876	1.926	3.637	2.003
Fe_2O_3	2.271	1.451	1.233	0.127	1.112	0.879
CaO	60.054	70.388	68.320	78.632	64.718	77.646
MgO	0.682	0.704	0.986	1.211	0.876	0.729
K_2O	0.710	0.456	0.542	0.277	0.401	0.221
Na_2O	0.115	0.109	0.102	0.110	0.222	0.125
P_2O_5	0.106	0.027	0.136	0.034	0.050	0.051
Mn_2O_3	0.159	0.203	0.112	0.116	0.060	0.102
TiO_2	0.253	0.184	0.092	0.105	0.213	0.123
Cr_2O_3	0.363	0.252	-0.023	-0.023	0.369	0.297
SO_3	0.513	0.189	0.136	-0140	-0.069	-0.112
Cl^-	0.007	0.007	0.007	0.007	0.006	0.006
$CaCO_3$	90.886	96.682	94.715	98.414	92.845	97.946

(Key: AS1= Ashaka 1, AS2 = Ashaka 2, MF1 = (Mfamosing 1, MF2 = Mfamosing 2, NK1 = Nkalagu 1, NK2 = Nkalagu 2)

Potential Industrial Applications

To determine their potential for industrial applications, we analyzed the limestone samples and assessed them against the standard requirements outlined in Table 4. This table specifies the general criteria that limestone must meet in order to be considered suitable for use in various industrial processes. By comparing our findings to these standards, we were able to gain insight into the viability of the sampled limestone as an industrial resource.

Table 3: Percentage (%) weight compositions of clinker minerals in the limestone samples compared with BS 7979:2020 standard

Compounds	AS1 (wt%)	AS2 (wt%)	MF1 (wt%)	MF2 (wt%)	NK1 (wt%)	NK2 (wt%)	BS Standard (wt%)
LSF	85.039	86.098	85.138	86.009	90.935	434.562	85 - 99
C_3S	54.524	50.121	56.435	56.485	59.283	56.168	50 - 60
C_2S	21.229	23.052	26.286	24.852	20.551	28.670	20 - 30
C_3A	8.873	9.273	9.890	8.580	9.730	8.822	8 - 15
C_4AF	6.910	4.416	0.587	0.587	3.384	2.674	0.5 - 10
LOI	32.150	31.310	30.820	32.850	33.280	31.390	30 - 35

(Key: AS1= Ashaka 1, AS2 = Ashaka 2, MF1 = (Mfamosing 1, MF2 = Mfamosing 2, NK1 = Nkalagu 1, NK2 = Nkalagu 2)

Steel Industry: To be suitable for use in the steel industry, the limestone must meet specific composition requirements, as outlined in ASTM C911-19, Vijayachittra *et al.* (2010), Hasanbeigi *et al.* (2010), and Ibrahim and Abdelmonem (2020). Specifically, limestone used in this industry should contain at least 52% CaO, less than 6% SiO_2, less than 3% $Al2O_3$, less than 3% FeO_3, and 2% MgO, with traces of P_2O_5 and SO_3 (see Table 4). We found that the MF2 and NK2 limestone samples met these specifications (as indicated in Table 2). While AS1, AS2, MF1, and NK1 did not meet all of the standard requirements, they still showed promise for other industrial applications. By reducing the level of contamination, particularly Al_2O_3 and SiO_2, during limestone processing, these samples may become viable options for steel production (Azubike *et al.* 2011).

Paper Industry: The paper industry requires limestone that meets specific chemical requirements, as specified in ASTM C911-19, Hamidullah and Akhya (2004), Harrison (2012), Jett (2017), Rajeb *et al*. (2018), and Ibrahim and Abdelmonem (2020) (see Table 4). To be suitable for paper production, limestone must have a high CaO content of at least 90%, and must not exceed certain maximum levels of SiO_2 (0.450%), Al_2O_3 (0.50%), Fe_2O_3 (0.130%), and MgO (0.5%). Additionally, a very light limestone is preferred in the paper industry to produce high-quality paper (Rajeb *et al*. 2018). After analyzing the limestone samples, we found that AS1, AS2, MF1, MF2, NK1, and NK2 (as shown in Table 2) did not meet these specifications and are therefore not suitable for paper production. It is important to ensure that the limestone used in this industry meets these specific requirements to produce high-quality paper products.

Table 4: Limestone standards for various industries

Industries	**Compounds (wt%)**								
	CaO	**MgO**	**Al_2O_3**	**Fe_2O_3**	**SiO_2**	**P_2O_5**	**Mn_2O_3**	**SO_3**	**$CaCO_3$**
Agriculture [1,2,3,4,6,7,13]	55.000	15.000	N/A	0.200	5.000	N/A	N/A	N/A	92.000
Bleaching Powder [1,2,3,4,9]	54.000	2.000	N/A	0.200	0.800	N/A	N/A	N/A	95.000
Calcium Carbide [1,2,4]	56.000	1.300	0.250	0.250	1.500	N/A	0.200	0.200	96.000
Cement OPC[1,2,3,5,6,7,8]	62.000	3.000	2.000	2.000	25.000	1.000	N/A	1.000	N/A
FGD [1,2,16]	53.000	2.000	1.500	3.000	3.000	N/A	N/A	N/A	95.000
Glass[1,4,11,]	55.200	1.000	0.500	0.150	0.500	N/A	N/A	N/A	97.500
Iron & Steel [1,4,13,17]	52.000	2.000	3.000	3.000	6.000	N/A	N/A	N/A	90.000
Paper[1,2,4,9,10,14]	90.000	0.500	0.500	0.130	0.450	N/A	N/A	N/A	98.500
Sugar [1,2,4,12,14]	50.000	1.000	0.750	0.750	2.000	N/A	N/A	N/A	80.000
Textile[1,4,14,15]	53.500	3.000	1.000	1.000	2.700	N/A	N/A	N/A	94.000

[1] (ASTM C911-19); [2] (Harrison, 2012); [3] (Oates, 2011); [4] (Ibrahim and Abdelmonem 2020); [5] (BS 7583: part 2); [6] (Ofulume *et al*. 2018); [7] (Ayuba *et al*. 2015); [8] (Noureddine *et al*. 2016); [9] (Rajeb *et al*. 2018); [10] (Mohamed, 2018); [11] (Hamidullah and Akhyar, 2004); [12] (Chen, 2013); [13] (Vijayachittra *et al*. 2010); [14] (Jett, 2017); [15] (Prashaut, 2012); [16] (De-Souza and Braganca, 2017); [17] (Hasanbeigi *et al*. 2010)

(Key: OPC= ordinary Portland cement, N/A= not available, FGD= flue gas desulphurization, min= minimum, max= maximum, wt= weight.)

Bleaching Industry: The manufacture of bleaching powder requires limestone that meets specific chemical requirements, as specified in ASTM C911-19, Oates (2011). Harrison (2012), Rajeb *et al*. (2018), and Ibrahim and Abdelmonem (2020) (see Table 4). To be suitable for this purpose, limestone must have a CaO content of more than 54%, and must not exceed certain maximum levels of SiO_2 (less than 0.80%), Fe_2O_3 (less than 0.20%), and MgO (less than 2%). After analyzing the limestone samples, we found that AS1, AS2, MF1, MF2, NK1, and NK2 (as shown in Table 2) met approximately 50% of these specifications. However, the content of impurities (Fe_2O_3 and SiO_2) can be reduced by processing the limestone (Azubike *et al*. 2011). It is important to ensure that the limestone used in the manufacture of bleaching powder meets these specific requirements to ensure optimal product quality. By processing the limestone to reduce impurities, it may be possible to improve its suitability for this purpose.

Calcium Carbide Production: To produce calcium carbide, limestone must meet specific chemical requirements, as specified in ASTM C911-19, Oates (2011), Harrison (2012), and Ibrahim and Abdelmonem (2020) (see Table 4). These requirements include a minimum $CaCO_3$ content of 96%, and maximum levels of SiO_2 (less than 1.5%), MgO (less than 1.3%), and Al_2O_3 + Fe_2O_3 (less than 0.50%). In addition, the limestone must contain traces of P_2O_5 and SO_3. After analyzing the limestone samples, we found that AS2, MF2, and NK2 (as shown in Table 3) met the specification for $CaCO_3$ and MgO. However, the content of impurities (SiO_2, Al_2O_3, and Fe_2O_3) exceeds the maximum levels specified. To reduce the content of these impurities, it may be necessary to process the limestone (Azubike *et al*. 2011). Ensuring that the limestone used in the production of calcium carbide meets these specific requirements is crucial to ensuring optimal product quality. By processing the limestone to reduce impurities, it may be possible to improve its suitability for this purpose.

Sugar Industry: The production of sugar requires limestone with specific chemical properties, such as a CaO content of more than 50%, less than 2% SiO_2, less than 1% MgO, and less than 1.5% Al_2O_3 + Fe_2O_3 (ASTM C911-19; Harrison, 2012; Jett, 2017; Ibrahim and Abdelmonem, 2020) (see Table 4). Among the limestone samples analyzed, AS1, AS2, MF1, MF2, and NK1 and NK2 (see Table 2) all met the CaO requirement. However, impurities such as Fe_2O_3, Al_2O_3, and SiO_2 can be found in higher concentrations and can affect the quality of the sugar. To address this, processing methods can be employed to reduce the impurities in the limestone (Azubike *et al*. 2011).

Glass Industry: The glass industry requires high purity limestone that contains at least 97.5% $CaCO_3$, and no more than 0.5% SiO_2, 0.5% $Al2O_3$, 0.1% MgO, and 0.15% Fe_2O_3 (ASTM C911-19; Hamidullah and Akhyar, 2004; Harrison, 2012;) (see Table 4). Limestone AS2, MF2, and NK2 (see Table 3) met the $CaCO_3$ requirement, but their impurity levels (Fe_2O_3, Al_2O_3, MgO, and SiO_2) can be reduced through processing (Azubike *et al*. 2011).

Textile Industry: To ensure high-quality textile production, limestone used in the manufacturing process should meet specific specifications. According to industry standards (ASTM C911-19;

Harrison, 2012; Prashaut, 2012; Jett, 2017; Ibrahim and Abdelmonem, 2020), limestone must contain at least 94% $CaCO_3$, less than 2.70% SiO_2, 3% MgO, and 2% Fe_2O_3 + Al_2O_3 (as listed in Table 4). Fortunately, the AS1, AS2, MF1, MF2, NK1, and NK2 limestone samples listed in Table 2 met these specifications, as they all contain the required amount of $CaCO_3$, the main component. However, if the content of impurities is higher than desired, it can be reduced by processing the limestone (Azubike *et al*. 2011).

Agricultural Practice: In agriculture, limestone is required to contain more than 92% $CaCO_3$, more than 55% CaO, less than 5% SiO_2, less than 0.2% Fe_2O_3, and 2% MgO, according to standards such as ASTM C911-19, Vijayachittra *et al*. (2010), Oates (2011), Harrison (2012), Ayuba *et al*. (2015), Ofulume *et al*. (2018), and Ibrahim and Abdelmonem (2020) (see Table 4). Based on Tables 2 and 3 results, limestone samples AS2, MF1, MF2, and NK2 met the required specifications for the main components. However, the content of impurities, specifically SiO_2 and Fe_2O_3, can be reduced through limestone processing techniques (Azubike *et al*. 2011).

Cement Industry: To produce Portland cement, limestone with a minimum CaO content of 62% is required. Additionally, the limestone should contain up to 15% SiO_2, less than 5% Al_2O_3, less than 3% Fe_2O_3, and no more than 3% MgO. Small amounts of P_2O_5, Na_2O, K_2O, and SO_3 are also acceptable (ASTM C911-19; BS 7583: part 2; Oates, 2011; Harrison, 2012 Ayuba *et al*., 2015; Noureddine *et al*., 2016; Ofulume *et al*., 2018) (refer to Table 4 for details). In reference to BS 7979:2020, C_3S requirement in limestone should be in the range of 50% to 60% which is responsible for initial and final strength development in cement, it is also responsible for rapid hydration (see Table 3). C_2S is required to be within 20% to 30% and is responsible for the hardening and strengthening of cement over a period of time (see Table 3). C_3A is require be in the range of 8% to 15% which play a crucial role in concrete quality and durability while, C_4AF is required to be in the range of 0.5% to 10%, it controls the colour of Portland cement and has no contribution to cement quality and strength (see Table 3). In cement production, LOI is required to be within 30% to 35% because high LOI decreases the strength of cement while low LOI increases the strength of cement (see Table 3). Also, LSF is required to be within 85% to 99%, this is because low LSF causes difficulty in the formation of Portland cement clinker during cement production (see Table 3). The limestone samples AS1, AS2, MF1, MF2, NK1, and NK2 all met the required specifications for Portland cement production (refer to Table 2, 3, and 4).

Flue Gas Desulfurization Process: To be suitable for flue gas desulfurization, limestone must have a CaO content of at least 53%, a $CaCO_3$ content of 95%, less than 3% SiO_2, less than 1.5% Al_2O_3, less than 3% FeO3, and a maximum of 2% MgO (ASTM C911-19, Harrison, 2012; De-Souza and Braganca, 2017) (see Table 4 for details). Limestone samples AS2, MF2, and NK2 (refer to Tables 2 and 3) met these requirements. While these limestone samples meet the specifications, their impurity content, particularly SiO_2 and Al_2O_3, could be reduced by processing (Azubike *et al*. 2011).

Conclusion

Limestone is a versatile and vital rock utilised in various industries such as steel, paper, bleaching, sugar, glass, textile and cement industry. In Nigeria, it is mainly mined for cement production in locations such as Ashaka, Mfamosing, and Nkalagu. However, the suitability of limestone for different industrial purposes depends on its chemical composition, which determines its purity. This study examined the chemical composition of limestone from three locations in Nigeria – Ashaka in the northeast, Mfamosing in the south-south, and Nkalagu in the southeast. And results indicate that limestone from AS2, MF2, and NK2 has a high purity level, with a CaO content of 70.388%, 78.632%, and 77.646%, respectively. However, trace amounts of other oxides were present in these samples. The high purity levels of these limestone samples make them ideal for various industrial applications, such as the steel industry, bleaching powder, calcium carbide, sugar, glass, textile production, agriculture, cement, and flue gas desulphurisation. However, it was observed that these limestone samples are not suitable for the paper industry. It is therefore recommended that the uses of limestone in Nigeria should be diversified and not limited to cement production alone. The industrial sector should explore the various applications of limestone, considering the availability of high-purity samples in locations like Ashaka, Mfamosing, and Nkalagu.

In conclusion, this study provides a preliminary insight into the potential industrial applications of limestone in the studied locations. Further research is necessary to identify more applications for limestone and other rocks available in the area.

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Author contributions:

Uche John Chukwu designed the experimental frame work and wrote the draft manuscript

Prince Michael carried out the sampling and conducted the laboratory experiments.

Conflict of Interest

The authors declare that they have no conflict of interest.

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