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ELEMENTAL COMPOSITION OF SOME BUILDING MATERIALS USED IN ZARIA, KADUNA STATE

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ABSTRACT
This study investigates the elemental composition of Cement, Granite, Ceramic tiles and Plaster of Paris (POP) which are extensively used as building material in Zaria, Kaduna State. X-ray fluorescence (XRF) technique was employed in this work to determine the elemental composition of the building materials. The samples were crushed to a fine powder, sieved through a 250 mm mesh and dried in an oven at 110^0 C to ensure the complete removal of moisture. The results showed the presence of (Mg, Al, Si, Ca, Fe, Sn, Cl, Ti, S, P, Mn, Co, Zn, Mo, Pb, Cr,V, Cu, Br, Cd, Ba, Hg, and Ni) in various concentrations. Mg, Al, Si, Ca, Fe, Sn, Cl, Ti and S were available in relatively high concentration in all the samples with P, Mn, Co, Zn, Mo and Pb, found in relatively lower concentrations in some of the samples while Cr and Ni were only present in Ceramic tile samples; which was attributed to coloring agents used in the tile making process. This shows that the elemental composition is in agreement with the composition of the earth crust which is the source of the building materials. The analysis is of importance and useful to the construction industry as well as dwellers of the Zaria built environment.
Keyword: Composition, Plaster of Paris, Cement, Granite, Ceramic Tile

INTRODUCTION

Ceramic tiles, cement, granite and plaster of Paris (POP) are building materials that are derived directly from diverse rock and soil types with specific mineral characteristics that represents the variety of geological formations and geochemical composition of the earth's crust. They constitute a very important and highly utilized component of the human built environment and indeed, they make up an essential and integral part of arguably all of Nigerian cities including Zaria.

The use of ceramic tiles granites and POP in building construction and industrial activities is becoming a routine venture in Zaria. Determining the chemical compositions of these products is very important not only for the end users but also for the manufacturers.

X-ray fluorescence technique (XRF) is the tool employed to determine the elemental composition of the building materials. The XRF technique has many advantages, it is fast, accurate and distinctive. It has a detection range of a few part per million (ppm) of most elements (Al Eshaikh and Kadachi, 2006; Ida etal 2005). For these reasons the XRF analysis method is widely use in many field such as metallurgy, industry, geology and mineralogy, food industry and environmental management. The use of XRF technique is very attractive in many fields (Goldsttein and Sivilis, 2002; Rutherford, 1993). The sample preparation for XRF is relatively simple that required less time consumption and effort. For example when the solid sample is homogenous then it needs only punishing to be ready for analysis (Blank and Eksperiandova, 1997).

Zaria and its environs is experiencing rapid physical growth and development. New buildings are continually being constructed within and around the city. This has led to an influx of variety and diverse building materials to satisfy the needs of the end users. The quality of these materials in terms of their sources and as such, their safe use as it relates to human health cannot be ascertained.

Ceramic tiles, cement, POP and granite are among the extensively utilized building materials. These are products that are directly derived from earth. Earth is a geological complex that is made up of different elements some of which are harmful to human health. It is therefore important to determine the concentration of the elements present in the building materials which are extensively used for building purposes in Zaria. It is therefore imperative that their associated elemental composition and hazard to human health is determined. The aim of this study is therefore to determine the elemental composition of ceramic tiles, Portland cement, Plaster of Paris and granite which are extensively used in Zaria and its environs as building materials.

MATERIALS AND METHODS

Study Area

Zaria is located in Kaduna state of Northern Nigeria. It lies within latitude $11^0$00'3" to $11^0$00'6" North and longitude $007^0$03'6" and $007^0$04'0" east of the Greenwich meridian. It covers an area of approximately 6,100 Ha. It has an estimated population of 975, 200 (year 2015).

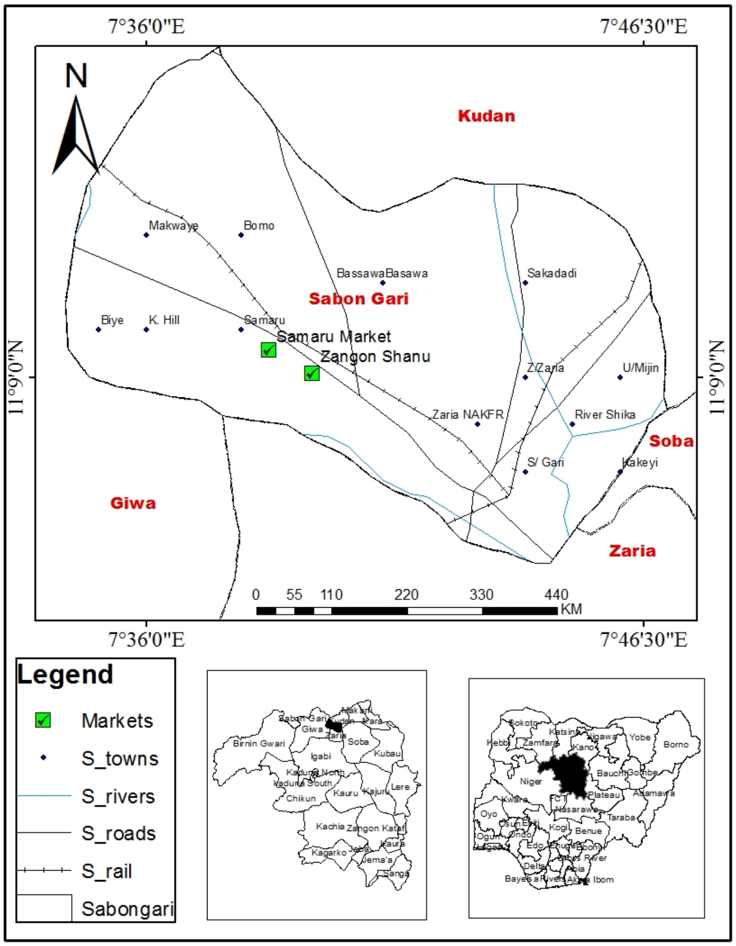

Fig 1: Map of Zaria showing the study area.

Sample Collection and Preparation

Nine samples were collected from building construction sites in Zaria. Four building material types were selected. The categories are named and coded accordingly as follows: Ceramic tiles (CrT), Cement (C), Granite (Gr) and Plaster of Paris (POP). The samples were crushed to a fine powder and sieved through a 250 mm mesh which is the optimum size enriched in heavy minerals. Each sample was dried in an oven at 110^0 C to ensure that moisture was completely removed. The weighed samples were placed in a polyethylene cylindrical beaker of about 200 cm^3 volume each. The collected samples were packed and sealed in a well-labeled polyethylene bag in order to avoid cross-contamination, after which they were analyzed for their elemental composition. The elemental concentration was quantitatively determined using XRF (x-supreme 8000 Oxford Instrument UK) portable system equipped with rhodium (Rh) target X-ray tube of 4 watt, 50 kv max and a silicon drift detector (SDD).

RESULTS AND DISCUSSION

Elemental Composition of Cement

The elements under investigation in this work were analyzed using XRF. The analysis of cement samples C_1 and C_2 shows that high concentration of Mg and Ca with concentration of 5441.335 mg/kg and 47920.561 mg/kg respectively was found to be present in sample C_1, and 4305.286 mg/kg and 53870.388 mg/kg for sample C_2.While P and Mn have a lower concentration of 70.535 mglkg and 32.289 mg/kg respectively for sample C_1 and 89.502 and 36.08mg/kg for sample C_2 respectively From Table 1, it is observed that the concentration of magnesium, titanium and silicon in C1 is higher than in C2 whereas the concentration in Al, P, S, Cl, Ca, Mn, Fe, Co and Sn are higher in C2 than in C1. This may be as a result of the geological variations of the raw materials used in making the products. These concentrations where higher than that obtained from Turkish cement (38000 mg/kg) as reported by Polat *et al.* (2014). The level of Fe concentration in cement sample (C1 and C2) as shown in table 1 showed that C2 has a higher concentration (3591.032 mg/kg) than C1 (3473.017 mg/kg). These concentrations are higher than that obtained from Turkish cement (37749 mg/kg) as reported by Polat *et al* (2004).

Elemental Composition of Granite

The results of analysis of the elemental composition of Granite (G1) is presented in Table 2. Si have the highest concentration (13139.861 mg/kg) followed by Al (10480.462 mg/kg) and Sn (8437.372 mg/kg) while Zn is the lowest concentration (9.792 mglkg)

The detection of S, Cl and Co were in agreement with the findings of El Taher, 2012 while Mg, Al, Si, Ca Ti Mn and Sn were absent in his research samples. These elements were found in the present study. Cu, Mo, Ni, Pb Se and V were present in (El Taher, 2012) but were absent in the present study. This could be due to the distribution of elements determined in granite samples studied with regards to their parent sediment and location. It is therefore evident that the elemental composition of granite samples varies according to rock type and consequently according to parent sediment from which these rocks are derived.

Elemental Composition of Ceramic Tiles

The results of analysis of the elemental composition of ceramic tiles (T1, T2, T3, and T4) are presented in Table 3. From the Table, it can be seen that the concentrations of T1 and T3 which are the floor tiles are almost the same across all the elements while the wall tiles in the elements are also similar. The detection of Si, Mg, Ti, Ca, Al, Fe, were in agreement with the report of Anufrik (2016) while Na, K, Pb, and Zr are present in Anufrik (2016) but absent in the present study. S, Cl, Cr, Mn, Ni, Sn, and Zn are in the present study but absent in Anufrik (2016) This may be due to origin or constituent of the tile. Cr and Ni were only present in tile samples T1, T2, T3 and T4 which could be due to the coloring agents used in tile making process (Ceramic tiles*,* 2019).

Table 1: Table showing Analyte concentration of cement samples

Elements	C1	C2
Mg	5441.335	4305.286
Al	2184.854	2660.491
Si	2200.933	2197.342
P	70.535	89.502
S	2516.01	2639.257
Cl	317.481	320.005
Ca	47920.561	53870.388
Ti	217.122	204.452
Mn	32.289	36.08
Fe	3473.017	3591.032
Co	0	16.03
Sn	7060.346	9665.777

Table 2: Table showing Analyte concentration of Granite sample

Elements	G1
Mg	7444.911
Al	10480.462
Si	13139.861
S	249.38
Cl	222.893
Ca	1729.697
Ti	724.732
Mn	107.423
Fe	330.516
Co	20.757
Zn	9.792
Sn	8437.372

Table 3: Table showing analyte concentration of ceramic tile samples

Elements	T1	T2	T3	T4
Mg	5467.684	12301.015	5997.958	10550.09
Al	14206.343	12839.989	12873.857	12281.08
Si	12632.681	10606.259	10879.78	9910.933
P	33.466	0	0	0
S	202.221	330.133	350.583	253.141
Cl	97.29	32.086	697.221	55.867
Ca	1677.042	5289.326	3472.622	6893.251
Ti	1141.257	1969.196	1158.444	1929.365
Cr	92.139	64.122	71.631	37.462
Mn	85.044	47.363	35.591	38.764
Fe	2512.727	6939.466	2509.025	6036.666
Co	12.493	41.27	12.191	35.486
Ni	17.946	23,967	17.328	17.765
Zn	27.408	267.963	46.016	257.971
Mo	0	11.156	9.882	0
Sn	4238.035	2377.714	2797.432	2631.318
Pb	9.041	31.015	11.754	29.014

Elemental Composition of Plaster of Paris

The result of the analysis of the elemental composition of sample P1 and P2 is presented in Table 4, showing approximate chemical composition of plaster of paris determined by XRF. From the table, it can be observed that P1 have higher concentration than P2.Sn has the highest concentration in sample P1, and P is the lowest concentration. Ca has the highest concentration in sample P2 and Ti is the lowest concentration.

Table 4: Table showing analyte concentration of POP samples

Elements	P1	P2
Mg	1681.487	4847.53
Al	1018.485	454.018
Si	1350.102	170.509
P	79.9	689.291
S	3252.121	65570.6
Cl	294.209	348.402
Ca	37208.082	40340.7
Ti	197.279	35.814
Fe	252.529	108.752
Sn	8122.174	3375.39

CONCLUSION

XRF analysis was used to determine 23 elements from 4 building material samples that were collected from building sites in Zaria. Major elements where determined in all the collected samples. The research work was carried out to determine the elemental composition of some common building materials in Zaria to facilitate establishing a data base for thier quality and safety. The result obtained have verified that the elemental composition of the selected building materials is in agreement with the composition of the earth crust which is their primary production raw material.

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