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Short Communication

Assessment of Pollution Potentialities of some Portland Cement

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ABSTRACT: Chemical analysis of some Portland cement commonly used in Nigeria was carried out. All the cement studies were found to be good for concrete work especially where no special property is required. The concentration levels of heavy metals in all the cement samples were above the tolerance limit and therefore need to be regulated.
Keywords: Portland cement, Heavy Metals, X-ray Analysis, Pollution, Sokoto

INTRODUCTION

Trace metals are naturally present in the biological world in acceptable quantities, but increase of these metals through an anthropogenic contribution has since the last century been known to harmed humans and environment (Archi *et. al.*, 2011). Environmental safety and management has always being strategic issue of discussion in every society that is striving to attain or has attained industrialization since industrialization is synonymous with environmental pollution.

Cement industry has been in operation in Nigeria for many decades and has contributed to Nigerian Economy greatly (Taylor, 2009). Despite the remarkable achievements recorded in the use of cement, it studies have shown that it is associated with some environmental problems such as emission of air pollutants in form of dust, gases, noise and vibration during the process of manufacture (Oleru, 1984). Cement is also associated with heavy metals as evident in many studies conducted (Ahmed *et al.*, 2009). Heavy metals are known to pose serious health problems to humans, affect plant growth and general damage to ecosystem (Bagudo *et al*., 2008; Peter *et al*., 2009).

The aim of this work is to assess the suitability of the selected cement for concrete work and to determine the levels of heavy metals in the cement samples for it potential harmfulness on human and environment.

MATERIAL AND METHOD

Sample collection

Different cement samples namely Ashaka, Burham, Dangote, Wapco were bought from Wuse Market in Abuja while Sokoto Cement was bought from Sokoto Market. 50g of each sample was taken in clean labelled polythene bag as soon as the cement bag was opened to avoid surface contamination and kept for further analysis.

Apparatus and reagents

Determination of heavy metals was done using Atomic absorption spectrophotometer (AAS) (Perkin – Elm 4000 model) at suitable wavelength for each metal. Cement chemical composition was done using XRF analyzer. All reagents used were of analytical grade.

Digestion of Sample

Cement sample (1g of each) was placed in a 1000 cm^3 micro Kjeldahl flask previously washed with nitric acid and distilled water. 10cm^3 of concentrated nitric acid was added, 1cm^3 of perchloric acid and then 2cm^3 of concentrated sulphuric acid. The mixture was swirled gently and slowly and then heated on digester in a fume cupboard. The mixture was then cooled, filtered as diluted into 100cm^3 volumetric flask to the mark. All Samples were treated in same manner

Determination of Free Lime

20cm^3 of ethylene glycol were placed in Erlenmeyer flask stopped and heated in a water bath at 70^{0}C.Then 0.5g of samples was transferred into the flask covered and shaken for 15 minutes and then filtered by vacuum filtration. 30cm^3 of 0.1M HCl was added to the filtrate followed by 50cm^3 of 0.005M potassium iodate solution 0.5g of potassium iodide.

The liberated iodine was titrated with 0.005M standard sodium thiosulphate solution with constant stirring until the mixture turned yellow. Then 5cm^3 of 2.0% of starch solution was added and titration continues until the solution changed from blue to colourless. Volume of the thiosulphate was recorded (Lau and Nina, 2001).

Determination of Loss on Ignition

1g of each sample were taken on weighed crucible and heated in a muffle furnace at 1100^0C for 30 minutes, cooled in a desiccators and weight difference were recorded (CCNN, 2010).

X-ray Analysis of the Sample

1g of lithium bromide was weighed into three (3) different crucible of the fluxer machine and 1g each of the calcined cement added into the crucible containing the lithium bromide. The mixture were melted and cooled as a glass seats, the glass seats formed were inserted into the X-ray machine to detect the percentage of compound presents in the sample after standard samples were used to calibrate the equipments.

Mineral Content of the Cements

The mineral content of the cements were calculated based on Bogue's formula as outline by Taylor (1990).

$C_3S = 4.07CaO - 7.6024SiO_2 – 6.7187Al_2O_3 – 1.4297Fe_2O_3$

$C_2S = -3.07CaO + 8.6024SiO_2 + 5.0683Al_2O_3 + 1.08Fe_2O_3$

$C_3A = 2.6504Al_2O_3 – 1.692Fe_2O_3$

$C_4AF = 3.0432Fe_2O_3$

AAS Analysis

Heavy metal analysis was done using atomic absorption spectrophotometer using direct air-acetylene flame at suitable wavelength for each metal (Basset *et al.*, 1997). Standards were prepared form 1000mg/kg stock solution of the metals.

RESULTS AND DISCUSSION

The results of the analysis carried out on the samples as shown in Tables 1-3. As shown in Table 1, the percentage compositions of the various major and minor constituents of the cement samples are within the specifications of American Standard for testing materials (ASTM C150). This means that the cement samples were of certain quality.

The SiO_2 content for all the samples is in the range of 19.07 – 22.33% with Ashaka recording the highest value i.e. Ashaka > Sokoto > Wapco > Dangote > Burham. SiO_2 content is an index for fineness or coerciveness and it determine the grindability of the cement clinker, level of water intake and strength of concrete (Frias and Sanchez, 1995).

Table 1: Percent composition of major constituent of the cement samples by XRF method.

Parameter	Ashaka	Burham	Dangote	Sokoto	Wapco
CaO	62.85 ± 0.05	56.17 ± 1.01	64.86 +0.04	64.53 ± 0.02	65.22 ± 0.01
SiO_2	22.33 ± 0.02	19.07 ± 0.88	19.96 ± 0.05	20.64 ± 0.14	20.04 ± 0.07
Al_2O_3	5.87 ± 0.05	5.30 ± 0.45	6.05 ± 0.02	5.40 ± 0.04	5.22 ± 0.05
Fe_2O_3	3.32 ± 0.01	3.15 ± 0.60	2.99 ± 0.01	3.99 ± 0.01	3.53 ± 0.02
MgO	0.71 ± 0.02	0.74 ± 0.12	1.26 ± 0.01	2.35 ±0.01	3.03 ±0.03
SO_3	2.17 ± 0.01	1.14 ± 0.06	1.99 ±0.01	1.77 ±0.04	1.62 ± 0.01
P_2O_3	0.22 ± 0.01	0.26 ± 0.01	0.24 ±0.02	0.52 ±0.01	0.32 ± 0.01
K_2O	1.04 ± 0.02	1.10 ± 0.03	1.09 ± 0.01	0.26 ±0.01	0.26 ± 0.01
Free CaO	1.59 ± 0.05	1.77 ± 0.07	2.15 ± 0.04	2.33 ± 0.04	1.02 ± 0.01
LOI	8.91	3.33	7.48	5.80	4.57

Dangote cement had the highest Al_2O_3 content which will lead to high content of C_3A (Table 2) that contribute to early strength development, while WAPCO cement had the least Al_2O_3 content. Thus more setting decelerating additives are needed for Dangote in a long period of cementing job. Ashaka shows the highest LOI value which is as a result of carbonation and impurity of free lime and free magnesia due to exposure to atmosphere. Ashaka also had the highest value of SO_3 and Burham the least SO_3 content which also favours formation of C_3S mineral compound which is responsible for initial set and early strength? The lower the SO_3 value the better (Taylor, 1990).

Sokoto cement shows the highest percentage of Fe_2O_3 as free CaO. The Fe_2O_3 is one of the parameters responsible for cement colouration which explain why Sokoto Cement is darker grey than all the cements. High free lime content results in expansion due to formation of $Ca(OH)_2$, Sokoto cement is therefore unsound due to the higher content of free CaO.

In the hydration of the cement powder, it is C_3A that causes the sudden hardening of the cement paste. Hence it is usually retarded by addition of gypsum. High amount of C_3A is undesirable. The C_3S and C_2S hydrate to form the calcium silicate hydrate that brings about the adhesive and the cohesive strengths of the cement structure (Ahmed *et al.,* 2009).

The calcium aluminoferrite (C_4AF) does not have significant role in the hydration of cement. However along with C_3A, it serves as a reservoir for the removal of some deleterious ions like Cl^- and SO_4^{2-} that cause the rusting of steel reinforced concrete (Taylor, 1990).

The concentration of toxic heavy metals in the cement samples as shown in Table 3, exceeded the maximum allowable concentration limit (Co 0.01, Mn 050, Ni 0.02, Cr 0.05 and Cd 0.003 ppm) stipulated by World Health Organisation (WHO, 1990), and US Environmental Protection Agency (USEPA, 1974).

Table 2: Mineral Composition of Cement Samples (%)

Sample	C_3S	C_2S	C_3A	C_4AF	Sum
Ashaka	35.70	37.07	10.00	10.09	93.49
Burham	42.91	29.94	12.51	11.08	96.44
Dangote	56.64	12.98	11.00	9.07	91.69
Sokoto	54.39	18.14	7.57	12.13	92.23
WAPCO	68.12	6.08	7.89	10.72	92.91

Table 3: Heavy metals Content in Cement Samples (ppm)

Samples	Co	Mn	Ni	Cr	Cd
Ashaka	11.31	12.77	4.22	0.69	2.30
Burham	10.94	8.04	3.65	0.97	2.80
Dangote	11.78	12.32	6.98	1.27	3.05
Sokoto	12.60	6.67	7.93	2.64	2.52
WAPCO	10.76	7.82	4.22	0.55	2.37

CONCLUSION

The result of the analysis indicates that the cement samples under study are generally good for concrete work especially where no other special properties are required. Burham seems to be the best one having the lowest SO_3 and free lime content and highest percentage of C_3A. More so, the heavy metal content recorded for Burham is also added advantage. Generally, the heavy metal content in all the samples is above the stipulated tolerance.

REFERENCES

Achi, M.M., Uzairu, A., Gimba C.E. and Okunola, O.J. (2011). Chemical Fractionation of Heavy Metals in Soils Around the Vicinity of Automobile Workshops in Kaduna Metropolis. *Journal of Environmental Chemistry and Ecotoxicology* **3(7):** 184-194

Ahmed. U.J., Birnin–Yauri, U.A. and Dangoggo, S.M. (2009). Studies on Leachability of Chromium From Ordinary Portland Cement. *Biological and Environmental Sciences Journal for the Tropics,* **6(2):** 89-91.

Bagudo, B.U., Birnin-Yauri, U. A. and Faruk, U.Z (2009). Determination of Hazardous Metal in Locally-made Aluminium Utensils. *Nigerian Journal of Basic and Applied Sciences,* **10:** 45-52.

Basset, J., Denny, R.C., Jeffery, G.H. and Mendham, J. (1997). *Vogel's Text Book of Quantitative Inorganic Analysis including Elementary Instrumental Analysis* 4th Edition Longman Publishing Co. Inc. London. PP 35 – 40.

CCNN (2010). Cement Company of Northern Nigeria, Laboratory Manual. PP. 1 – 9.

Frias, M.I. and Sanchez, R. (1995). Determination and Quantification of Total Chromium and Water Soluble Chromium Content in Commercial Cement. *Cement and Concrete Research,* **25 (2):** 432 – 439.

Lau, O. and Nina, I.N. (2001). Determination of Free Lime in Clinker by Iodometric *Method Journal of Chemical Education,* **78(2):** 1671.

Oleru, U.G. (1984). Pulmonary Function and Symptoms of Nigerian Workers Exposed to Cement Dust. *Environmental Research,* **33:** 379 – 385.

Peter, S.Y., Thomason, E. and Krombout, H. (2009). Personnel Exposure to Inhalate Cement Dust Among Construction Workers. *Journal Environmental Monitoring,* **11(1):** 174 – 180.

Taylor, H.F.W. (1990). *"Cement Chemistry*" Academic Press, London, Pp10-69.

Taylor, I. (2009). *Cement Operation Course*. Inter. Services Pty. Ltd Geelong North Victoria, Australia Publishers Pg 1 – 15.

US Environment Protection Agency (USFEPA) (1974). Manual of methods for chemical analysis of water and waste, USFEPA Washington DC, pp. 72-78.

World Health Organisation (WHO) (1990). International Standard for drinking water, 2nd edition, Geneva, pp. 28-31.