J. Chem Soc. Nigeria, Vol. 45, No. 3, pp 403 - 409 [2020]

HAZARDS ASSOCIATED WITH EMMISSION FROM CEMENT KILN DUST; A CASE STUDY OF OBAJANA CEMENT FACTORY

S. Kabiru*[1], M. Fatima[1] and Y. Rufai[1]

[1]CHEMISTRY DEPARTMENT, FEDERAL COLLEGE OF EDUCATION, OKENE, KOGI STATE

[*]**Correspondents Author:** suleimankabiru885@gmail.com, +2347035823548

Received 01 March 2020; accepted 03 April 2020, published online 28 May 2020

Abstract

During the last decades, the emission of dust from cement factories has increased alarmingly due to expansion of more cement factories to meet the requirement of cement materials for construction of building. Cement factory caused environmental pollution problems; the pollutants from the cement factory have adverse effects on the immediate environment. Exposure to cement or concrete dust can cause nose and throat irritation. Long term exposure to concrete dust containing crystalline silica can lead to a lung disease called silicosis. A total of twelve Dust samples were collected from the four cardinal directions (north, south, west and east) around the cement factory by placing a wide surface plastic bow at each collection point on a high place and the sample was collected at every five day for a period of thirty days.1.00g of the dust sample was digested in acid mixture prepared from 15mL HNO_3 and 5mL HCl (3:1). Metal concentration was determined using Atomic absorption spectrophotometer (AAS) perkin Elmer model 460 and flame photometer for the sodium and potassium , the oxides of calcium, aluminum, iron, potassium, magnesium, sulfur and silica were analyzed using Thermo scientific x-ray fluorescence analysis software (OXSAS 1.1), ARL 9900 intelli-power series. X-ray fluorescence (XRF) analysis of dusts sample shows that the mean dust values for CaO, SiO_2, Al_2O_3 and Fe_2O_3.MgO, K_2O, Na_2O and SO_3 are 22.59%, 49.30%, 9.13%, 7.98%, 1.45%, 1.45%, 1.42% and 0.17% respectively and the result of Atomic Absorption Spectrophotometry analysis follows the same pattern as that of X- ray fluorescence analysis except for iron oxide which is higher at the west direction. This study has revealed that kiln dust released from Obajana cement factory posed some health challenge not only to the workers but also to the host community

Key words: *Cement-kiln dust, Obajana, factory*

Introduction

Even in the twenty-first century, millions of people are working daily in a dusty environment. They are exposed to different types of health hazards i.e., fume, gases and dust, which are risk factors in developing occupational disease. Cement dust causes lung function impairment, chronic obstructive lung disease, restrictive lung disease, pneumoconiosis and carcinoma of the lungs, stomach and colon[1- 4].

The pollutants are in the form of cement dust, stack emissions of the kiln flue dust in form of smoke and particulates released to the atmosphere. This affects the environment and the inhabitants to whom development is intended.

This research tends to identify the major chemical constituents of the dust pollutant, their quantities as well as directional characteristics.

Cement industry is one of the major air polluting industries among the 17 identified by the Central Pollution Control Board (CPCB). Others are Aluminum, Cement, Chlor Alkali, Copper, Distillery, Dyes and dye intermediates, Fertilizers, Iron & steel, Oil Refineries, Petrochemicals, Pharmaceuticals, Pulp & Paper, Sugar, Tannery, Thermal Power Plants, Zinc and Pesticides[5].

The cement industry in its various processes emits suspended particulate matter (SPM) and carbon dioxide, which is produced during calcinations process. The emission of carbon dioxide depends on the type of production processes, their efficiency, fuel used etc. Particulate matter is the main pollutant emitted from cement industries. [5]

In the cement production, dust is emitted throughout the production line. From explosions to obtain limestone (quarrying) ; conveying in conveyor belt (or by truck) mixing with clay and sand, crushing of the raw material in the raw material mills to the crushing of the clinker and mixing with gypsum all give rise to dust. Cement storage as well as packing result in enormous emission of cement dust.

During the production of Portland cement the four essential chemical components tricalcium silicate($3CaO.SiO_2$) or C_3S, dicalcium silicate($2CaO.SiO_2$) or C_2S, tricalcium aluminate ($3CaO.Al_2O_3$) Or C_3A, and tetracalcium aluminoferrite ($4CaO.Al_2O_2.fe_2O_3$) or C_4AF combine with one another by reacting both in the soil and in the liquid phase. The calcium salts are fused into complex materials other than compounds.[6]

The result of x-ray fluorescence analysis of cement's dust emitted by the Eastern Moroccan cement factory and deposited on the soil of the Ain Lahjar shows that these dusts are basic and contain a high free lime (43% CaO) [7]. Dust from a cement industry in Benue state, Nigeria was examine using atomic absorption spectrophotometry (AAS) .The result shows that the dust is chemically composed of silicon, aluminium, sulphur, calcium, and iron [6].

Materials and Methods

Dust sampling

Dust samples were collected from the four cardinal directions (north, south, west and east) around the cement factory. At each sampling point, sub-samples was collected randomly and homogenized; the representative sample was taken for analysis. The samples were coded N_x E_x W_x S_x representing north, east, west and south respectively while the subscript x represent the integer 1-3. The sampling location covers within a radius 0.5 to 2km around the cement factory. In each of the cardinal point, three dust samples were collected (at an interval of 0.5km), giving a total of twelve samples. The samples were collected by placing a wide surface plastic bow at each collection point on a high place and the sample was collected at every five day for a period of thirty days. Dusts collected on the fifth day was stored in a polythene bottles and kept in the laboratory.

Polythene bottles used to store the dust samples was initially washed and dried before being used for storage.

Samples Preparation for Analysis

All the dust samples collected were dried at 105^0C for 24 hours [7]

1.00g of the dust sample was digested in acid mixture prepared from 15mL HNO_3 and 5mL HCl (3:1). The solution was placed in the fume chamber overnight, which was subsequently heated to 120^0C in a regulated hot plate for 2h. On cooling, the solution was filtered through whatman No 1 filtered paper. The filtrate was made up to 100mL with deionized water. Metal concentration was determined using Atomic absorption spectrophotometer (AAS) perkin Elmer model 460 and flame photometer for the sodium and potassium , the oxides of calcium, aluminum, iron, potassium, magnesium, sulfur and silica were analyzed using Thermo scientific x-ray fluorescence analysis software (OXSAS 1.1), ARL 9900 intelli-power series.

Statistical Analysis

The statistical software package Graphpad – prism 8 was used for the analysis of variance ANOVA to examine the significance level of the parameters measured. Tukey's multiple comparisons test was used for means comparison. The level of significance for means comparison was at $p<0.05$.

Result and Discussion

Table 1 present the physio-chemical parameter of dust samples. The pH of dust sample ranges from 9.63 ±0.13- 9.18 ± 0.19. The result as indicated shows that the dust is alkaline in nature. The conductivity of the dust sample ranges from 613±0.32 – 512 ± 0.47. There was no significant difference ($p<0.05$) in the conductivity of the dust sample between north and west as well as between the south and east. However there was significantly different in the pH of the entire sample sites of the dust sample.

TABLE 1: RESULT OF PHSIO-CHEMICAL PARAMETER OF DUST SAMPLES

SAMPLE	p^H	Cond (µS/cm)	Colour	Crystallinity
N	9.63^a ±0.13	512^a ±0.47	Brown	powder
S	9.18^b ±0.19	612^b ±0.47	Brown	powder
E	9.49^c ±0.07	613^b ±0.32	Brown	powder
W	9.25^d ±0.03	512^a ±0.47	Brown	powder

N- North, S- South, E- East, W-West, Cond- Conductivity. Mean values in the same column followed by the same superscript letters are not significantly different ($p<0.05$).

X-ray fluorescence (XRF) analysis of dusts sample shows that the mean dust values for CaO, SiO_2, Al_2O_3 and Fe_2O_3.MgO,K_2O,Na_2O and SO_3 are 22.59%,49.30%,9.13%,7.98%, 1.45%, 1.45%, 1.42% and 0.17% respectively table 2. These result indicated that the samples essentially contained CaO, SiO_2, Al_2O_3 and Fe_2O_3. Comparing the mean of this result of each constituent in table 2 shows that silicon oxide has the highest value followed by calcium oxide, iron II oxide, aluminium oxide, potassium oxide, sodium oxide, magnesium oxide and sulphur oxide. The maximum means for silicon oxide, calcium oxide, aluminium oxide and iron oxide for dust samples were all obtained from the south direction except calcium oxide and iron oxide that ware obtained from the north and west directions respectively (fig. 1). However, this situation may not be permanent as wind direction alters periodically

TABLE 2: MEAN VALUE OF X-RAY FLUORECENCE (XRF) ANALYSIS OF DUST SAMPLES

	(%) COMPOSITION							
SAMPLE	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	K_2O	Na_2O	SO_3
N	20.22^a ±0.88	5.33^a ±0.15	3.56^a ±0.23	37.80^a ±0.53	0.95^a ±0.02	0.77^a ±0.02	0.58^a ±0.02	0.10^a ±0.01
S	66.03^b ±1.96	9.78^b ±1.33	6.84^b ±0.61	19.66^b ±4.90	0.75^a ±0.09	2.30^b ±0.49	1.42^b ±0.46	0.12^a ±0.05
E	57.85^c ±0.47	6.47^c ±1.62	3.95^a ±0.63	31.94^c ±5.83	0.80^a ±0.16	1.34^c ±0.42	0.71^a ±0.38	0.17^a ±0.06
W	49.30^d ±0.64	9.13^b ±0.37	7.98^c ±0.88	22.59^d ±0.05	1.45^b ±0.20	1.45^c ±0.20	1.42^b ±0.08	0.17^a ±0.03

N- North, S- South, E- East, W-West

Mean values in the same column followed by the same superscript letters are not significantly different ($p<0.05$). The result of Atomic Absorption Spectrophotometry analysis in table 3 follows the same pattern as that of X- ray fluorescence analysis (fig 2). The mean concentration of Cr in the Dust samples shows that the result is higher at the southern direction of the factory with a value of 31.18 ppm followed by northern direction with 25.52ppm, while the eastern and western directions has 15.82ppm and 14.56ppm respectively. In the cement industry the linings for the rotaries contain chromium, which could be liberated by wear and friction and could be the source of chromium in the dust samples [8].

TABLE 3: MEAN VALUE OF ATOMIC ABSORPTION SPECTROPHOTOMETRY (AAS) ANALYSIS OF DUST SAMPLES

	CONCENTRATION				
SAMPLES	Ca (ppm)	Si (ppm)	Fe (ppm)	Al (ppm)	Cr (ppm)
N	17.88^{a} ±2.13	10.72^{a} ±1.49	1.52^{a} ±0.23	2.75^{a} ±0.21	25.52^{a} ±0.02
S	9.46^{b} ±3.31	31.17^{b} ±1.94	1.97^{a} ±0.05	3.07^{b} ±0.02	31.18^{b} ±0.14
E	16.52^{c} ±2.02	20.61^{c} ±4.42	1.01^{b} ±0.02	2.32^{a} ±0.44	15.82^{c} ±0.02
W	14.57^{d} ±2.30	19.97^{d} ±4.8	2.17^{c} ±0.29	2.83^{a} ±0.23	14.56^{d} ±0.01

N- North, S- South, E- East, W-West. Mean values in the same column followed by the same superscript letters are not significantly different ($p<0.05$).

TABLE 4: MEAN VALUE OF FLAME PHOTOMETRY ANALYSIS OF DUST SAMPLE

	concentration	
Sample	Na (ppm)	K (ppm)
N	$3.40^{a} \pm 0.11$	$3.45^{b} \pm 0.14$
S	$4.38^{b} \pm 0.05$	$3.47^{b} \pm 0.06$
E	$3.64^{a} \pm 0.03$	$4.23^{c} \pm 0.09$
W	$3.32^{a} \pm 0.02$	$3.42^{b} \pm 0.05$

N- North, S- South, E- East, W-West. Mean values in the same column followed by the same superscript letters are not significantly different ($p<0.05$).

The mean value of the x-ray fluorescence analysis for SiO_2 and CaO show that there are significant different in all the four cardinal direction at ($p<0.05$). There is also significant difference between sample concentration from south and that of the north, east except for the west which shows no significant difference for Al_2O_3. There is no significant difference for Fe_2O_3 between the north and east but there is significant difference between the south and west (table 2).

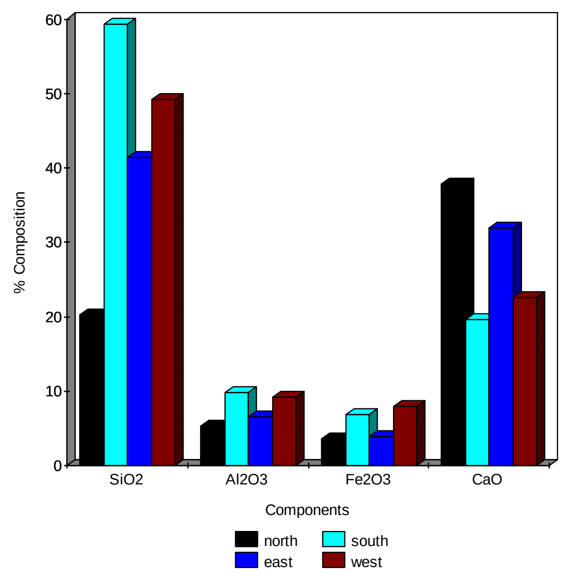

Figure 1: Bar chart showing the result of X-ray fluorescence analysis of dust samples

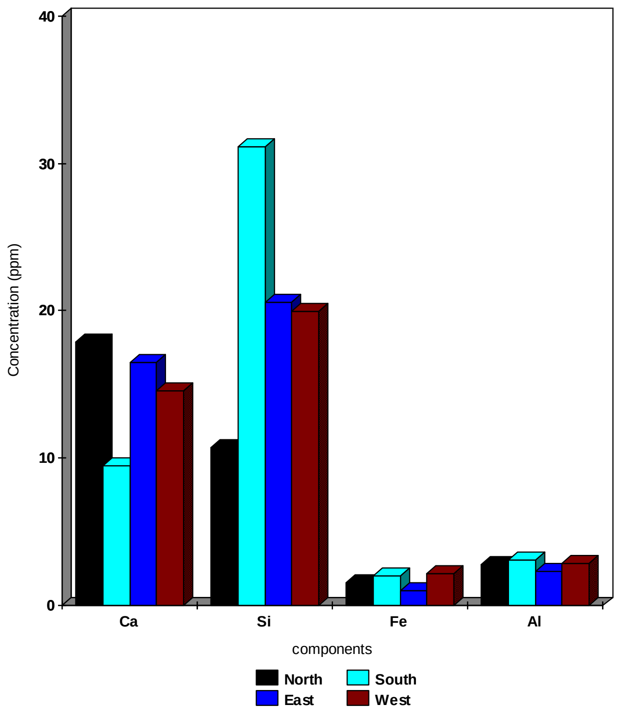

Figure 2: Bar chart showing the result of Atomic absorption Spectrophotometry of Dust samples

Spectrophotometry of Dust samples

Comparatively, the x-ray fluorescence analysis of result obtained in the studied area is higher than what was obtained in eastern Moroccan cement factory except for CaO, MgO, and K_2O [7].

The health implication of this ugly trend is quite obvious. This dust with its high silica and sulphur content has a high vulnerability of causing cough in both children and adults during inhalation. Inhalation of siliceous dust causes siliceous diseases of the lungs [6]. Dust very close to the factory is capable of peeling off the honey layer of the skin, irritating the soles of the feet when dissolve in the body sweat.

Oral interactions with some members of the host community revealed that ailment like headache, chest pain, peeling off of the outer layer of the skin are very common in the community.

It has been observed that inhalation of some mineral particles can produce diseases in persons working in mines as well as processors and users of minerals. These mainly affect the lungs and the major pathogenic effect is the formation of fibrotic tissues in the lungs [6].

The degree of incapacitation or loss of operational capacity of the lungs is dependent on the amount and the type of mineral dust inhaled. This response of lungs to mineral dust with the attendant formation of fibrotic tissues is commonly referred to as pneumocomosis. These diseases not only affect quarry workers but also processors and users with varying degree of severity [6].

Dust also settle on the building walls, roofs, windows panes and doors causing mechanical abrasion and athletic blight. The presence of sulphur in the dust can also give rise to acid rain at distant locations as the dust move.

The factory losses useful raw material as well as finished products in form of dust as wastes. This massive ray material and product wastes coming from the factory in form of dust have negative effect on the economics of the factory due to low optimization of materials. Urgent attention is required to reverse this trend.

Apart from these direct effect of dust on man, its effect are also felt indirectly as it settles on dried foodstuffs, that is rice, groundnut, maize, yam, flour, and dried cassava. When the moisture contents of these foodstuffs are still high, the dust dissolves in this moisture and become absorbed and thereby contaminates the foodstuff.

Conclusion

This study has revealed that kiln dust released from Obajana cement factory posed some health challenge not only to the workers but also to the host community. Precipitation method is recommended for cleaning up the dust generated from the kiln, whatever products obtained can be used further.

Keeping in view the hazards of cement dust, it is advisable therefore, that the cement industry management, their workers and health officials should work together to adopt technical preventive measures, such as well-ventilated work areas and workers should wear appropriate apparel, mask, safety goggles. It is also suggested that cement mill workers must undergo pre-employment and periodic medical surveillance tests.

REFERENCES

1. U. G. Oleru (1984), pulmonary function and symptoms of Nigerian workers exposed to cement dust. Environ. Research, **33**: 379-385.
2. A.N.M. Abou Taleb, A.O. Musaniger, and R. B. Abdel Moneim (1995). Health status of cement workers in the United Arab Emirates, *J. Roy. Soc. Health*. **2**,378- 383.
3. V. Rafnsson, H. Gunnarsdottir, and M. Kiilunen (1997), Risk of lung cancer among masons in Iceland. Occup, Environ. Med. **54**, 184-188.
4. M.E. Mc Dowall (1984), a mortality study of cement workers, *Br. J.Ind. Med.*; **41**,179 -182.
5. http://www.docstoc.com/docs/65707447/Air-Pollution-Control-in-Cement-Industry-Project-Report---DOC.
6. E. W. Nsi, and P. Shallsuka (2001), Industrial pollution: A case study of dust pollution from a cement industry, *Journal of chem. Society of Nigeria*, **27** (1), 85-87
7. Z. Zerrouqi, M. Sbaa, M.Oujidi, M .Elkharmouz, S. Bengamra, and S. Zerrouqi (2007), Assessment of cement's dust impact on the soil using principal component analysis and GIS. *Int. J. Environ. Sci. Tech*., **5** (1), 125-134
8. T. Yahaya, and O. Joy (2011),Variation in Exposure to Cement Dust in Relation to Distance from Cement Company. *Research Journal of Environmental Toxicology*, **5**,*203-212.*