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AIR QUALITY ASSESSMENT IN THE VICINITY OF CEMENT COMPANY

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Abstract: This study investigated effect of cement production activities and seasons on the concentration of air pollutants such as Total Suspended Particle (TSP), Thoracic Particulates viz respairable and inhalable sizes ($PM_{2.5}$ and PM_{10}) and gaseous pollutants: Carbon monoxide (CO), Sulphur dioxide (SO_2), Oxides of Nitrogen (NO_x) and Hydrogen sulphide (H_2S). The cement company is located in Ogun State, Nigeria between latitude 6^{o} $54^{'}$ N – 6^{o} $55^{'}$ N and longitude 3^{o} $12^{'}$ E – 3^{o} $12^{'}$ E – 3^{o} $13^{'}$ E; studied between July – December, 2010. Sampling was carried out at Production plant (starting point), Administrative office (400 m), Ewekoro community (500 m), Cement mill (800 m), Ajobiewe community (1000 m) and Agbesi estate (1500 m). The samplers used were Stage gravimetric sampler (for suspended particulate matters), Tetra multi-gas monitor (CH_4, CO and H_2S), Multi gas meter, Land Duo (CO_2, NO and NO_x) and BW, Model 0539, gas alert (SO_2). Data were analyzed using descriptive statistics and analysis of variance. Test of significance of the means was by the Least Significant Difference and Duncan Multiple Range test. Significant concentrations of TSP, PM_{10}, $PM_{2.5}$, SO_x, NO_x CO and H_2S were observed in the vicinity of Cement Company. Higher concentration of PM was observed in the dry season than wet season. Cement production activities release air pollutants. There is need to reduce the rate of emission during cement production to the lowest minimal level by using air trapping devices.

Keywords: Air, Quality, Cement, Production

INTRODUCTION

Air pollution is the introduction of chemicals, particulate matter or biological materials into the atmosphere that causes damage to human health and the natural environment (EPA, 1997). The introduction may be natural or anthropogenic. In addition to the natural changes that occur in the atmosphere such as volcanic eruption, wildfires and dust storm, many human activities release trace amounts of gases or particulates that can result in a variety of impacts on the environment (Clayton and Clayton, 1982; Nriagu and Davidson, 1986). The burning of coal, oil, and natural gas, as well as deforestation and various agricultural and industrial practices, have led to the increase in atmospheric concentrations of a number of greenhouse gases, such as carbon dioxide, methane, nitrous oxide, chlorofluorocarbons, and ozone in the lower part of the atmosphere (EPA, 1997). Exposure to air pollution can cause acute health effects include eye irritation, headaches and nausea; and chronic health effects include decreased lung capacity and

lung cancer resulting from long-term exposure to toxic air pollutants (Sunyer, 2001). Industrialization is a prerogative for any country that intends to develop its economy. In Nigeria, one of the fast growing industrial sectors is cement company. The cement industry is one of the oldest and the most important industries in Nigeria's developing economy as well as one of the greatest environmental polluters (Akeredolu *et al*., 1994). The main environmental issues associated with cement production are emissions to air and energy use. About 8 million tones of cement are produced per annum from the 8 companies operating in Nigeria (All Africa, 2008). These companies vary both in technology and status. The older the technology used, the more environmentally unfriendly the industry. Assessing air quality within the premises and the communities located around a cement company will help to anticipate the impacts of cement production on the concentration of greenhouse gases in the atmosphere that could contribute to climate change since the number of cement company is kept increasing in Nigeria. However, the objectives of this research work were to identify the air pollutants associated with cement production and determine effect of seasons on the concentration of air pollutants in the vicinity of the cement company.

MATERIALS AND METHODS

Study area

Figure 1 shows the location of the cement company with respect to communities, farmlands, water resources and road networks in Ewekoro Local Government Area, Ogun State, Nigeria. The climate of the study area follows a tropical pattern with the rainy season lasting for between seven and eight months between April and October with an interruption in August and the dry season running through November till February. The monthly agrometeorological condition of the Local Government Area was shown in Table 1.

Air sampling and analysis

A total of six (6) sampling points which include the Production plant (starting point), Administrative office (400 m), Cement mill (800 m) and neighboring communities (Ewekoro, 500 m, Ajobiewe, 1000 m, and Agbesi Estate, 1500 m) were used. Sampling coordinates and the distance of the sampling locations from the Production plant were given in Table 2. The parameters measured were Total Suspended Particle (TSP), Thoracic Particulates viz respirable and inhalable sizes ($PM_{2.5}$ and PM_{10}) and gaseous pollutants: Carbon monoxide (CO), Sulfur dioxide (SO_2), Oxides of nitrogen (NO_x).

Total Suspended Particle (TSP)

Sampling was undertaken using a single stage low volume-sampling pump (Negretti 1000 air sampler) fitted with steady state flow regulator, timer and flow meter. The concentration of TSP in $\mu g/m^3$ collected per volume of ambient air sampled was obtained by dividing the difference between the filter weight after and before sampling by the total volume of air sampled.

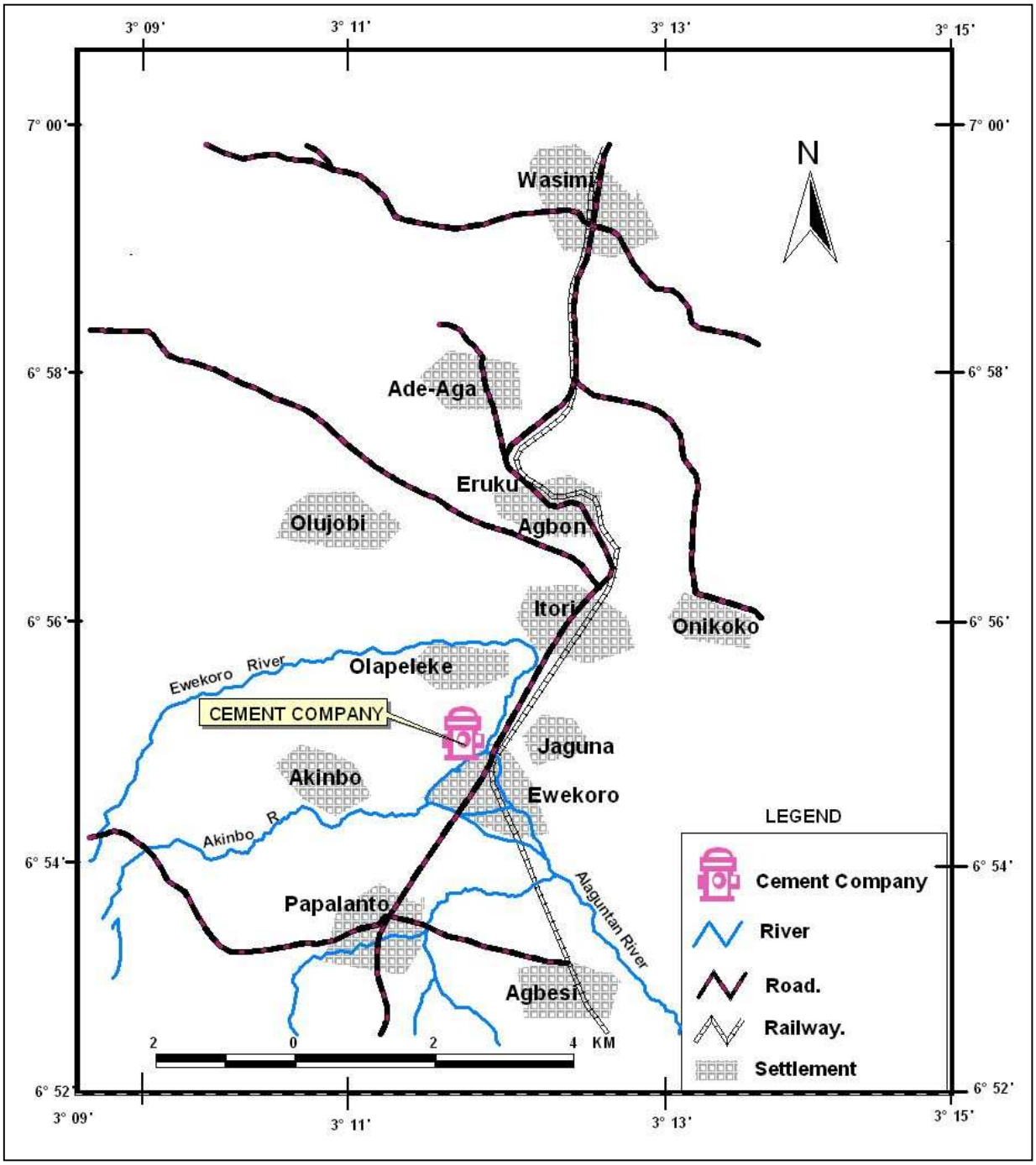

Figure 1: Location of the cement company in Ewekoro Local Government area

Table 1: Monthly agrometeorological observation

Parameter	Jan	Feb	March	April	May	June	July	Aug	Sep	Oct	Nov	Dec
Rainfall (mm)	4.4	41.2	58.9	112.7	169.6	98.3	322.9	266.6	257.6	172.3	94.7	0.0
Relative humidity (%)	80.9	78.3	78.8	78.8	80.5	85.4	87.7	85.9	85.9	81.7	86.0	81.1
Sunshine (hours)	5.3	6.4	3.9	7.0	7.2	7.1	5.5	4.5	5.3	6.2	6.4	7.2
Wind speed (km/day)	2.3	11.9	10.6	7.5	4.3	2.8	5.9	5.9	3.1	1.1	0.6	0.4
Evaporation (mm)	4.1	5.5	4.9	5.7	5.3	2.3	3.3	1.5	3.0	3.1	3.1	3.0
Temperature (°C)	28.1	30.7	29.4	28.5	28.0	27.4	25.9	26.1	26.7	27.3	27.1	27.2

Source: FUNAAB Meteorological Station, 2010

Table 2: Coordinates and distance of sampling locations from production plant

Sampling location	Distance / m	Latitude	Longitude
Production plant	0	N6°54.180'	E3°12.456'
Administrative office	400	N6°54.092'	E3°12.273'
Ewekoro	500	N6°54.479'	E3°12.496'
Cement mill	800	N6°54.125'	E3°12.420'
Ajobiewe	1000	N6°53.885'	E3°12.144'
Agbesi Estate	1500	N6°53.592'	E3°12.017'

$PM_{2.5}$ and PM_{10}

Air is drawn into the combined $PM_{2.5}$ and PM_{10} sampler (the stacked Gent sampler) through the Stacked Filter Unit (SFU). For $PM_{2.5}$ and PM_{10}, the concentration of particulate matter of a specific aerodynamic diameter was then computed.

Gaseous pollutants

Tetra multi-gas monitor was used to measure CH_4, CO and H_2S.
For CO_2, NO and NO_x, Multi gas meter (Land Duo) was used.
BW (Model 0539) gas alert was used to measure oxides of sulphur (SO_x)

Statistical analysis

Data were analyzed using descriptive statistics (for instance mean). Analysis of Variance (ANOVA) was used to determine the significant effect of sampling location and seasons

on the concentration of $PM_{2.5}$, PM_{10} and TSP. Test of significance of the means was by the Least Significant Difference (LSD) and Duncan Multiple Range (DMR) test. Pearson correlation coefficient was carried out to know the association between distance and suspended particulate matter.

RESULTS

Concentration of suspended particulate matters in the vicinity of the cement company
Concentration of the Total Suspended Particulate (TSP) decreased significantly ($P < .05$) with distance from production plant (Table 3). Significant increase in the concentration of TSP was observed at the production plant while the least concentration was observed at Ajobiewe community. However, no significant ($P < .05$) difference in TSP between Administrative office area, Ewekoro community and cement mill.
Production plant had higher concentration of particulate matter with aerodynamic diameter size of 10 i.e. PM_{10} compared to other locations (Table 3). Ajobiewe community had the lowest concentration.

Table 3: Effect of distance on the concentration of suspended particulate matter ($\mu g/m^3$) in the vicinity of cement company.

Sampling location	Distance / m	TSP	PM_{10}	$PM_{2.5}$
Production plant	0	386.53^a	215.15^a	21.40^e
Administrative office	400	288.22^b	100.51^c	50.56^c
Ewekoro	500	284.69^b	93.10^c	75.87^a
Cement mill	800	303.90^b	75.22^d	27.79^d
Ajobiewe	1000	152.46^d	58.20^d	13.81^f
Agbesi estate	1500	228.94^c	179.08^b	58.43^b

Means in the same column followed by the same superscript are not significantly ($P < .05$) different according to Duncan Multiple Range Test (DMRT)

Ewekoro community had the highest concentration of particulate matter with aerodynamic diameter size of 2.5 i.e. $PM_{2.5}$ followed by Agbesi Estate and Administrative office area (Table 3). The least concentration was observed in Ajobiewe community. There was significant ($P < .05$) negative correlation between distance and suspended particulate matter (Table 4).

Concentration of suspended particulate matters in relation to different seasons
Different seasons of the year virtually had significant ($P < .05$) effect on the concentration of particulate matter observed at various locations within the vicinity of cement company (Table 5). Concentration of TSP ranged from 209.92 – 501.53 $\mu g/m^3$ in dry season and 95.00 – 271.54 $\mu g/m^3$ in rainy season (Table 5). Highest concentration of TSP was observed in the production plant in both the dry and wet season. Concentration of TSP in the dry

season at the production was 84.56 % higher than that of wet season in the same location (production plant). Similar trend was observed for other locations in both dry and wet seasons. Concentrations of TSP decreased significantly ($P < .05$) with increased distance from the production plant in both dry and wet seasons.

Concentration of PM_{10} ranged from 70.00 – 326.75 µg/m^3 and 41.61 – 157.65 µg/m^3 in dry and wet seasons respectively (Table 5). Concentration of SPM_{10} decreased with distance away from the production plant in both dry and wet seasons. Concentration of PM_{10} in the dry season at the production plant was 107.00 % higher than the concentration of PM_{10} in the same production plant during the rainy season.

However, concentration of $PM_{2.5}$ in the dry season ranged from 9.33 – 112.14 µg/m^3. It ranged from 15.21 – 43.98 µg/m^3 in the wet season (Table 5). At every location, expect Ajobiewe community, concentration of $PM_{2.5}$ in the dry season was higher than in the wet season. In both the dry and wet seasons, the concentration of $PM_{2.5}$ decreased with distance away from the production plant. Concentration of $PM_{2.5}$ in the dry season at the production plant was 68.75 % higher than the wet season at the same production plant.

Table 4: Correlation coefficient between distance and suspended particulate matter

	Distance	TSP	PM_{10}	$PM_{2.5}$
Distance	1.000			
TSP	-0.757*	1.000		
PM_{10}	-0.191	0.559	1.000	
$PM_{2.5}$	0.133	0.045	0.041	1.000

* Correlation is significant at the 0.05 level (1-tailed).

Table 5: Effects of seasons on the concentration of TSP, PM_{10} and $PM_{2.5}$ (µg/m^3) in the vicinity of cement company.

Sampling location	Distance / m	Dry season			Wet season		
		TSP	PM_{10}	$PM_{2.5}$	TSP	PM_{10}	$PM_{2.5}$
Production plant	0	501.53	326.75	26.62	271.54	103.56	16.19
Administrative office	400	326.83	135.68	57.16	249.60	65.34	43.98
Ewekoro	500	339.01	144.58	112.14	250.96	41.61	39.61
Cement mill	800	318.43	70.23	40.37	268.80	80.21	15.21
Ajobiewe	1000	209.92	73.73	9.33	95.00	42.67	18.29
Agbesi estate	1500	255.54	200.51	89.59	202.34	157.65	27.09

Sum	1951.26	951.48	335.21	1338.24	491.04	150.37
LSD (0.05)	20.83	16.80	2.13	20.83	16.80	2.13

LSD: Least Significant Difference

Greenhouse gases concentration in the vicinity of the cement company

Significant increase in sulphur dioxide concentration was observed at Production plant and Ewekoro community (Table 6) while Cement mill, Ajobiewe community and Agbesi Estate had the least. Higher concentration of nitrogen oxide (NO_x) was observed at the Production plant followed by the Ewekoro community and Administrative office (Table 6). The least NO_x were observed at Cement mill, Ajobiewe community and Agbesi Estate. However, significant increase in the concentration of carbon monoxide (CO) was observed at the production plant followed by the Administrative office and Ewekoro community (Table 6). Cement mill, Ajobiewe community and Agbesi Estate had the least. Highest concentration of Hydrogen sulphide (H_2S) was observed at the production plant and cement mill while Ajobiewe community and Agbesi Estate had the least (Table 6).

DISCUSSION

Significant increase in the concentration of Total Suspended Particulate (TSP) matter was observed at the production plant. Total suspended particulate is mostly generated at the production plant during the process of crushing the limestone into smaller pebbles before it is milled into powdery form (Blezard, 1998; EIPPC, 2001). Blezard (1998) also stated that in the process of cement production, the steps of raw material processing, fuel preparation, clinker burning and cement grinding constitute major emission sources for particulate components. The concentration of the TSP decreased with increasing distance from the production plant. Particulate found at other locations might be due to wind action on ambient air and various activities performed at the different locations such as milling of lime stone at the cement mill and packaging of the cement into bags.

Concentration of the inhalable fractions of particulate matter (PM_{10}) reduced as the distance increased. This might be due to large fractions of PM_{10} which cannot be carried farther away by air. Concentration of PM_{10} within 0 – 500 m was greater than the recommended standard of

Table 6: Greenhouse gases concentrations (ppm) in the vicinity of cement company

Sampling location	Distance / m	SO_2	NO_x	CO	H_2S
Production plant	0	3.63	4.50	0.48	0.09
Administrative office	400	0.97	2.81	0.30	0.08
Ewekoro	500	3.33	3.90	0.30	0.08
Cement mill	800	0.09	0.09	0.09	0.09
Ajobiewe	1000	0.09	0.09	0.09	0.33
Agbesi estate	1500	0.09	0.09	0.09	0.33

LSD (0.05)	0.52	1.23	0.05	0.02

80 µg/m^3 (World Bank, 1998). Concentration of the respairable fractions ($PM_{2.5}$) was not uniform. It was observed to be higher at locations situated within the range of 400 – 800 m and the value (27.79 - 75.87 µg/m^3) was higher than the set standard of 25 µg/m^3 (WHO, 2005). This might be due to the light weight of $PM_{2.5}$ and the easy to be transported by wind. Hence they were blown farther away from the point source.
Concentrations of SPM were higher during the dry season compared to the wet season. This might be due to the fact that during the dry season the weight of the particulates are lighter hence they can be blown easily by air to farther locations from the point source unlike during the wet season when the dust would have been washed down by rain thereby reducing the effect of wind action on it.

Greenhouse gases such as Sulphur dioxide (SO_2), Nitrogen dioxide (NOx), Carbon monoxide (CO) and Hydrogen sulphide (H_2S) were observed in vicinity of the cement Company. The most important environment, health and safety performance issues facing cement industry are atmospheric releases including greenhouse gases emission: NO_x, SO_2, and particulates (Francis, 1977; EIPPC, 2001; PCA, 2007). Blezard (1998) stated that higher SO_2 emissions by rotary kiln systems in the cement industry are often attributable to the sulphides contained in the raw material, which become oxidized to form SO_2 at the temperatures between 370 °C and 420 °C prevailing in the kiln preheater. Significant concentrations of SO_2, NOx, CO and H_2S observed at Ewekoro community (500 m) compared to administrative office (400 m) might be due to activities going on in former area. Ewekoro community is also known as tanker packing lot. The exhaust from the trailers when the engines were on could also contribute to the concentration of SO_2 present at the location. .However, the concentrations of SO_2, NOx, CO and H_2S obtained for all locations were within the set standards (World Bank, 1998; WHO, 2005).

CONCLUSION

Air pollutants such as TSP, PM_{10}, $PM_{2.5}$, SO_x, NO_x CO and H_2S were observed in the vicinity of Cement Company. Concentrations of air pollutants decreased with distance. Higher concentration of PM was observed in the dry season than wet season.

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