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AIR QUALITY AROUND SOME CEMENT INDUSTRIES IN PORT HARCOURT, NIGERIA

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ABSTRACT

The quality of air around some cement industries operating in Port Harcourt Nigeria was assessed using WHO recommended methods involving a high volume sampler, a train of impingers fitted with bubbler devices and digital gas monitors. The results showed low levels of gaseous pollutants. The concentrations of SPM and NO_2 varied between 678.9 and 996.2µg/m^3 and 7.8µg/m^3 and 20.0 µg/m^3 respectively at Atlas cement and were lower than 607.7 and 23,198.5µg/m^3 and 27.45 and 140.7µg/m^3 respectively at Eagle cement area. Statistical analysis showed significant difference ($P<0.05$) between the indoor and outdoor mean concentrations of SPM at the cement industries. The concentrations of SPM in all the stations and NO_2 at station 1 at Eagle cement exceeded guideline values. These imply serious environmental and health concern. Cement dust in form of SPM arising from cement unloading, transfer, bagging and loading on to trucks was found to be the major problem in the cement industry and bagging of cement in an open area is better than enclosed factory. Therefore the quality of air around cement industries need to be monitored regularly.

Key words: Air, Pollutant, Cement, Dust, Pollution.

INTRODUCTION

There is increasing recognition of the need for concerted and effective action to improve the quality of air in our environments. Air pollution is becoming a major factor in the quality of life of urban and rural dwellers, posing a risk both to human health and to the environment. In order to develop appropriate air quality management plans, however, it is necessary first to have reliable information about the state of pollution.

Airborne particulate matter, also called suspended particulate matter (SPM) can be found in ambient air in the form of dust, smoke, or other aerosols. SPM may be anthropogenic and/or natural origin. Direct sources of SPM include burning of fossil fuels (coal, oil wood) for power generation, heating and transportation; construction and industrial activities; as well as soil erosion (wind blown dust), forest fires, volcanic eruptions, and pollen. SPM can occur as a secondary aerosol resulting from atmospheric transformation of gaseous pollutants emitted from combustion sources (e.g. power plants and automobiles) or natural sources such as forests. Particles can also result from condensation of volatile elements and species in the atmosphere to

form very small particles or absorb on the surface of already formed, finely, divided particles. The effects of SPM depend on its chemical composition and physical characteristics. SPM can soil painted surfaces, corrode metals, reduce visibility, and aggravate respiratory and cardiovascular disease.

Carbon (iv) oxide (CO) is emitted into the atmosphere mainly as a product of the incomplete combustion of carbonaceous material. The major sources of CO exposure for the general, non-smoking population are exhaust emissions from combustion engines and the burning of fossil fuels. Smoking provides an addition to source of CO for the non-smoking public. In addition to these exogenous sources, CO is generated endogenously mainly from the breakdown of haem proteins. Healthy individuals can tolerate low-level exposures to CO but it can be hazardous at higher concentrations and even at low concentrations for those with unusual susceptibility. Carbon (iv) oxide is a poisonous gas having a lifetime of two to four months in the atmosphere. It affects the oxygen-carrying capacity of hemoglobin.

The sources of H_2S are microbial decay of organic matter and reduction of sulphate ion as represented in equation 1 below.

$$SO_4^{2-} + 2(CH_2O) + 2H^+ \longrightarrow H_2S + 2CO_2 + 2H_2O \quad \text{---------- (1)}$$

Because of high concentration of sulphate ion in seawater, bacterially mediated formation of H_2S causes pollution problems in some coastal areas and is a major source of atmospheric sulphur (Manahan, 1979).

Ammonia is present in the atmosphere as a result of natural biochemical and chemical processes. Ammonia in polluted atmosphere reacts readily with acidic materials such as sulphuric acid aerosol droplets to form ammonium salts as shown in equation 2:

$$NH_3 + H_2SO_4 \longrightarrow NH_4HSO_4 \quad \text{---------- (2)}$$

Animals are exposed to air pollutants via three pathways: (1) inhalation of gases or small particles, (2) ingestion of particles suspended in food or water, or (3) absorption of gases through the skin. An individual's response to a pollutant varies greatly and depends on the type of pollutant involved, the duration of exposure and the amount taken up by the animal. Factors such as the individual's age, sex, health and reproductive condition also play a role in its response (Maniero, 1996). In addition to affecting individual animals or populations directly, air pollutants also affect wildlife indirectly by causing changes in the ecosystem. (Maniero, 1996)

Volatile organic compounds (VOC) and nitrogen oxides (NO_x) once emitted undergo chemical transformation in atmosphere in the presence of sunlight to form ozone. Ozone, sulphur (iv) oxide and nitrogen (iv) oxide primarily affect the respiratory system and studies on laboratory animals and humans show that all three pollutants irritate the lining of the lungs and cause respiratory stress (Coffin and Stokinger, 1976).

Sulphur dioxide is regarded as being the most important phytotoxic air pollutant emitted from industrial sources and NO_2 as the second most important (Fowler and Cape, 1982). SO_2 and NO_2 when released into the atmosphere may become incorporated in clouds and be deposited later as rainfall in the form of dilute sulphuric and nitric acids. Sulphur dioxide and nitrogen oxides emitted as a result of fossil fuel combustion undergo chemical transformation in the atmosphere and occur as sulphate, nitrate and hydrogen ions when dissolved in precipitation. An ecosystem's

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susceptibility to acidification is determined by the alkalinity or acid neutralizing capacity of its soil and water (Munson and Gherini, 1991).

This study was carried out to evaluate the current state of the ambient air environment around cement industries operating around Port Harcourt and create awareness among workers and the host communities.

THE STUDY AREAS

The Atlas cement facility is located along the Onne Creek (Nmu Ngololo River), a tributary of the Bonny River upstream of the Federal Ocean Terminal at Onne. Cement bagging is done on a barge-the Atlas Enterprise, that is berthed on the creek while the loading facilities and the truck turning and marshalling area are on a reclaimed swampy area that is piled into a platform.

The Eagle cement (Eastern Bulkcem) company limited, a cement bagging company is located in Rumuolumeni community along the New Calabar River. Cement is imported in confined moveable vessels of 2, 500 tons of cargo capacity. The company has two other subsidiaries Milford Marine limited and Port Harcourt sacks limited which produces paper sacks for the cement industry.

The climate of the area is humid and of the semi-hot equatorial type. Rainfall is heavy and mostly round the year except for a short dry season between November to January. The area has a double maxima rainfall with first peak usually around June/July and the second in September before the onset of dry season (Oyegun and Ologunorisa, 2002)

MATERIALS AND METHODS

Air pollutants measurements were made at different locations within and outside the cement companies. The choice of the locations was based on accessibility and wind direction. The stations are identified below:

Station 1: Loading/bagging bay
Station 2: Located inside sack factory/ bagging ship
Station 3: Located within the premises (outside factory)
Station 4: Located at the Jetty/terminal access.

Seven potential air pollutants were determined. These are suspended particulate matter (SPM), Nitrogen dioxide (NO_2), sulphur dioxide (SO_2), Carbon monoxide (CO), Total Hydrocarbons (THC), Ammonia (NH_3), and Hydrogen Sulphide (H_2S).

SAMPLE COLLECTION AND ANALYSES

The sampling equipment used include a high volume sampler for SPM, a train of impingers fitted with bubbler devices for NO_2, SO_2, THC, NH_3, H_2S and an automatic gas monitor for carbon monoxide. Adequate quality control and assurance measures were employed during sample collection and analyses. For instance the impingers were wrapped with aluminum foil, SPM soiled filters were sealed in envelopes, while gaseous samples except CO were collected in amber bottles and stored in a cooler. Also measurements were made at about 1.5m above ground and replicated analyses were made.

The modified USEPA high volume gravimetric method was used for the collection of Suspended Particulate Matter (SPM). The technique involves drawing a known volume of air through a preweighed glass fiber filter by means of a heavy duty

turbine blower at a flow rate of 1.3m^3/min (WHO, 1976: Lahman, 1992).

The Griess Saltzman method was used for the collection of Nitrogen dioxide. The technique is based on the reaction of nitrite ion with diazotizing coupling reagents to produce a deeply colored azo-dye which is measured on a spectrophotometer (Saltzman 1954, Lahman, 1992).

The West Gaeke method was used for the collection of Sulphur dioxide. Its principle is based on the interaction of sulphur dioxide with potassium Tetrachloro mercurate solution. The resultant complex reacts with pararosaniline and formaldehyde to produce a colored complex which is measured on a spectrophotometer (WHO, 1976: Harrison 1982).

The method for the collection of Hydrogen sulphide involves reacting the sample solution with standard iodine solution. The resultant solution is acidified and titrated with standard Sodium thiosulphate solution. (APHA, 1995).

The hydrocarbon in the air was absorbed into an organic solvent such as toluene and analyzed by chromatographic and spectrophotometric methods (Manahan, 1979).

The phenate method based on the formation of an intensely coloured indophenol was used for the collection of Ammonia and the intensity was measured in a spectrophotometer (APHA, 1995).

The methods of analysis used in this study are mainly those recommended by the World Health Organization (WHO) which has been adopted by the Federal Ministry of Environment. The choice of methods was based on criteria such as stability, sensitivity, repeatability and capability for calibration.

RESULTS AND DISCUSSION

The results of ambient air pollutants measured around Eagle and Atlas cement companies are presented in Tables 1 and 2.

Low levels of gaseous pollutants were measured at both study areas. The concentrations of SPM were found to be generally higher than gaseous pollutants because during abatement periods of the wind, the heavier SPM are easily deposited while the gaseous pollutants disperse faster.

Stational variations of pollutant levels were observed owing to location which was based on the direction of the prevailing wind, and the period of the day when samples were colleted at each station. In general samples were collected during moderate relative humidity (75%), low temperature ($29^{o}C$) and the wind speed varied between 2m/s and 5m/s. the south-westerly (SW) wind was predominant throughout the sampling period. The low levels of pollutants measured could be attributed to dilution and dispersion. Rainfall cleanses the atmosphere of emissions from natural and anthropogenic sources.

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Table 1: Concentrations of air pollutants measured around Atlas Cement Company

Station No	Pollutants						
	SPM $\mu g/m^3$	NO_2 $\mu g/m^3$	SO_2 $\mu g/m^3$	NH_3 $\mu g/m^3$	H_2S $\mu g/m^3$	THC $\mu g/m^3$	CO ppm
1	827. 1	20.0	<25.0	<0.5	<0.1	15.3	2.0
2	996.2	7.8	<25.0	<0.5	<0.	48.5	2.0
3	909.8	19.4	<25.0	<0.5	<0.1	27.5	1.0
4 (control)	678.9	13.8	<25.0	<0.5	<0.1	39.5	1.0

Table 2: Concentrations of air Pollutants Measured around Eagle Cement Company

Station No	Sample NO.	Pollutants					
		SPM $\mu g/m^3$	NO_2 $\mu g/m^3$	SO_2 $\mu g/m^3$	THC $\mu g/m^3$	NH_3 $\mu g/m^3$	CO ppm
1	1	23,183.0	141.4	25.0	50.0	40.0	5.0
	2	23,198.5	140.7	25.0	51.25	38.8	5.0
2	1	1,253.1	53.8	25.0	10.0	0.5	2.0
	2	1226.05	52.15	25.0	9.25	0.5	2.0
3	1	1,879.7	45.0	25.0	37.9	0.8	3.0
	2	1833.85	46.5	25.0	40.95	0.8	3.5
4	1	626.6	28.2	25.0	7.0	0.5	3.0
(control)	2	607.65	27.45	25.0	7.0	0.5	3.0

Table 3: Comparison of Mean Concentrations of air pollutants with FEPA Guidelines

Pollutants	Mean Concentration								FEPA
	Station 1		Station 2		Station 3		Station 4		
	Eagle	Atlas	Eagle	Atlas	Eagle	Atlas	Eagle	Atlas	
SPM	23,190.8	996.2	1,239.6	827.1	1,856.8	909.8	617.1	678.9	600
NO_2	141.1	20.0	53.0	7.8	45.8	19.4	27.8	13.8	75
SO_2	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	260
NH_3	39.4	0.5	0.5	0.5	0.8	0.5	0.5	0.5	200
THC	50.6	48.5	9.6	15.3	39.4	27.5	7.0	39.5	160
CO	5.0	2.0	2.0	2.0	3.5	1.0	3.0	1.0	10

The concentrations of SPM and NO_2 varied between 678.9 and 996.2 $\mu g/m^3$ and 7.8$\mu g/m^3$ and 20.0$\mu g/m^3$ respectively at Atlas cement and were lower than 607.7 and 23198.5$\mu g/m^3$ and 27.45 and 140.7$\mu g/m^3$ respectively measured at Eagle cement area. There is high positive correlation between the concentrations of SPM (r = 0.7380) and NO_2 (r = 0.5017) between Eagle and Atlas cement companies. The concentrations of SO_2 were below detection limits (25$\mu g/m^3$) of the analytical method. This could be attributed to the very low sulphur content of fuels burnt in the area. However appreciable levels of NH_3 was measured only at Eagle cement (0.5$\mu g/m^3$ – 40.0$\mu g/m^3$) while the concentrations of NH_3 at Atlas cement area were below detection limit (0.5$\mu g/m^3$).

The high level of NH_3 measured at station 1 at Eagle cement could be attributed to chemical reactions of emissions from machines, paints, etc within the station which is poorly ventilated.

The levels of THC at Atlas cement varied between 15.3µg/m^3 and 48.5µg/m^3 while the levels varied between 7.0µg/m^3 and 51.3µg/m^3 at Eagle cement area. Although the THC levels at Eagle cement is slightly higher, appreciable levels of THC were measured at both sites. The levels of CO at Atlas cement varied between 1.0ppm and 2.0ppm while at Eagle cement the levels varied between 2.0ppm and 5.0ppm.

The concentrations of air pollutants measured around Eagle cement were higher than those measured around Atlas cement. The highest concentrations of SPM (996.2µg/m^3), NO_2 (20.0µg/m^3) and THC (48.5 µg/m^3) were measured at station 1. The transfer of cement from the ship to the production bardge through an open pontoon as well as emissions from the exhausts of the electric generators greatly influenced the level of pollutants measured at station 1 which is located at the down wind direction on the bardge. The high level of pollutants at stations 1 and 2 at Eagle cement result from the fact that they are located indoors. While station 1 is a loading bay with its attendant cement dust and fumes, station 2 is a sack bag manufacturing factory with sack flakes, printing paint/ink and machines. This observation is attributed to poor ventilation and minimal wind speeds at the indoor locations at Eagle cement while all production operations at Atlas cement were located outdoor. At both stations, the poor ventilation and circulation of wind influenced the dispersal of the dust and other pollutants, hence their increased levels measured. Statistical analysis showed significant difference ($p < 0.05$) between the indoor and outdoor mean concentrations of SPM measured at Eagle Cement Company. However, there was no significant difference ($p > 0.05$) between the mean concentrations of SPM ($r = 0.8839$), NO_2 ($r = 0.4910$) and THC ($r = 0.9056$) measured at Eagle and Atlas cement operational areas. The result therefore showed high positive correlation in the concentrations of SPM and THC between Eagle and Atlas cement companies.

It was observed that at Eagle cement with the exception of CO, higher concentrations of pollutants were measured within the company than those measured outside the company (station 4) which serves as control. The concentration of CO at the control was influenced by emissions from the surrounding settlement. Also at Eagle cement with the exception of CO, the least level of pollutants were measured at station 4, the control site. Although ambient measurements were made at stations 3 and 4, the results at station 3 are higher than those at station 4. This could be attributed to vehicular activities, emission from electric generators and air born cement dust within the premises. With the south-westerly wind which was prevailent during sampling, the company is at the upwind of the road leading to the company. Therefore the pollutants measured were not mainly caused by activities on the untarred road leading into the company. At Atlas cement area the pollutant concentrations did not show any regular pattern. While the least concentrations SPM and CO were measured at the control site, the least concentrations of NO_2 and THC were measured at the bagging area. The high levels of NO_2 and THC at the control site at Atlas cement and CO at Eagle cement are attributed to emission from vehicular activities within and outside (access roads) the company premises and domestic activities from nearby communities especially at the Eagle cement site. However, the

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concentrations of SPM measured in the areas were mainly contributed by cement dust from the transfer, loading and offloading of cement and emissions from loading machines. In addition, during momentary reversal of the wind direction emission from vehicles stopped at the gate for security clearance also influenced the levels of pollutants measured in the areas.

The values of NO_2 obtained in this study can combine with water vapour to form trioxonitrate (v) acid which is a component of acid rain. In combination with hydrocarbon in the atmosphere, oxide of nitrogen may form photochemical oxidants which irritate the eyes. The levels of THC measured could stain materials. In particular, ethylene can inhibit plant growth while polynuclear aromatic hydrocarbons are carcinogenic.

Carbon monoxide is a poisonous gas having a life time of two to four months in the atmosphere, and affects the Oxygen carrying capacity of haemoglobin.

The low level of CO measured in the study areas is due mainly to natural sources such as biological processes and anthropogenic sources such as combustion of carbon-containing fuels.

The mean concentrations of the pollutants were compared with the air quality guidelines suggested by the Federal Ministry of Environmental of Nigeria (FEPA, 1991). The concentrations of SPM in all the stations of both companies and NO_2 at station 1 at Eagle cement exceeded the guidelines values. These could lead to serious environmental and health problems. Suspended Particulate Matter has adverse effects on human health. It can soil painted surfaces, corrode metals; reduce visibility and aggrevate respiratory and cardiovascular diseases. The level of SPM measured is very high and can easily cause asthma or other respiratory diseases as the place was choking during sampling. However Bennett et al., (1987) showed that variability in the deposited fraction of SPM is a function of breathing pattern. Further studies have also shown that during resting and spontaneous breathing, the deposition of particles is independent of age (Bennett et. al., 1996).

The level of Nitrogen dioxide measured at station 1 can cause respiratory and sense impairment. In general, NO_2 can combine with SO_2 and water vapour to form acid rain. It can also combine with hydrocarbons in the atmosphere to form photochemical oxidants which irritate the eyes. The levels of NO_2 and THC at the control (station 4) at Atlas cement and CO at Eagle cement are attributed to emissions from adjacent roads and momentary reversals of the wind direction.

There was significantly high correlation between SPM and NO_2 ($r = 0.9455$), NH_3 ($r = 0.9991$), THC ($r = 0.598$), CO ($r = 0.8291$). There was also Significant correlation between NO_2 and NH_3 ($r = 0.9353$), CO ($r = 0.8736$). Also there was Significant correlation between NH_3 and CO ($r = 0.8176$).

CONCLUSION

The results of this study have shown that cement dust in form of SPM arising from cement unloading, transfer, bagging loading on to trucks is a major problem in the cement industry and bagging of cement in an open area as in Atlas cement company is better than enclosed factory. This implies that workers at Eagle cement and those in similar enclosed places are at higher risk. Appropriate protective covers, nose masts and frequent health check-up are essential for the workers in this sector.

Thus the quality of air around the cement industries need to be regularly monitored to ensure compliance with recommended regulations.

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