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Assessment of Indoor Air Quality in a Chemical Fertilizer Company, Onne, Nigeria

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Abstract: The indoor air quality of a nitrogenous fertilizer company was assessed using high volume sampler, impingers and noetox gas monitor. The parameters determined were suspended particulate matter, ammonia and carbon monoxide. The results showed that the mean levels of suspended particulate matter varied from 216.8±56.2-2,460.4 $\mu g\ m^{-3}$ at the study sites and 42.5 $\mu g\ m^{-3}$ at the control site. The mean values of ammonia ranged from 234.7±193.9 -805.2±53.9 $\mu g\ m^{-3}$ at the sites and 51.4±4.2 $\mu g\ m^{-3}$ at the control site. The mean values of Carbon dioxide varied between 1.07 ppm±0.71 and 4.65 ppm±7.93. The differences between the mean values of suspended particulate matter and ammonia at the study sites and control (Training house) were significant ($p<0.05$). The study showed that the levels of suspended particulate matter and ammonia at indoors of the selected sites present a health hazard, indicating that the factory workers are at high risk. The health impact of indoor pollution in the production areas of the company should therefore be closely monitored.

Key words: Air, indoor, fertilizer, pollution, parameters, production areas

INTRODUCTION

Indoor air pollution is one of the pollution problems that are potentially threatening man's health and wellbeing. In the past, air pollution assessment was based on data obtained from ambient air quality. However, such data do not represent actual total human exposure and are therefore not suitable for evaluating the health effects of indoor air pollution because people usually spend 80-90% of their time indoors (at home and/or in the office, or some other public areas) and the concentration of many major air pollutants such as Carbon monoxide (CO), Nitrogen dioxide (NO_2), Respirable Particulates (RP), formaldehyde (HCHO) and Volatile Organic Carbons (VOCs), have been found to be greater indoors than outdoors.

The health effects of air pollutants vary according to the intensity and duration of exposures and the health status of the persons exposed. It is therefore important to measure where the people are "for the assessment of total exposure (Smith, 1994). It has been reported that particles larger than about 10mm in diameter deposit in the vicinity of the sources, but smaller (respirable) particles remain air borne for extended period and are transported to long distances (UNEP/WHO, 1988). Under normal conditions indoor levels of Suspended Particulate Matter (SPM) are higher than outdoor levels. However, this depends generally on the type of activity such as vehicular or industrial (e.g. gas flaring), distance from activities and the occupation of the inhabitants (Ideriah *et al*., 2001).

In China, indoor air pollution is often more severe than outdoor air pollution owing to the use of coal for cooking and heating. Studies of the human health affects of air pollution carried out in various locations through out China and over a long period, show that air pollution suppresses the immunological function, decreases lung function and increases respiratory symptoms as well as respiratory disease.

Although indoor air pollution is largely attributable to combustion of biomass fuel, this study examines the indoor air quality status of selected sites of a nitrogenous fertilizer complex. Suspended Particulate Matter (SPM) and carbon monoxide are important indoor air pollutants and were determined along with ammonia as indices of air quality in the bagging, bagging loading floor, bulk storage and training house (control) within the complex.

The nitrogenous fertilizer complex owned and operated by the National Fertilizer Company of Nigeria Ltd. Onne is located between 4.49'and 4.5' North and 6.59' and 7.0$^{?}$East of the Greenwich Meridian.

MATERIALS AND METHODS

Site selection and description: Four study sites including a control were selected within the company; these sites are: Bagging floor, Bagging loading floor, Bulk storage and Training house. The housing structure for the first three sites is in the form of warehouses. The bagging loading floor is a block house with a tall zinc roof. There

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are two big entrance doors in opposite direction for the movement of lorries/trailers. The floor is cemented and activities go on inside the house. The Bagging room is upstairs of the bagging loading floor. Only bagging of fertilizers goes on there. In the bulk storage there is only one big door to allow vehicles but it is shielded by tarpaulin and has extractor fans but no windows. The control site is the training building within the plant complex.

Sample collection and analysis: The parameters determined were ammonia (NH_3), Suspended Particulate Matter (SPM) and Carbon monoxide (CO). Eight hour averaging time was used for ammonia, 24h for SPM and spontaneous measurement for CO.

A manual method of sample collection employing impinger with bubbler devices was used. The analytical procedure was based on the phenate method (APHA, 1995). The principle of the method is the formation of an intense blue compound, indophenol, catalyzed by a manganous salt. The intensity of the colour was measured at 630nm using a spectrophotometer (Spectronic 20). The concentration of ammonia was determined from a calibration curve of standards and related to the volume of air sampled in m^3.

The Suspended Particulate Matter (SPM) were collected on previously weighed glass fiber filter by a Hi-volume sampler and then analysed gravimetrically (WHO, 1988; Lahmann, 1992). The principle of the Hi-volume technique used is based on drawing in air by the Hi-volume into a covered housing through the filter by means of a heavy duty turbine blower at a flow rate of 1.6 m^3 min^{-1} which allows suspended particulate matter of size range of 0.1-100 µm diameter to be collected on the glass fiber filter. The mass concentration of particles in the indoor air was computed by dividing the mass of collected particulate matter by the volume of air sampled in m^3.

On the spot measurement was carried out with a portable Neotox CO monitor. Measurements were made at three points (both entrance/exit and centre) at each sampling site. The principle of the neotox CO monitor is based on the non-dispersive infra red technique. The air was sampled within breathing height.

RESULTS AND DISCUSSION

Results: The results of the indoor air quality study are given on Table 1-3. Table 1 gives the concentration of the suspended particulate matter at the selected sites. Mean values ranged from 216.8-2,460.4 µg m^{-3} at the study sites and 42.5 µg m^{-3} at the indoor of the control. Maximum values ranged from 273.0-4,515.9 µg m^{-3} at the study sites and 42.5 µg m^{-3} at a control site.

Table 1: Concentrations of SPM on the indoors of selected sites in a fertilizer complex

	Conc. (µg m^{-3})			
Sampling sites	Am	Asd	Max	Min
Bagging floor	216.8	±56.2	273.0	160.0
Bagging loading floor	226.7	±39.4	266.0	187.3
Bulk storage	2460.4	-	4515.9	404.8
Control	42.5	-	42.5	42.5

Am = Arithmetic mean, Asd = Arithmetic standard deviation, Max = Maximum, Min = Minimum

Table 2: Concentrations of ammonia (µg m^{-3}) at the indoors of selected sites in a fertilizer complex

	Conc. (µg m^{-3})			
Sampling sites	Am	Max	Min	Asd
Bagging floor	805.2	869.1	730.3	±53.9
Bagging load floor	478.5	572.0	330.4	±105.9
Bulk storage	234.7	565.1	77.8	±193.9
Control	51.4	55.5	47.2	±4.2

Table 3: Concentrations(ppm) of indoor carbon monoxide at selected sites at NAFCON.

	Sample point	Max.	Min	Am	Asd
Bagging floor	entrance	3	0	1.60	±0.82
	Center	3	0	1.07	±0.71
	End	3	0	1.22	±0.66
Bagging loading	entrance	47	1	4.39	±5.37
	Center	60	0	4.60	±6.62
	2nd entrance	35	0	4.46	±6.78
Bulk storage	Entrance	62	0	4.08	±8.17
	Centre	51	0	4.65	±7.93
	End	43	0	4.45	±6.68
Training house	1st entrance	3	0	1.96	±0.81
	Center	3	0	1.70	±0.98
	2nd entrance	3	0	1.53	±0.80

The levels of ammonia are presented on Table 2. Mean values ranged from 234.7- 805.2 µg m^{-3} within the sites and 51.4 µg m^{-3} at the control. Maximum values varied from 565.1- 869.1 µg m^{-3}.

Table 3 gives the concentrations of CO measured at the various sites. At the bagging floor and training house sites the maximum CO values of 3ppm did not vary. However the maximum for the bagging loading floor and bulk storage ranged from 35-62 ppm. In the bagging loading floor, the center had the highest value of 60 ppm, whereas in the bulk storage, the first entrance had the highest value of 62 ppm.

Discussion: The level of Suspended Particulate Matter (SPM) measured at the sites are attributed to fertilizer bagging and storage activities and emissions from trucks and lorries working within the sites. Maximum values were very high and are several folds higher than that of the control site (42.5 µg m^{-3}). The WHO recommendation for exposure to particulate mater for the general population gives a maximum, as measured by high volume sampler, of 150-230 µg m^{-3}, each being interpreted as the 98 percentile of daily average concentrations (WHO, 1998). The corresponding guideline in respect of chronic effects related to long- term exposures are 60-90 μg m^{-3} for SPM. Industrial sources are a major source from which SPM are emitted. These contain Polycyclic Aromatic Hydrocarbons (PAHs) some of which are known to be carcinogenic (WHO, 1984). The high maximum SPM values observed in this study 4,515.9 μg m^{-3} may cause health problems to the workers populations in this sector of the company. The threat is aggravated by the fact that at the indoor site studied there is no good ventilation and therefore no good equilibrium between indoor and outdoor air. In such circumstance, pollutants emitted indoor could persist for long. SPM includes Respirable Suspended Particulate (RSP) matter i.e. particles having a diameter less than 3.5 μm. These are inhaled into the terminal alveolar sacs in the lungs, where they usually are absorbed by the body defence system and remain there permanently. If the respirable matter is biologically active, e.g. carcinogenic, it acts over a prolonged period (WHO, 1984). High concentration of SPM at the sites therefore implies high human exposures because people (workers) actually spend long time in these places. Since SPM contains polycyclic aromatic hydrocarbons which are known to be carcinogenic or mutagenic (Sawicki, 1977). The high SPM levels indicate that there is increased risk of cancer and possibly also of birth defects among those who experience prolonged exposure to high levels of these particulates.

The levels of ammonia obtained in this study show that as high as 869.1 μg m^{-3} could be found indoors. This is 15.7 fold higher than the value at the control site. Ammonia is an air pollutant and a very important component of the nitrogen cycle. Indoor ammonia may originate from cleaning agents, metabolic processes and smoking or from external sources (Sisovic *et al*., 1986). Although ammonia is in the list of chemical irritants which may cause bronchial asthma (Kunkel *et al*., 1982), it’s presence in the indoor environments has been neglected, as it is considered to be a non-occupational hazard and is therefore not included in guidelines for indoor air quality (Sisovic *et al*., 1986). Prolonged exposure above a certain limit could result in chronic and irreversible damage to the respiratory tract, especially substances with irritant action like ammonia. They could impair respiratory function by disrupting normal defense mechanisms and enhance the risk of infection (WHO, 1984).

Mean values of carbon monoxide 1.07-4.65 ppm are within the normal range for indoor CO but the occasional maximal range of 35-62 ppm is high for an indoor environment with poor ventilation facilities. Indoor air pollution can be a serious problem if ventilation is poor. The entrance of the bulk storage had the highest CO level of 62 ppm followed by the middle of the bagging loading floor, 60ppm. The high CO level is attributed to emissions from the front end loaders working inside the bulk storage. In the bagging loading floor trailers and lorries are packed in the middle with their engines on waiting to be loaded. This relatively high value emanating from the center of the room is diluted and mixed with ambient air coming in through the two exit doors. Thus the maxima at the two doors are lower than at the center of the room. The difference in the maxima observed for entrance, center and end of the bagging loading floor and bulk storage implies that the air inside these buildings are not uniformly mixed. This of course is attributed to poor ventilation and the architectural design of the building. Carbon monoxide is an important indoor pollutant released from combustion sources and or vehicle exhaust. Concerns for high CO levels arises from carboxy-haemoglobin which restrict oxygen binding and transport in the blood and may lead to adverse neuro-behavioural and cardio-vascular effects, permanent impairment or death in closed environments (WHO, 1987). The principal health impacts of CO inhalation are various forms of hypoxia induced by the reduction in oxygen availability in body tissues. The CO range observed in this study is comparable with various other indoor studies carried out in Zagreb (WHO, 1982), China (WHO, 1985), Gambia (WHO, 1988)) and Kenya (WHO, 1987) where a range of 1.6-70.6ppm was observed for all of them.

CONCLUSION

The findings of this study show especially for SPM and ammonia in indoor of the selected sites, that the situation presents a health hazard. For CO, the levels are high occasionally but not in orders of magnitude as they are for SPM and ammonia. The health impact of indoor air pollution in major sites in the company should therefore be monitored. Indoor and outdoor studies should be done to provide information on total exposure and for two seasons of a year to establish if there is any seasonal effect on the indoor concentration of the pollutants.

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