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Assessment of Indoor Air Quality of Major Departments at a Medical Center in Abia State, Nigeria

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ABSTRACT

This study assessed the indoor air quality of selected departments at a medical centre in Abia State, Nigeria. Sampling was done in the morning peak (7:00 am to 9:00 am), and evening peak (4:00 pm to 6:00 pm) for each location. Sampling involved open-air sampling in the departments/wards, and this was done twice a week for a total of four months; July (M1), August (M2), September (M3) and October (M4). Sensitive air sampler device was used for carbon monoxide (CO), and particulate matter ($PM_{2.5}$ and PM_5) measurements. Extech thermo-anemometer was used for measurement of meteorological parameters like temperature, wind speed and relative humidity. The result shows that the mean wind speed was 0.52, 0.73, 0.71 and 1.20 m/s for M1 to M4 respectively. Mean carbon monoxide concentration was 3.49, 3.37, 3.33, and 3.50 ppm while mean particulate matter 2.5 were 144.38, 151.15, 165.79, and 142.21 ppm for M1 to M4 respectively. Mean particulate matter 5.0 were 126.37, 100.51, 147.71, and 167.54. for the first, second, third and fourth month respectively. Means of the control samples were all below the standard organization of Nigeria standard of 20 ppm for CO and 150 ppm for particulate matter respectively. Means of the CO, $PM_{2.5}$ and PM_5 differed significant ($P \leq 0.05$) over time. It was observed that the environment had low-moderate pollutant composition in the air and recommended that the use of poor gasoline engines, improper vehicular movement, incineration of waste generated from the hospital should be controlled.

1. INTRODUCTION

Air pollution is the introduction of chemicals, particulate matter or biological materials that cause harm and discomfort to human and other living organisms (Apte et al., 2015; Shittu et al., 2019). Air pollution is one of the most serious environmental threats to human populations, and it is associated with increased morbidity and death rate (Cohen *et al*., 2005, Lelieveld, *et al*., 2015; Amsalu *et al*., 2019). In the past few decades, global urbanization requiring intense energy consumption has resulted in increased emissions into the atmosphere and a decrease in urban air quality. Cities have increasingly become the nexus of air pollution due to emissions from anthropogenic activities within the cities (WHO, 2007; Hansen *et al*., 2013).

Indoor air quality (IAQ) refers to the air quality within and around buildings and structures, especially as it relates to the health and comfort of building occupants. Most people consider air pollution to be an environmental issue that occurs only in the outdoor environment (i.e., smog, ozone, airborne haze, or some smell from a nearby chemical factory), but contrary to this view, the air inside homes, offices, and other buildings can be more polluted than the air outside (Zhang et al., 2017; Seraj, 2019). Typical pollutants found in the air inside homes are formaldehyde, fire-retardants, radon, microscopic dust mites from moulds, volatile chemicals from fragrances used in conventional cleaners (Fann *et al*., 2012). According to Stevenson *et al.* (2016), some pollutants are tracked into the home through the introduction of building materials, furnishings like a new mattress, carpet cleaners, or a coat of paint on the walls and human activities.

Poor indoor air quality is among the top five environmental risks (USEPA, 2016). Improving IAQ in buildings can significantly improve the wellbeing of occupants. Pollutants in a building's air supply can cause dizziness and headaches as well as aggravate allergies and asthma (Kim *et al.,* 2013) and human mortality (Fang *et al*., 2016; Lin *et al*., 2016). While cleaning and vacuuming can improve indoor air, cleaning alone will not solve IAQ problems. Good IAQ carries numerous, valuable benefits. It helps improve the health, the productivity of employees and happiness of occupants, decreases absenteeism, increases learning and performance levels and creates a more positive customer experience (Lin *et al*., 2017).

Indoor environments contain a complex mixture of live and dead microorganisms, fragments, toxins, allergens, volatile microbial organic compounds, and other chemicals (WHO, 2007). Indoor air quality is one of the most important factors that influence our general life quality. We breathe 10 m^3 air every day, and we spend 80–95% of our lives indoors. Several factors can affect the indoor air quality of a building, including, the physical layout of the building, the building's heating, ventilation, and air condition. Also, the outdoor climate, the people working at these buildings and contaminants inside and outdoor the buildings are considered as influential factors (Amsalu *et al*., 2019). This study thus assessed the indoor air quality of significant departments at a medical centre in Nigeria.

2. MATERIALS AND METHODS

2.1. The Study Area

This study was carried out at a medical centre in Abia State, Nigeria. The State is located on Latitude 5.4309° N and Longitude 7.5247° E. Abia State occupies about 5,243.7 sq. km with a population density of 450/km. It is bounded in the north and northeast by Ebonyi State. It is bordered in the West by Imo State, to the east and Southeast are Cross-River, and Akwa Ibom State and to the South is Rivers State. By the projection of the National Bureau of Statistics, based on the 2006 census and the National Population Commission Allocation 2006, Abia State is about 2,833,999 in the population (NPC, 2006).

2.2. Sampling Technique

Ethical clearance was first obtained from the Heads of the selected Departments in the Medical centre to access the wards for samples collection. Three sampling points were established in the various wards of the departments in the medical centre also and a control study site outside the hospital facilities for comparison. Sampled pollutants include carbon monoxide (CO), and particulate matter ($PM_{2.5}$, PM_5) at the height of four feet from the ground which is considered for the study because it best represents the height of breathing of people, whether standing or seating. Sampling was done in the morning peak (7:00 am to 9:00 am), and evening peak (4:00 pm to 6:00 pm) for each location and it involved open-air sampling, which was done twice a week for a total of four months; July (M1), August (M2), September (M3) and October (M4) 2019. Multi-Gas Monitor Model GT 521 and Particulate counter were used for CO, PM2.5 and PM5 measurements respectively. Garmin Handheld Global Positioning System (GPS) was used to determine the exact coordinates of the sampling sites. Meteorological parameters such as wind speed (WS), relative humidity (RH) and temperature were also measured using Extech, thermo-anemometer for each phase of the measurements. Data analysis was conducted using IBM SPSS Statistics (Version 26) to examine the relationship between some of the gases under considerations.

3. RESULTS AND DISCUSSION

The wind speed and carbon monoxide levels in the study area are shown in Table 1. From the result, the total mean wind speed was 0.52, 0.73, 0.71, and 1.20 m/s for M1 to M4, respectively. Mean carbon monoxide was 3.49, 3.37, 3.33, and 3.50 ppm for M1 to M4, respectively. Mean of the carbon monoxide were all below the Standard organization of Nigeria (SON) permissible limit of 20 ppm. Mean of the wind speed, and carbon monoxide differed significant ($P \leq 0.05$), over time. Particulate matter (PM) levels in the study area are shown in Table 2. From the result, mean $PM_{2.5}$ were 144.38, 151.15, 165.79, and 142.21 ppm for M1 to M4 respectively. Mean PM_5 were 126.37, 100.51, 147.71, and 167.54 for M1 to M4, respectively. Means of the control samples were all below the SON limit of 150 ppm. Means of the $PM_{2.5}$ and PM_5 differed significant ($P \leq 0.05$) over time. Temperature and relative humidity levels in the study area are shown in Table 3. From the result, the total mean temperature was 29.19, 26.31, 28.65, and 28.18. for M1 to M4 respectively. Mean relative humidity was 63.95, 74.25, 67.03, and 69.94. for M1 to M4 respectively. Mean of temperature, and relative humidity differed significant ($P \leq 0.05$) over time.

The impact of air pollution on human health depends firstly on the type of air pollutant. Research has found particulate matter to cause systematic inflammatory response resulting in the stimulation of the bone marrow ultimately contributing to cardiorespiratory morbidity (Vizcaíno *et al*., 2016; Kinney, 2018; Gu *et al*., 2020). Fandiño *et al.* (2020) observed associations with CO might have been a result of the influence of a combination of pollutants in the traffic exhaust due to CO being emitted directly from nearby motor vehicles and not readily reacting with the atmosphere to form other compounds. The report of Ahmed *et al.* (2019) states that lung tissues and cells can be affected negatively by air pollutants by damaging the air sacs that are found in the lungs where oxygen and carbon dioxide are exchanged.

Table 1: Wind speed and carbon monoxide levels in the study area

Time	Location	M1		M2		M3		M4	
		WS (m/s)	CO (ppm)	WS (m/s)	CO (ppm)	WS (m/s)	CO (ppm)	WS (m/s)	CO (ppm)
Morning	ICD	0.36	3.25	0.24	4.33	0.60	6.33	0.78	5.00
	ED	0.29	3.33	0.35	3.00	0.67	3.00	0.59	3.00
	PN	0.91	5.67	1.18	10.00	0.80	4.33	2.05	4.33
	Control	0.53	0.00	1.83	0.00	0.38	0.00	2.05	0.00
Evening	ICD	0.39	6.00	0.56	3.67	1.60	5.33	1.06	5.00
	ED	0.29	3.00	0.44	3.00	0.43	3.33	0.29	6.33
	PN	0.23	6.67	0.80	5.83	0.80	4.33	1.83	4.33
	Control	1.12	0.00	0.45	0.00	0.37	0.00	0.90	0.00
Mean		0.52^{a}	3.49^{b}	0.73^{b}	3.37^{a}	0.71^{b}	3.33^{a}	1.20^{c}	3.50^{b}
SON		20 (ppm)							

Total means with different superscript alphabet are significantly different ($P \leq 0.05$), Intensive care unit (ICD), Emergency department (ED), Postnatal department (PN).

Table 2: Particulate matter levels in the study area

Time	Location	M1		M2		M3		M4	
		$PM_{2.5}$ (ppm)	PM_5 (ppm)	$PM_{2.5}$ (ppm)	PM_5 (ppm)	$PM_{2.5}$ (ppm)	PM_5 (ppm)	$PM_{2.5}$ (ppm)	PM_5 (ppm)
Morning	ICD	181.12	15.36	205.43	29.16	139.41	301.02	139.41	301.02
	ED	216.97	153.97	171.74	163.23	164.7	71.64	139.41	301.02
	PN	213.92	191.84	112.64	174.3	164.7	71.64	288.69	67.21
	Control	1.52	1.28	1.32	0.95	1.29	0.94	1.35	0.89
Evening	ICD	179.39	166.47	139.41	301.02	139.41	301.02	139.41	301.02
	ED	169.49	157.45	288.69	67.21	139.41	301.02	139.41	301.02
	PN	191.4	323.49	288.69	67.21	288.69	67.21	288.69	67.21
	Control	1.22	1.1	1.26	0.97	288.69	67.21	1.35	0.89
Mean		144.38^{b}	126.37^{b}	151.15^{c}	100.51^{a}	165.79^{a}	147.71^{c}	142.21^{a}	167.54^{d}
SON		150 (ppm)							

Total means with different superscript alphabet are significantly different ($P \leq 0.05$)

Table 3: Temperature and relative humidity levels in the study area

Time	Location	M1		M2		M3		M4	
		Temp. (°C)	RH %	Temp. (°C)	RH %	Temp. (°C)	RH %	Temp. (°C)	RH %
Morning	ICD	26.92	76	26.92	71.5	26.92	70.08	26.58	71.5
	ED	27.67	74.17	28.92	74.5	28.58	64.17	34.08	65.67
	PN	34.42	50.25	27.5	65.75	31.58	58.42	26	69.92
	Control	27.67	68.42	26.67	81.17	26.58	79.08	26	69.92
Evening	ICD	29.17	63.08	18.42	78.17	28	71.92	28.42	75.75
	ED	28.33	70.33	27.83	66.5	27.83	66.33	26.75	67.42
	PN	30.92	55.83	27.33	79.58	33	49.67	31.25	63.17
	Control	28.42	53.5	26.92	76.83	26.67	76.58	26.33	76.17
Mean		29.19^{c}	63.95^{a}	26.31^{a}	74.25^{d}	28.65^{bc}	67.03^{b}	28.18^{b}	69.94^{c}

Total means with different superscript alphabet are significantly different ($P \leq 0.05$)

The findings of this study show that carbon monoxide concentration across the study area was within the SON permissible limit (20 ppm). The concentration of $PM_{2.5}$ and PM_5 was high compared to the SON permissible limit (150 ppm), this suggests that the environment of the hospital possess possible health risk. This high concentration can be mainly attributed to the activities of other business and the use of electric generators around the hospital. This was similar to the findings of Pat-Mbano and Nkwocha (2012) that particulate matter and other coarse materials (fly ash, dust) are deposited close to the electric generators within a distance of 0 to 70 m. This was also consistent and with observations of Abulude *et al.* (2019) and Shittu *et al.* (2019) in their studies in South-Western Nigeria. Findings of Njoku *et al.* (2016) from studies of other business areas in Nigeria, reported that open incineration led to the production of high concentrations levels of two primary criteria pollutants $PM_{2.5}$ and PM_5. From their studies, the mean concentration level of $PM_{2.5}$ and PM_5 of most non-control sites exceeded the recommended standard of 150 ppm by large factors. Burnett *et al.* (2018) found a more significant and more frequent association between mortality and PM components during colder months when, according to them, these components have higher concentrations as cool-season averages were roughly twice those of warm season. From this study, it is found that as wind speed and relative humidity are high; the dispersion is high and vice versa. According to Comunian (2020), wind speed and relative humidity are found to affect the distribution of pollutants the most.

4. CONCLUSION

This study assessed the indoor air quality at a medical centre. According to the results, it was observed that the environment had low-moderate gaseous pollutants available in the air. Traces of increased particulate matter were observed but were reasonably within permissible limits. The CO levels were low, and the available level may be because of vehicular movement and use of electric generator in and outside the hospital. The overall assessment of air quality in the area indicated a result that would be described as healthful; meaning that the general health of workers and patients in the hospital is not endangered. This study recommends that the use of poor gasoline engines, improper vehicular movement, incineration of waste generated from the hospital should be controlled.

5. ACKNOWLEDGMENT

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6. CONFLICT OF INTEREST

There is no conflict of interest associated with this work.

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