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Research Paper

Determination of Particulate Matter In Residential Buildings In Wukari, Taraba State, Nigeria

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ABSTRACT
The presence of particulate matter in many residential buildings has become a subject of concern, owing to the fact that its constituents such as endotoxins, allergens, acid salts among others have been associated with respiratory and cardiovascular problems in humans. In this study, the indoor particulate matter levels in some selected residential areas in Wukari, Taraba state were determined. Different residential buildings were used for the analysis in distinct areas. These areas include the students' residential hostels in Federal University Wukari, staff quarters in Federal University Wukari, students' residence opposite Federal University Wukari, Mission quarters and Government Residential Area. The analysis was conducted for the months of July and August, 2018. The results for the month of July showed that the students' hostel ranges from 6.00±1.00 µg/m^3 to 10.67±3.51 µg/m^3, the staff quarters' ranges from 7.33±1.53µg/m^3 to 10.33±1.53µg/m^3, the students' residence opposite school ranges from 12.33±5.77µg/m^3 to 16.33±7.51µg/m^3 and that of downtown ranges from 11.00±6.25µg/m^3 to 27.00±1.00µg/m^3. The result for the month of August showed that the result for students' residential hostel ranges from 1.33±0.58µg/m^3 to 31.00±6.56, the staff quarters' ranges from 1.00±0.00µg/m^3 to 3.00±1.00µg/m^3, the students' residence opposite school ranges from 1.67±0.58µg/m^3 to 8.33±2.89µg/m^3 and that of downtown ranges from 1.00±0.00µg/m^3 to 14.33±2.08µg/m^3. The result showed that the particulate matter concentrations in the residential buildings are in the normal range value though it was higher in certain areas. This increase could be due to certain factors which may include; burning processes, cooking activities, use of insecticides, treatment of waste, how far garbage is from the main building, the use of chemicals including perfumes and insecticides, whether the building is painted or not and how ventilated the building is. All these factors introduce new chemicals in the residential building with the application of these materials in the built environment; it leads to constant exposure to this particulate matter which results to health implications that are deleterious to human body.

Keywords: *Particulate matter; Residential buildings; Particulate matter concentration; Particles; $PM_{2.5}$*

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I. Introduction

Particulate matter (PM), commonly referred to as dust, has historically been a concern due to its presence in a variety of residential buildings (Chao and Cheng, 2002). Particulate matter is composed of inert carbonaceous cores with multiple layers of various adsorbed molecules, including metals, organic pollutants, acid salts and biological elements, such as endotoxins, allergens and pollen fragments) (EPA, 2005). Particulate matter pollution is considered a major threat, as it is associated with detrimental effects on human health and the quality of life (Jimoda, 2012). Strong evidence points to the negative effects of short and long term exposure to particulate matter as the respiratory and cardiovascular health of humans (Megaritis *et al.*, 2013). In particular, particles with a diameter of less than 2.5mm ($PM_{2.5}$) are of high concern because of their adverse effects on respiratory system (Naeher *et al.*, 2000). $PM_{2.5}$ has been used commonly as one of indicators to describe particulate matter. It has been shown that long-term exposure to $PM_{2.5}$ is a strong risk factor of mortality (Megaritis *et al.*, 2013).

The concentration of particulate matter in residential buildings in Wukari Metropolis is dependent on various factors including building structure, types of human activities, the opening and closing of doors and meteorological factors such as temperature, wind, rainfall and humidity. A higher rate of air exchange dilutes the concentration of particulate matter generated in residential buildings in Wukari Metropolis. Particulate matter in indoor environments consist of very different particles which considerably varying in terms of size

form and chemical composition (Naeher *et al.,* 2000). Whereas the larger particles determine primarily the mass of environmental aerosol, the particle number concentration (PNC) and the particle surface are dominated almost exclusively by the ultra-fine particles (>100nm) (Nazaroff, 2004). Air-borne particulate matter consists of a broad class of chemically and physically diverse substances and particulate matter may be classified as a solid or liquid (Otitoju *et al.,* 2021). The levels of indoor particulate matter in some selected residential areas in Wukari, Taraba state is yet to be elucidated. Therefore, this research was undertaken to investigate indoor particulate matter in selected residential areas in Wukari, Taraba state.

II. Material and Methods

PM analyser/meter

Different residential buildings were mapped within Wukari metropolis. These sites include; Federal University Wukari Staff quarters, School hostels, the Government Reserve Area (GRA), mission quarters, Students' residence opposite the school. The readings were taken in triplicates in all the residential buildings used within the metropolis. The analysis was repeated after one month. Periodic measurements describe a measurement regime that is carried out at specific intervals, one month. Screening is done using easily portable measuring equipment, traversing a large area that may prove a problem (indoors).

III. Results and Discussion

Table 1 shows the result of Particulate matter level in residential hostels in Federal University Wukari for the month of July, 2018. The result shows that PM ranges from 6.00±1.00 to 10.67±3.51µg/m^3.Hostel D3 has least PM while Hostel A3 has the highest PM level.

Table 1: Particulate matter for students' residential hostels in Federal University Wukari for the month of July, 2018.

LOCATION	PARTICULATE MATTER (µg/m^3)
Hostel A1	6.00±1.00
Hostel A2	8.00±4.58
Hostel A3	10.67±3.51
Hostel B1	7.67±3.06
Hostel B2	7.00±4.58
Hostel C1	9.00±1.73
Hostel C2	9.00±1.73
Hostel D1	9.00±1.00
Hostel D2	9.67±1.15
Hostel D3	6.00±1.00

Table 2 shows the result of Particulate matter level in staff residential buildings in Federal University Wukari for the month of July, 2018. The result shows that PM ranges from 7.33±1.53 to 10.33±1.53µg/m^3. Junior staff quarters 2 have the least PM while junior staff quarters 1 has the highest PM level.

Table 2: Particulate matter for staff residential buildings in Federal University Wukari for the month of July, 2018.

LOCATION	PARTICULATE MATTER (µg/m^3)
Junior Staff Quarters 1	10.33±1.53
Junior Staff Quarters 2	7.33±2.31
Senior Staff Quarters 1	8.67±1.53
Senior Staff Quarters 2	10.33±0.58

Table 3 shows the result of Particulate matter level in students' residence opposite Federal University Wukari for the month of July, 2018. The result shows that PM ranges from 12.33±5.77 to16.33±7.51 µg/m^3. Oklahoma 1and 2 has the least PM while YCL has the highest PM level.

Table 3: Particulate matter for students' residence opposite Federal University Wukari for the month of July, 2018.

LOCATION	PARTICULATE MATTER (µg/m^3)
Oklahoma 1	12.33±5.77
Oklahoma 2	12.33±5.77
YCL	16.33±7.51
Emonumage	16.00±5.00
Naya 1	16.00±5.00
Naya 2	17.67±2.52

Table 4 shows the result of Particulate matter level in mission quarters Wukari for the month of July, 2018. The result shows that PM ranges from 11.00±6.25 to 27.00±1.00µg/m^3. Mission 4 has the least PM while GRA has the highest PM level.

Table 4: Particulate matter level in mission quarters Wukari for the month of July, 2018.

LOCATION	PARTICULATE MATTER (µg/m^3)
Mission 1	14.33±3.21
Mission 2	15.00±2.00
Mission 3	16.67±8.14
Mission 4	11.00±6.25
Mission 5	11.33±1.15
GRA	27.00±1.00

Table 5 shows the result of Particulate matter level in residential hostels in Federal University Wukari for the month of August, 2018. The result shows that PM ranges from 1.33±0.58 to 31.00±6.56µg/m^3. Hostel A3 has least PM while Hostel A1 has the highest PM level.

Table 5: Particulate matter for students' residential hostels in Federal University Wukari for the month of August, 2018.

LOCATION	PARTICULATE MATTER (µg/m^3)
Hostel D1	31.00±6.56
Hostel D2	6.00±2.00
Hostel D3	1.33±0.58

Table 6 shows the result of Particulate matter level in staff residential buildings in Federal University Wukari for the month of August, 2018. The result shows that PM ranges from 1.00±0.00 to 3.00±1.00µg/m^3. Junior staff quarters 1 has the least PM while senior staff quarters 2 has the highest PM level.

Table 6: Particulate matter for staff residential buildings in Federal University Wukari for the month of August, 2018.

LOCATION	PARTICULATE MATTER (µg/m^3)
Junior Staff Quarters 1	1.00±0.00
Senior Staff Quarters 2	3.00±0.00
Senior Staff Quarters 1	1.67±0.58
Senior Staff Quarters 2	3.00±1.00

Table 7 shows the result of Particulate matter level in students' residence opposite Federal University Wukari for the month of August, 2018. The result shows that PM ranges from 1.67±0.58 to 8.33±2.89µg/m^3. Oklahoma 1 has the least PM while YCL has the highest PM level.

Table 7: Particulate matter for students' residence opposite Federal University Wukari for the month of August, 2018.

LOCATION	PARTICULATE MATTER (µg/m^3)
Oklahoma 1	1.67±0.58
Oklahoma 2	2.33±1.53
YCL	8.33±2.89
Emonumage	4.67±2.08
Naya 1	3.00±1.73
Naya 2	2.33±0.58

Table 8 shows the result of Particulate matter level in mission quarters Wukari for the month of August, 2018. The result shows that PM ranges from 1.00±0.00 to 14.33±2.08µg/m^3. Mission 1 and 4 has the least PM while GRA has the highest PM level.

Table 8: Particulate matter level in mission quarters Wukari for the month of August, 2018.

LOCATION	PARTICULATE MATTER (µg/M^3)
Mission 1	1.00±0.00
Mission 2	1.67±1.15
Mission 3	2.33±0.58
Mission 4	1.00±0.00
Mission 5	1.67±1.15
GRA	14.33±2.08

A number of factors could cause elevated particulate matter in a location. Each location has unique characteristics that contribute to the particulate matter and size distribution of that particulate matter in a location. While many of the factors influencing particulate matter are similar throughout the locations, the difference in the locations is most significant for statistical purposes.

This research identified that the greatest concentration of particulate matter occurred in GRA and Hostel D3. The mean at this location was greater than all other location's respective means for the particulate matter size ratio. This observation is consistent with the activities carried out which include; burning processes, cooking activities, use of insecticides, treatment of waste, how far garbage are from the main building. All these factors introduce new chemicals in the residential building with the application of these materials in the built environment; the emission of pollutants occurs with installation and continues over a prolonged time (Otitoju *et al.,* 2021). Hostel A1 and Hostel D3 shows the least concentration of particulate matter in all size ratios. This is consistent with expectations because the two hostels are well ventilated, less occupant, neat and clean.

This research also observed that there is also elevated concentration of particulate matter in YCL. This may be as the result of change in relative humidity, temperature, effective dust, over population, use of insecticide, method of cooking and lack of ventilation. The concentration of PM in homes is dependent on various factors including building structure, types of human activities, the opening and closing of doors and meteorological factors such as temperature, wind, rainfall and humidity (EPA, 2005). Differences in temperature indoors and outdoors influence natural ventilation through the movement of air. A higher rate of air exchange dilutes the concentration of PM generated indoors (EPA, 2005). Changes in temperature also affect PM by influencing the change of chemical reaction rates and atmospheric mixing heights that affect the vertical dispersion of pollutants and modifying local wind and flow patterns that control the transportation of pollutants (Nazaroff, 2004)**.** Studies have shown that the use of wood and/or coal for cooking or heating can be a significant source of particulate matter inside homes (Samoli *et al.,* 2008). Therefore, poor indoor air quality due to the combustion of biomass or fossil fuels can pose significant health risks due to exposure to increased levels of pollutants such as particulate matter.

Comparing the means of the locations, it appears that the use of cosmetics, insecticides and deodorants contribute to the elevated PM in Oklahoma 1 and 2, Naya 1 and 2. It appears that Hostel A1 and D2 demonstrate similar particulate matter concentrations. Hostel A1 and D2 did not yield statistically different results in any size ratio for particulate matter. Hostel C1, C2, D3 and D3 have variation. This variation in PM may be due to the frequent use of chemicals indoors but by the occupants. Hostel A1 and D3 the least concentration of particulate matter in all size ratios. This is consistent with expectations because the two hostels are well ventilated, less occupants, neat and clean. With comparing the means of the staff residential buildings, it appears that the junior staff quarters 1 and senior staff quarters 2 have elevated level of PM. This high PM is as the result of the

residents employing the use of chemicals especially insecticides indoors which can drastically increase the PM level.

Due to less relative humidity and temperature in July compared to August, the PM levels are relatively high. There exists statistical difference between the concentrations of particulate matter between the residential buildings.

IV. Conclusion

The result for this study showed that there were low levels of particulate matter in the residential buildings used in this research. Exposures to such levels are in such that they don't have any health effects on residents. However, continue exposure over a prolonged time to this PM can lead to cardiovascular diseases, asthma, respiratory infections, cancer, building sickness etc. Finally, the use of inorganic chemicals indoors should be minimized as they can be detrimental to health.

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