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DETERMINATION OF INDOOR VOLATILE ORGANIC COMPOUND LEVELS IN SOME RESIDENTIAL AREAS IN WUKARI, TARABA STATE, NIGERIA

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ABSTRACT

One of the hazardous pollutants of indoor air is volatile organic compounds (VOCs).These compounds are organic emissions from products used on daily basis. They include a variety of hazardous chemicals, and high levels of these organic compounds could mean serious health threat to humans that come in contact with them.In this study, the levels of indoor volatile organic compounds in some residential areas in Wukari, Taraba State, Nigeria were determined.Different locations/sites were mapped within Wukari Metropolis. These sites include; the Government Reserve Area (GRA), Mission Quarters, Students' Residence and the School Hostels. Automated TVOC metre was used in collecting the data. This equipment was allowed to boot properly and the readings were taken one after the other after 30seconds each. The readings were taken in triplicates in all the residential buildings used within the Metropolis. The process was repeated after one month.The result shows that the total volatile organic compounds (TVOCs)in students'residential hostels ranges from 0.06±0.04 to 0.23±0.06mg/m^3 with hostel C1 having the least TVOCs while Hostel A3 has the highest TVOCs level. The result also shows that the TVOCs ranges from 0.02±0.01 to 0.21±0.07mg/m^3 in Federal University Wukari Staff Quarters with Junior staff quarters 1 having the least TVOCs whereas the junior staff quarters 2 has the highest level.The level of TVOCs in students' residence opposite Federal University Wukari ranges from 0.09±0.0 to 0.14mg/$m^3$with Naya2 having the least TVOCs level while Oklahoma2 has the highest level.The range of TVOCs level in mission quarters Wukariwas found to be 0.06±0.03 to 0.14±0.05mg/m^3 with Mission 4 has the least TVOCs while GRA1 has the highest level.The result for this study showed that there were low levels of total volatile organic compounds (TVOCs) in the residential buildings considered in this research. At such concentration, it can be said that health challenge(s) to this effect is a rare scenario. However, prolonged exposure to TVOCs at a particular dose can lead to chronic health challenges such as respiratory disease, neurological damage among others.

KEYWORDS: Volatile organic compounds, Residential buildings, Concentration, Hazardous pollutants, Indoor air.

I. INTRODUCTION

Volatile organic compounds (VOCs) are organic emissions from products used on daily basis. They could also mean gases that are emitted from certain solids or liquids, and include a variety of chemicals hazardous to human health (Yang *et al.,* 2007). Some have distinct odours, or are not concentrated enough for the average nose to detect, and others are completely odourless (Koppmann, 2007).There are numerous human activities which results in the release of VOCs into the atmosphere. These toxic substances when released indoors can interfere with the quality of the indoor air within residential buildings. Activities such as cleaning kitchen counters with chemical cleaners release VOCs into the home's air, and a high level of VOCs could mean serious health threats to the occupants (Posudin, 2012). Other sources of VOCs include household materials like flooring components such as paints, additives, colorants, solvents and plasticizers, carpets components (synthetic fibres, latex components and adhesives furnishings) among others. Also, Production and manufacture of wood furniture is accompanied with the technology of elaboration of wood surfaces with various chemicals that perform the protective or decorative functions. These chemicals (paints, lacquers, varnishes and other coatings) can emit hazardous VOCs and present certain health risk in indoor air (Hayashi *et al.,* 2004**).** Household chemicals which can also serve as sources of VOCs include cleaners, waxes, room fresheners, deodorants, furniture polishes, paints, lacquers, adhesives and cosmetics. The application of decorative materials in residential buildings also provokes the emission of aromatic hydrocarbons (Ingrosso, 2002).

The use of chemicals indoors in residential buildings within Wukari metropolis of Taraba state has grossly reduced the quality of air in the region and beyond. The use of chemicals such as insecticides to kill mosquitoes, cockroaches among others,owing to effectiveness these chemicals in killing insects, especially mosquitoeshas constantly been practised indoors in Wukari. The most commonly used chemicals are Snipers (2,2-dichlorovinyl dimethyl phosphate), DD (dichloropropane-dichloropropene), etcetera. It has also been observed that people use mosquito coils as a form of insecticide which can generate substances that are toxic when inhaled at a particular dose. Building inhabitants constantly emit metabolic products and their exhaled breath can also be a source of VOCs. The major VOC in the breath of healthy individuals include isoprene (3-methyl-1,3-butadiene), acetone, ethanol, and methanol. Isoprene is the most abundant measurable in the breadth of humans (King *et al.,* 2010). VOCs concentrations in buildings are dependent on a number of factors such as age of building, renovation, decoration, room climate, ventilation regime, air velocity, temperature, relative humidity and of course the season (Posudin, 2012). The ability of volatile organic compounds to cause health effects varies greatly from those that are highly toxic, to those with no known health effects. As with other pollutants, the extent and nature of the health effect will depend on many factors including level of exposure and length of time exposed.Most of these compounds are readily absorbed by our bodies and are capable of causing cancer (Ando, 2002). Eye and respiratory tract irritation, neurological damage, headaches, dizziness, visual disorders, and memory impairment are among the immediate symptoms that some people have experienced soon after exposure to some organics (Shinohara *et al.,* 2004). At present, not much is known about the levels of volatile organic compounds in some residential areas in Wukari, Taraba State, Nigeria, Hence, the need for this research.

II. METHODOLOGY

A. TVOC metre (model: DM105)

Different locations/sites were mapped within Wukari metropolis. These sites include the government reserve area (GRA), mission quarters, students' residence opposite and the school hostels. Automated TVOC metre was used in collection of data. This equipment was allowed to boot properly and the readings were taken one after the other after 30seconds each. The readings were taken in triplicates in all the residential buildings used within the metropolis. The process was repeated after one month. Periodic measurements describe a measurement regime that is carried out at specific intervals, one month. The measurement equipment was brought to the site of interest only when the monitoring was required. Screening is done using easily portable measuring equipment, traversing a large area that may prove a problem (indoors).

III. RESULTS AND DISCUSSION

Table 1**:** Total volatile organic compounds (TVOCs) for students' residential hostels in Federal University Wukari for the month of July, 2018.

LOCATION	TVOCs (mg/m^3)
Hostel A1	0.20±0.09
Hostel A2	0.14±0.04
Hostel A3	0.23±0.06
Hostel B1	0.17±0.06
Hostel B2	0.09±0.01
Hostel C1	0.06±0.04
Hostel C2	0.20±0.08
Hostel D1	0.10±0.00
Hostel D2	0.07±0.01
Hostel D3	0.19±0.00

Table I shows the result of total volatile organic compounds (TVOCs) level in all the residential hostels in Federal University Wukari for the month of July, 2018. The result shows that TVOCs ranges from 0.06±0.04 to 0.23±0.06mg/m^3 with Hostel C1 having the least TVOCs while Hostel A3 has the highest TVOCs level.

Table 2: Total volatile organic compounds (TVOCs) for Staff Quarters in Federal University Wukari for the month of July, 2018.

LOCATION	TVOCs (mg/m^3)

Junior Staff Quarters 1	0.02±0.01
Junior Staff Quarters 2	0.21±0.07
Senior Staff Quarters 1	0.15±0.00
Senior Staff Quarters 2	0.06±0.03

Table 2 shows the result of TVOCs level in the staff quarters of Federal University Wukari for the month of July, 2018. The result shows that TVOCs ranges from 0.02±0.01 to 0.21±0.07mg/m^3. Junior staff quarters 1 have the least TVOCs whereas junior staff quarters 2 have the highest level.

Table 3: Total volatile organic compounds (TVOCs) for students' residence opposite Federal University Wukari for the month of July, 2018.

LOCATION	TVOCs (mg/m^3)
Oklahoma 1	0.10±0.03
Oklahoma2	0.13±0.03
YCL	0.05±0.00
Emonumage	0.09±0.02
Naya 1	0.11±0.01
Naya 2	0.06±0.04

Table 3 shows the result of TVOCs level in students' residence opposite Federal University Wukari for the month of July, 2018. The result shows that the range of TVOCs is 0.05±0.00 to 0.13±0.03mg/m^3. YCL has the least TVOCs whereas Oklahoma2 has the highest level.

Table 4: Total volatile organic compounds (TVOCs) for residence in Mission Quarters Wukari for the month of July, 2018.

LOCATION	TVOCs (mg/m^3)
Mission 1	0.11±0.04
Mission 2	0.11±0.02

Mission 3	0.09±0.02
Mission 4	0.06±0.03
Mission 5	0.07±0.02
GRA 1	0.14±0.05

Table 4 shows the result for TVOCs level in Mission Quarters Wukari for the month of July, 2018. The result shows the range of TVOCs to be 0.06±0.03 to 0.14±0.05mg/m^3. Mission 4 has the least TVOCs while GRA1 has the highest level.

Table 5: Total volatile organic compounds (TVOCs) for students' residential hostels in Federal University Wukari for the month of August, 2018.

LOCATION	TVOCs (mg/m^3)
Hostel D1	0.13±0.02
Hostel D2	0.07±0.01
Hostel D3	0.24±0.04

Table 5 shows the result of TVOCs level in all the residential hostels in Federal University Wukari for the month of August, 2018. The result shows that TVOCs level ranges from 0.07±0.02 to 0.24±0.04mg/m^3. Hostel D2 has the least while Hostel D3 has the highest TVOCs level.

Table 6: Totalvolatile organic compounds (TVOCs) for Staff Quarters in Federal University Wukari for the month of August, 2018.

LOCATION	TVOCs (mg/m^3)
Junior Staff Quarters 1	0.07±0.01
Junior Staff Quarters. 2	0.05±0.01
Senior Staff Quarters. 1	0.13±0.00
Senior Staff Quarters. 2	0.05±0.02

Table 6 shows the result for TVOCs level in the staff quarters in federal university Wukari for the month of August, 2018. The result shows that the range of TVOCs is from 0.05±0.01 to 0.13±0.00mg/m^3. Junior staff quarters2 has the least TVOCs while Senior Staff Quarters has the highest level.

Table 7: Total volatile organic compounds (TVOCs) for students' residence opposite Federal University Wukari for the month of August, 2018.

LOCATION	TVOCs (mg/m^3)
Oklahoma 1	0.10±0.01
Oklahoma 2	0.14±0.02
YCL 1	0.12±0.02
Emonumage	0.10±0.02
Naya 1	0.12±0.02
Naya 2	0.09±0.00

Table 7 shows the result of TVOCs level in the students' residence opposite Federal University Wukari for the month of August, 2018. The result shows that the range of TVOCs is from 0.09±0.0 to 0.14mg/m^3. Naya2 has the least TVOCs level while Oklahoma2 has the highest level.

Table 8: Total volatile organic compounds (TVOCs) for residence in Mission Quarters Wukari for the month of August, 2018.

LOCATION	TVOCs (mg/m^3)
Mission 1	0.07±0.00
Mission 2	0.09±0.01
Mission 3	0.06±0.01
Mission 4	0.06±0.01
Mission 5	0.03±0.01
GRA 1	0.15±0.03

Table 8 shows the result for the TVOCs level in mission quarters Wukari for the month of August, 2018. The TVOCs ranges from 0.03±0.01 to 0.15±0.03. Mission5 has the least TVOCs whereas GRA1 has the highest level.

The presence of volatile organic compounds (VOCs) in indoor air is of significant health concern because of the hazardous effects caused by these compounds on the health and well being of building occupants (Posudin, 2012). Newly constructed buildings tend to have higher level of TVOCs which might have originated from interior materials that contained synthetic chemicals, and terpenes originated from woody materials (Hayashi *et al.*, 2004). Hostels C1 and A3 are female blocks, and the increase in TVOCs level in one relative to the other may be due to the use of chemicals which may include cosmetics and perfumes. In average, the result made it clear that it was the female hostel that had the highest level of TVOCs. This is

because females use lots of substances that can generate TVOCs relative to their male counterparts. Another factor maybe how ventilated each of these rooms is. A difference in TVOCs for staff quarters was also observed. Though both sampling points were painted, the rise in TVOCs for certain buildings may likely be due to the frequent use of chemicals indoors. In addition, how ventilated a building is can also be a determining factor in this respect, regarding the increase TVOCs level.

Oklahoma2 residence is a newly built residence and it has just been recently been painted. It was observed that the residents of Oklahoma2 use chemicals extensively and having limited ventilation which contributes to the increase in the TVOCs level. Comparing the two buildings; Oklahoma2 residence and Yoruba community lodge (YCL), YCL is a relatively old building and has been painted for relatively longer time. TVOCs level was found to be higher in Oklahoma2 than in YCL owing to the fact that Oklahoma2 is a more recent building compared to YCL, and TVOCs are mainly emitted from wooden materials. This agrees with the findings of Park et al. (2010). Mosquitoes bites in the month of July, August and September in Wukari is high and certain residents have persistently employed the use of chemicals especially insecticides indoors which can drastically increase the level TVOCs and pose serious threat to the health of the residents. From the result for the month of August, 2018 in the hostel, a relatively high level of TVOCs was seen in Hostel D1. Photocopiers are also sources of indoor air pollution. A photocopier's toner and dispersant contain heavy-treated naphtha, a mixture consisting primarily of decane, which is known to be toxic to humans (Posudin, 2012). It was observed that photocopier was constantly used in the said hostel room, coupled with poor ventilation, hence,high level of TVOCs. According to Mølhave (2010), TVOC concentrations lower than 200 μ g/m3 have no effects on health or comfort of occupant. This concentration was not exceeded across board in the results obtained; implying that the occupants are not threatened health wise by the concentration of TVOCs measured.

In comparing the results for the two months, it was observe that the TVOCs for certain locations were on the increase, some decreased while one of the residential buildings remained the same. On the average, the TVOCs level for the month of July was higher compared to that of August, 2018. Furthermore, the result the for hostels was actually of note due to the higher level of TVOCs relative to the other sites used in the research work.

IV. CONCLUSION

The result for this study showed that there were low levels of total volatile organic compounds (TVOCs) in the residential buildings used in this research. At such concentration, it can be said that health challenge to this effect is a rare scenario. However, prolonged exposure to TVOCs at a particular dose can lead to chronic exposure health challenges such as respiratory disease, neurological damage, etc. Finally, the use of chemicals particularly insecticides indoors should be discouraged as they can be detrimental to health and can also lead to permanent impairment of certain organs in the body, especially those of upper respiratory tract.

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