Continental J. Applied Sciences
Mbabie and Osuagwu (2025) 20 (2): 121 – 137 Doi: 10.5281/zenodo.18099209

Research Article

Characterization of Indoor Air Quality of Federal University of Technology, Minna, Niger State

Juliet Akudo Mbabie[1*] and Ifeanyi Magnus Osuagwu[2]
Chemistry Advanced Research Centre, Sheda Science and Technology Complex, Abuja, Nigeria
[1] (ORCID: 0009-0000-4658-8856), [2] (ORCID: 0009-0000-1490-138)
***Corresponding author: ajulietmbabie@gmail.com**

Abstract

Globally, including in Nigeria, air quality has been a significant concern. Both indoor and outdoor air quality are monitored. The study's focus was indoor air quality. This study's objective was to evaluate the air quality of fifty indoor locations on the FUT Bosso campus in Minna, including five classrooms, one male hostel, eighteen labs, ten offices, one restroom, two libraries, one stairwell, eleven lecture halls, and one café. Formaldehyde (HCHO), Total Volatile Organic Compounds (TVOC), $PM_{1.0}$, $PM_{2.5}$, and PM_{10} were measured using a multifunction air detector (Model: WP6910 made-in-China: Detector Description). According to the manufacturer's instructions, a Multifunction Air Detector was utilized for the assessment, and a Mini GPS was employed to pinpoint the locations. HCHO (0.00-0.16 mg/m^3), TVOC (0.00-0.55 mg/m^3), $PM_{1.0}$ (0.41-42 µg/m^3), $PM_{2.5}$ (0.53-44 µg/m^3), and PM_{10} (0.61-51 µg/m^3) were the findings. The outcomes fell short of the WHO and EPA's annual pollution recommendations. The toxicity potential (TP) was less than 1. Even if the areas appeared safe, it is advised that adequate ventilation be supplied and that the inside be continuously monitored.

Keywords: Indoor air quality, HCHO, WHO, Federal University of Technology, Bosso campus, Minna.

Received: 23 April 2025 **Accepted: 11 August 2025**

ISSN: 3043–6087. Science and Education Development Inst., Nigeria

Introduction

Globally, there is growing concern about indoor air quality because it mostly affects children, pregnant women, and the elderly. Volatile organic compounds (VOC), Total Volatile Organic Compound (TVOC) formaldehyde (HCHO), fine particulate matter (PM), ozone (O_3), carbon monoxide (CO), carbon dioxide (CO_2), and aldehydes are common indoor pollutants that are brought on by indoor emission sources such as furniture, paints, combustion appliances, low ventilation, seasonal variations, weather, and numerous other environmental factors (Lee et al., 2018; Walgraeve et al., 2011).

Air pollution (Indoor air pollution) poses a major risk to human health. According to studies, indoor air pollution concentrations can occasionally be two to five times greater than outdoor air, and in certain instances, they can be more than 100 times higher (U.S. Consumer Product Safety Commission (CPSC), 2012). Because people spend more than 90% of their time indoors, it is important to assess, monitor, and reduce indoor pollution. When thinking about air pollutants indoors, indoor air quality (IAQ) and the toxicity potential (TP) of the pollutants are crucial. The two educate people about the standard of the rooms and the risks that could arise if the pollutants are higher than what is advised. Sonibare et al. (2005) state that TP is a quantitative toxic equivalence that expresses the possible impact of a chemical unit released into the environment. This is represented as the ratio of the measured levels of ambient pollutants to the ambient concentration limit set by law.

$$\text{Toxicity Potential} = {}^{Mp}/_{Sp}$$

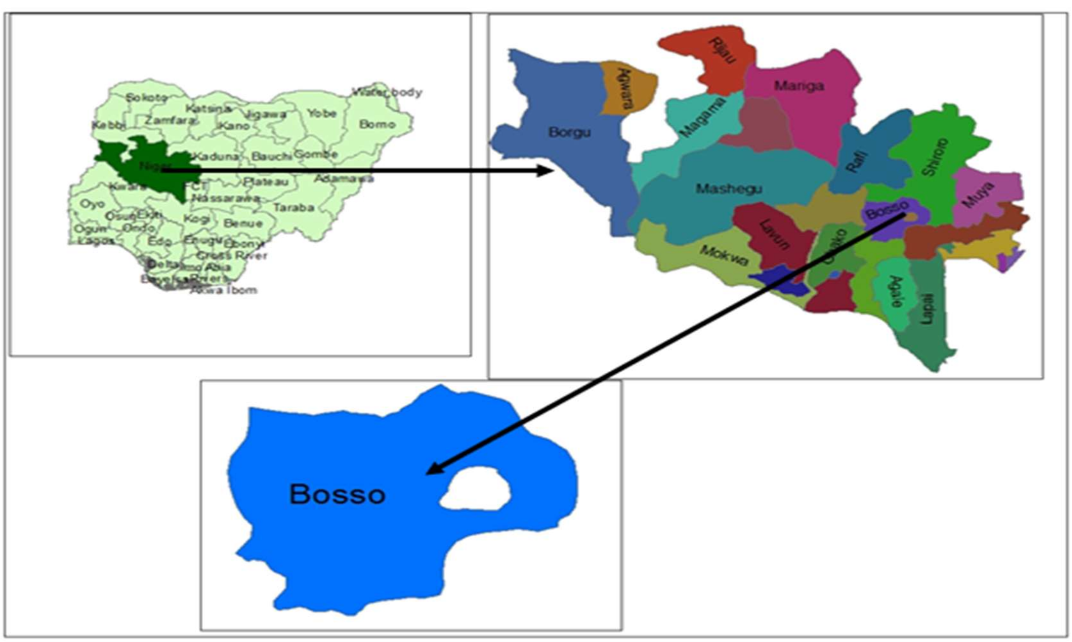
Mp is the measured concentration of the pollutant; Sp is the statutory limit established for that pollutant using the ASHRAE and FMEnv standards. TP is helpful in identifying the detrimental impacts on human health of emissions from indoor source contaminants (Ayodele et al., 2016). The degree to which human needs are satisfied inside is referred to as IAQ. People need clean, pleasant air that doesn't harm their health (Fanger, 2006).

Numerous studies on indoor air quality have been published, such as Wang et al. (2008), Petry et al. (2014), Chen et al. (2016), Shi et al. (2016), Meñciarová et al. (2017), and Lee et al. (2018). Many of these studies focused on PM, TVOC, formaldehyde, O_3, CO, CO_2, and other aldehydes. A large number of their observations showed parameter levels that were higher than advised. Air pollution parameters have been determined and identified using various source apportionment (Li et al., 2014; Ma et al., 2016), methodologies (Chen et al., 2016; Shi et al., 2016; Meñciarová et al., 2017; Lee et al., 2018), and instruments (Jiao et al., 2015; Van den Bossche et al., 2016; Zikova et al., 2017; Lee et al., 2018). There aren't many studies on indoor air pollution in Nigeria, but the few that have been found were conducted in Enugu (Ezezue and Diogu, 2017), Warri (Akpofure, 2015), Ile-Ife (Afolabi et al., 2016), Ido Ekiti (Ayodele et al., 2016), and Minna. In light of this, the study's objective was to evaluate the levels of formaldehyde (HCHO), total volatile organic compounds (TVOC), $PM_{1.0}$, $PM_{2.5}$, and PM_{10} at the Federal University of Technology, Bosso Campus, Minna, Niger State, Nigeria. The results would be statistically analyzed, and the pollutants' possible toxicity would also be ascertained.

Materials and Methods

Study Area

Niger State's capital city is Minna (Figure 1). It is among Nigeria's most picturesque cities. Over the past few decades, it has continued to see increasing urbanization and industrialization. Similar to other cities across the globe, Minna's air quality has been severely impacted by the city's rapid economic growth and housing expansion. Serious particle pollution, particularly formaldehyde (HCHO), total volatile organic compounds (TVOC), $PM_{1.0}$, $PM_{2.5}$, and PM_{10} pollution, has not been detected in Minna in recent years, unlike other megacities in Nigeria.



Source : Oluibukun et al. (2015)

Figure 1: This depicts map of Nigeria, Niger State, and Bosso where the university is located

Table 1: The names of the sites within the location assessed

S/N	Location
1	Student Hostel
2	Cafeteria
3	Remote sensing Laboratory
4	Preparatory Room (Chemistry Laboratory 1)
5	Chemistry Laboratory 1
6	Chemistry Laboratory 2
7	Preparatory Room (Chemistry Laboratory 2
8	Biochemistry Laboratory 2
9	Microbiology Laboratory 1
10	Microbiology Laboratory 2
11	Biochemistry Research Laboratory
12	Biological Laboratory 1
13	Biological Laboratory 2
14	Cartography laboratory
15	Library Reference Section
16	Geography Department (Lecture Room 1)
17	Geography Department (Lecture Room 2)
18	Geography Department (Lecture Room 3)
19	Geography Department (Office)
20	Physics Laboratory (100 Level)
21	Physics Laboratory (200 Level)
22	Mathematics Department (Office)
23	School Physical Sciences (Deans Office)
24	School Physical Sciences (Registry)
25	FUT Secondary Library
26	FUT Secondary Classroom 1
27	FUT Secondary (Staff room)
28	FUT Secondary (Computer room)
29	FUT Secondary (Classroom 2)
30	FUT Secondary (Classroom 3)
31	FUT Secondary (Classroom 4)
32	Primary School (Classroom 1)
33	FUT Primary School (Classroom 2)
34	FUT Primary School (Classroom 3)
35	FUT Primary School (Classroom 4)
36	FUT Primary School (Classroom 5)
37	FUT Primary School (Classroom 6)

ISSN: 3043–6087. Science and Education Development Inst., Nigeria

38	FUT Primary School (Classroom 7)
39	FUT Primary School (Classroom 8)
40	FUT Primary School (Classroom 9)
41	FUT Primary School (Classroom 10)
42	FUT Primary School (Office)
43	NHL II
44	NHL I
45	Public Toilet (Educational Technology Department)
46	Educational Technology Staircase
47	Genetic central Lab (Office)
48	Discovery Res. Lab
49	Educational Technology Office 1
50	Educ. Tech. Office 1 (Lobby close)

Figure 2: The multifunctional detector used for the assessment

Parameter Measurements

The current measurements were conducted in 50 indoor places in Minna, including classrooms (5), a male hostel (1), labs (18), offices (10), restrooms (1), a library (2), a staircase (1), lecture rooms (11), and a café (1) (Table 1). A multifunction air detector (Model: WP6910 made-in-China: Detector Description) was used to measure HCHO, TVOC, $PM_{1.0}$, $PM_{2.5}$, and PM_{10} (Figure 2). The use of this detector was motivated by the fact that Minna City does not currently have any national-controlling ambient air quality monitoring sites. The guidelines and instructions provided by the makers were closely adhered to. The detection equipment was positioned in the middle of the room at a height of roughly 1.1 meters above the floor for one hour during the indoor assessments. All

ISSN: 3043–6087. Science and Education Development Inst., Nigeria

windows and doors were closed throughout the measurement times, and all air conditioners, fans, and other ventilators were turned off prior to the measurements. Since the hostel, classrooms, lecture halls, labs, and offices are the main venues where staff and students spend the majority of their time, assessments were conducted there. The PM ratios were also calculated.

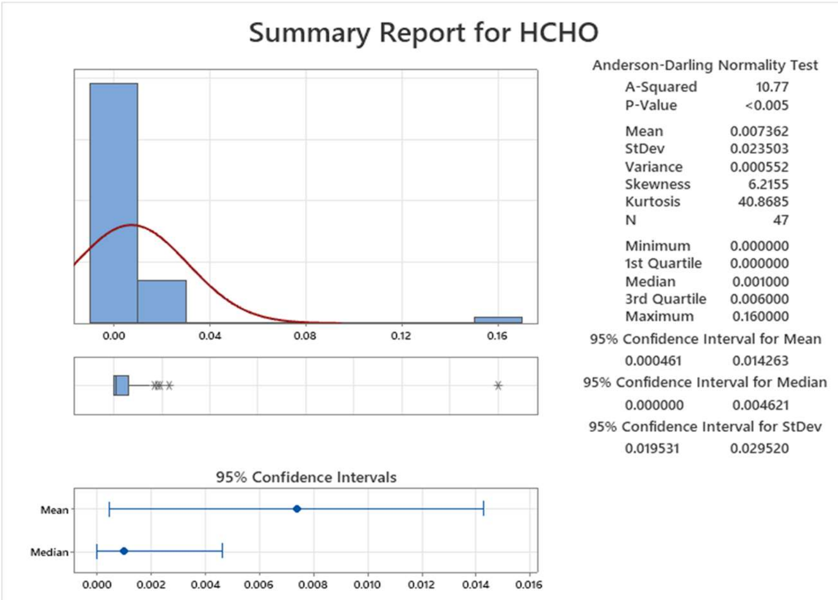
Statistical Analysis

Minitab 16 (Minilab Ltd. UK) and Microsoft Office Excel 2007 (Microsoft Corporation Technology Company, Washington, US) were used to statistically analyze the experimental measurement results.

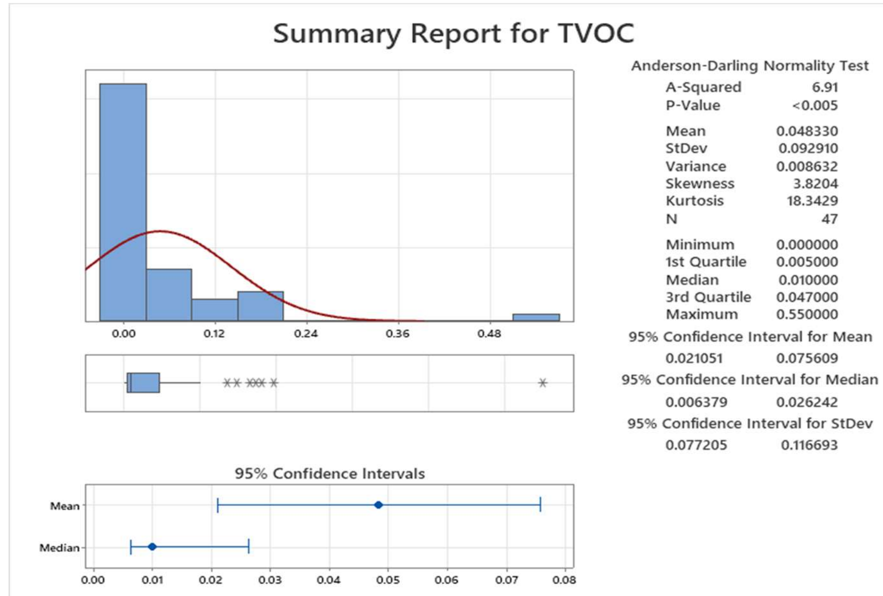
Results and Discussion

The Anderson-Darling Normality Test was shown in the Figure 3 (a-d). The test examines the empirical distribution of data, assesses if the population's data is normally distributed, offers deviations such as skweness, and contrasts the significant levels (5%, 1%). For HCHO, the Anderson-Darling findings are A-squared: 10.77, the P-value was less than 0.005 and did not follow a normal distribution. Additionally, the mean (0.01), median (0.001), standard deviation (0.02), skewness (6.22) to the right, and kurtosis (40.87) varied. This demonstrates how substantially non-normal the distribution is. A portion of the higher reading may have an effect on the surroundings or occupants' well-being. The TVOC's mean (0.05), standard deviation (0.09), and obtained Kurtosis (18.34) indicate extreme outliers. Even though the TVOC levels in this study are modest, ongoing observation is still required. A-Squared (2.11), mean (23.69), median (24.00), Skweness (-0.85), and Kurtosis (8.98) are all present in the PM_1. PM_{10} (35.93 $\mu g/m^3$), $PM_{2.5}$ (31.39 $\mu g/m^3$), and $PM_{1.0}$ (23.69 $\mu g/m^3$) were the average values of particulate matter. The PM10 findings were lower than those found in subway offices (27.5 to 267.9 $\mu g/m^3$), according to Lim et al. (2005). In a retirement community and dorm, Hassanvand et al. (2014) investigated the indoor/outdoor relationships of PM_{10}, $PM_{2.5}$, and PM_1. They found PM_{10} (7.5-240 mg/m^3), $PM_{2.5}$ (4.4-72.3 mg/m^3), and PM_1 (3.1-42.0 mg/m^3). The study's findings were in good agreement with those published by the authors. Due to the increased activity of the occupants during the weekdays, the indoor mean values of PM_{10}, $PM_{2.5}$, and $PM_{1.0}$ in this study were lower on weekends than throughout the week. Goyal and Khare (2010) reported similar outcomes, albeit with higher concentrations than those seen in this investigation.

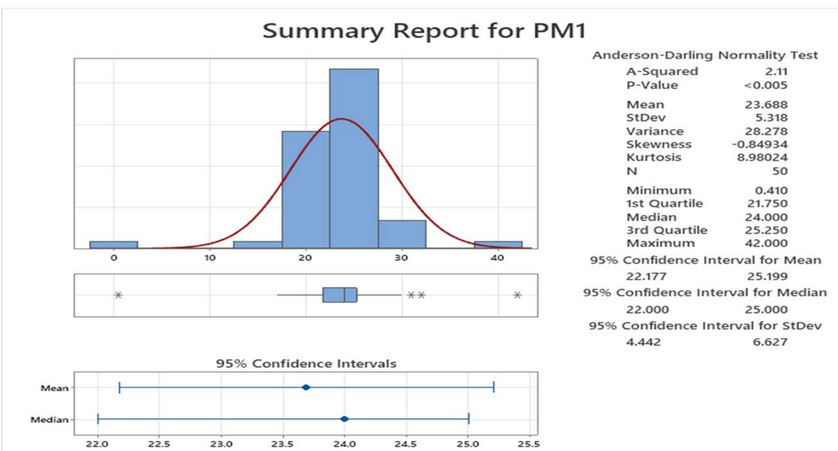
ISSN: 3043–6087. Science and Education Development Inst., Nigeria


Summary Report for HCHO
Anderson-Darling Normality Test
A-Squared 10.77
P-Value <0.005
Mean 0.007362
StDev 0.023503
Variance 0.000552
Skewness 6.2155
Kurtosis 40.8685
N 47
Minimum 0.000000
1st Quartile 0.000000
Median 0.001000
3rd Quartile 0.006000
Maximum 0.160000
95% Confidence Interval for Mean
0.000461 0.014263
95% Confidence Interval for Median
0.000000 0.004621
95% Confidence Interval for StDev
0.019531 0.029520
95% Confidence Intervals
Mean
Median

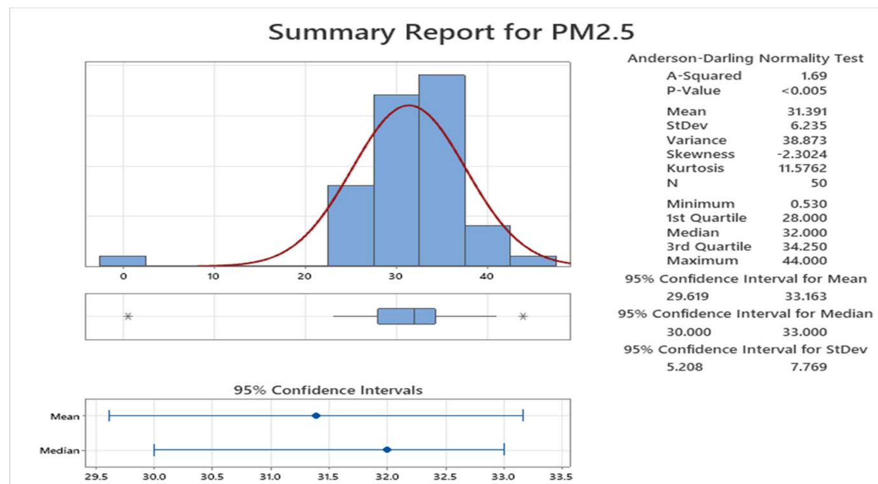
(a)


Summary Report for TVOC
Anderson-Darling Normality Test
A-Squared 6.91
P-Value <0.005
Mean 0.048330
StDev 0.092910
Variance 0.008632
Skewness 3.8204
Kurtosis 18.3429
N 47
Minimum 0.000000
1st Quartile 0.005000
Median 0.010000
3rd Quartile 0.047000
Maximum 0.550000
95% Confidence Interval for Mean
0.021051 0.075609
95% Confidence Interval for Median
0.006379 0.026242
95% Confidence Interval for StDev
0.077205 0.116693
95% Confidence Intervals
Mean
Median

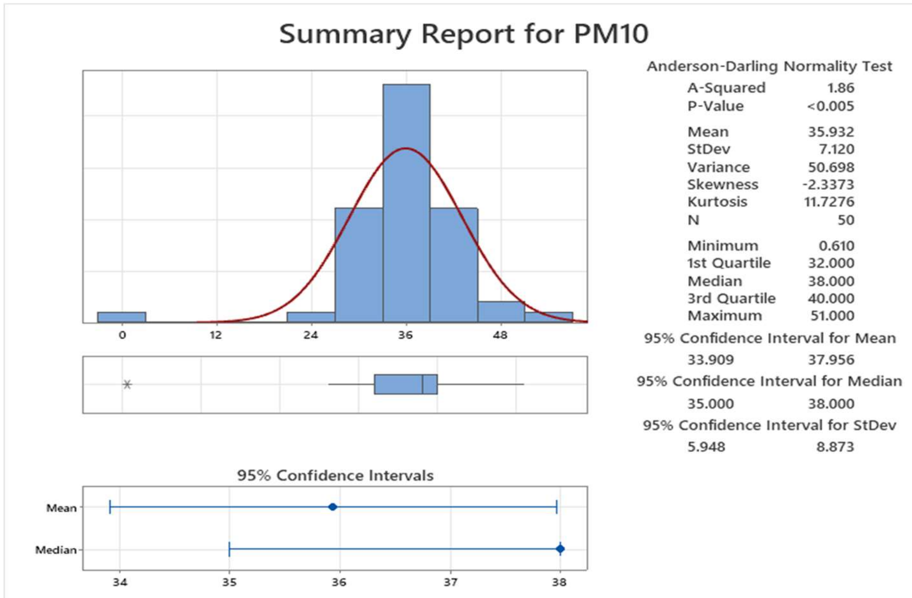
(b)


Summary Report for PM1
Anderson-Darling Normality Test
A-Squared 2.11
P-Value <0.005
Mean 23.688
StDev 5.318
Variance 28.278
Skewness -0.84934
Kurtosis 8.98024
N 50
Minimum 0.410
1st Quartile 21.750
Median 24.000
3rd Quartile 25.250
Maximum 42.000
95% Confidence Interval for Mean
22.177 25.199
95% Confidence Interval for Median
22.000 25.000
95% Confidence Interval for StDev
4.442 6.627
95% Confidence Intervals
Mean
Median

(b)


Summary Report for PM2.5
Anderson-Darling Normality Test
A-Squared 1.69
P-Value <0.005
Mean 31.391
StDev 6.235
Variance 38.873
Skewness -2.3024
Kurtosis 11.5762
N 50
Minimum 0.530
1st Quartile 28.000
Median 32.000
3rd Quartile 34.250
Maximum 44.000
95% Confidence Interval for Mean
29.619 33.163
95% Confidence Interval for Median
30.000 33.000
95% Confidence Interval for StDev
5.208 7.769
95% Confidence Intervals
Mean
Median

(c)



(d)

Figure 3 (a-d): The Anderson-Darling Normality Test of contaminants in Bosso campus

ISSN: 3043–6087. Science and Education Development Inst., Nigeria

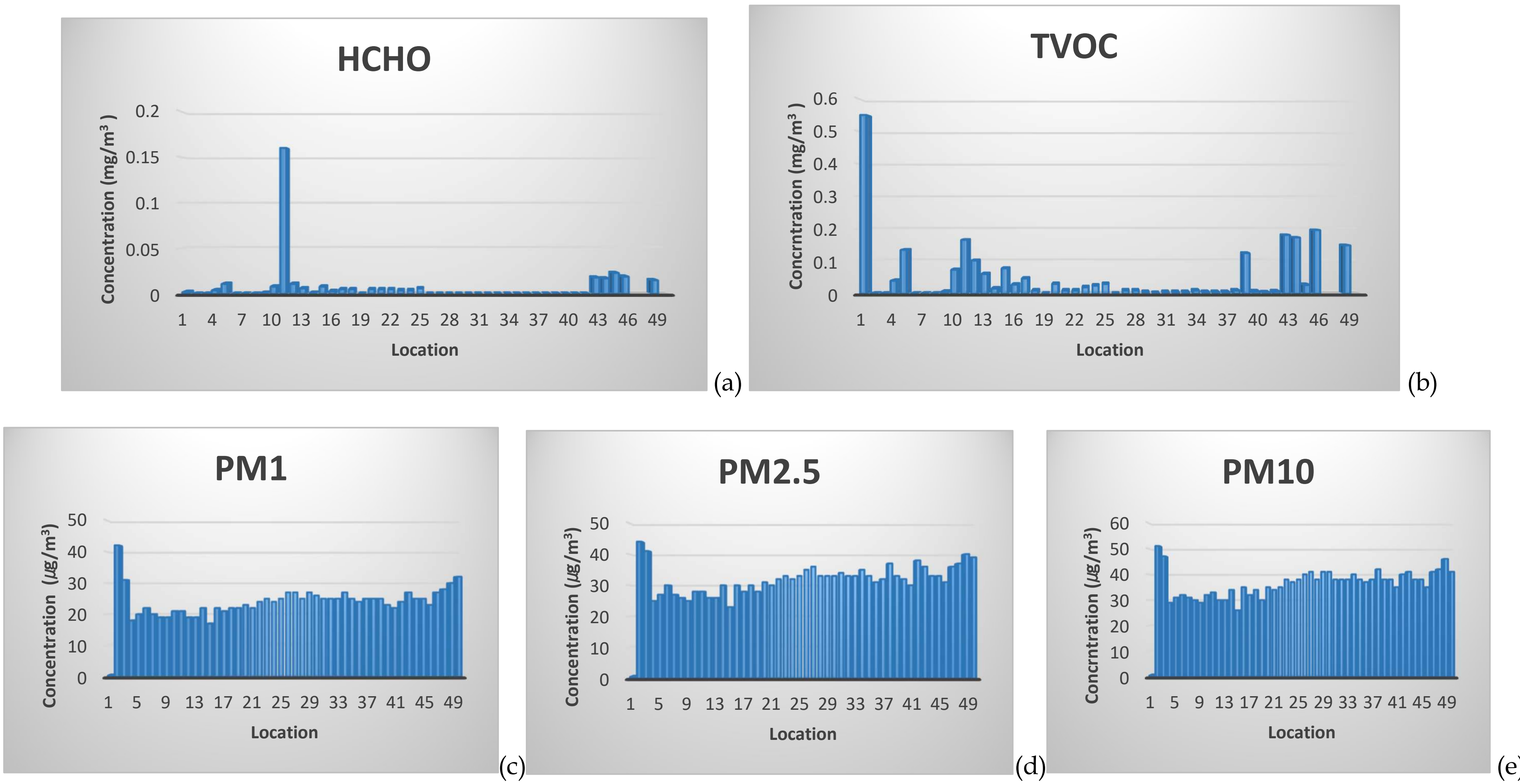


Figure 4 (a-e): Bar chart of the results of contaminants in Bosso campus

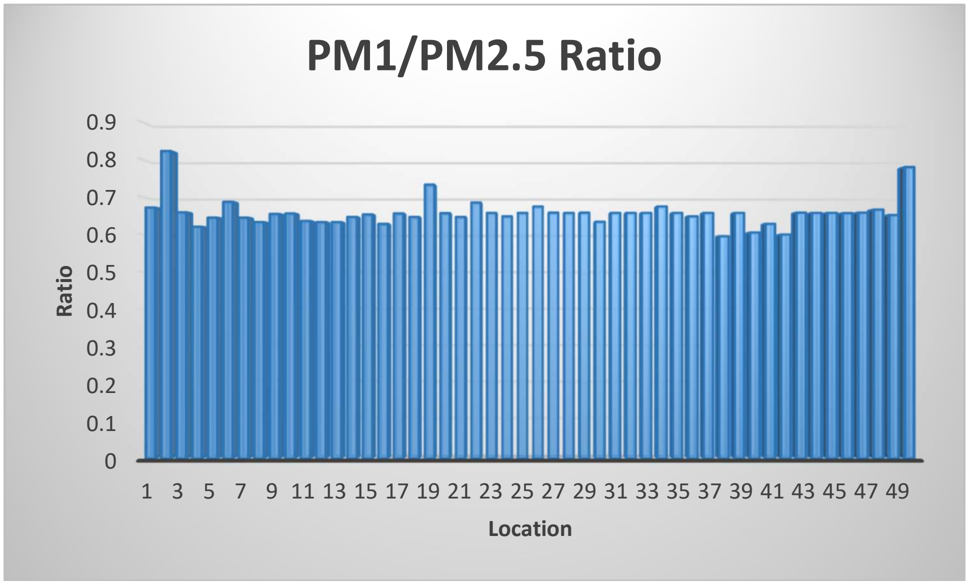
ISSN: 3043–6087. Science and Education Development Inst., Nigeria

A major interior pollution event, such as glue and off-gassing from furniture and building materials, is depicted by the right-skewed distribution of formaldehyde with high kurtosis. High HCHO exposure is dangerous, particularly indoors. Indoor air quality is impacted by TVOCs such formaldehyde and benzene. In addition to long-term health hazards, it causes headaches and discomfort. TVOC is difficult to identify without continuous monitoring since it is confined and fleeting. PM_1 is a tiny particle that penetrates biological barriers and increases indoor health risks. During peak hours, $PM_{2.5}$ reaches the bloodstream and lungs, causing respiratory and cardiovascular disorders. The summary of these findings demonstrated the links found in this investigation. Nigerian PM standards are equivalent to the WHO's daily average PM_{10} and $PM_{2.5}$ concentration levels of 50 and 25 mg/m^3, respectively. As of right now, PM_1 has no set limit. Our findings suggest that they are below the WHO standards. The little rainfall reported throughout the course of the seven-day monitoring could be the cause.

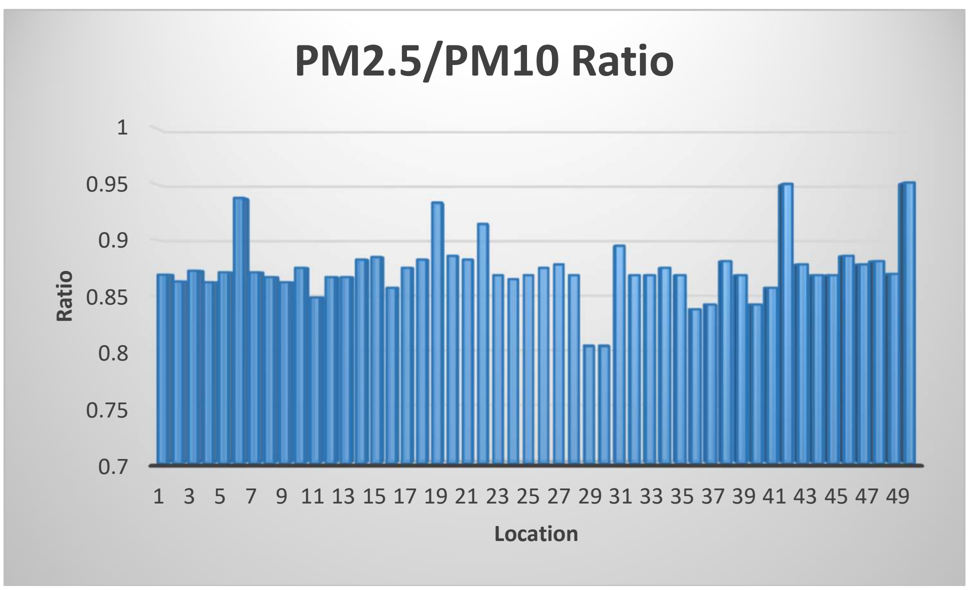
The outcomes of the evaluations made throughout this investigation were displayed in Figure 4 (a-e). The parameters (HCHO, TVOC, $PM_{1.0}$, $PM_{2.5}$, and PM_{10}) have the following ranges: 0.00-0.16, 0.00-0.19, 17.00-32.00, 25.00-45.00, and 26.00-61.00. The Educational Technology Staircase was the sole location where the highest formaldehyde value of 0.02 mg/m^3 was found; this could be due to the scent and the new furniture in the space. The fact that the value was below the limits for eye irritation (0.1 mg/m^3), nose biting sensation (0.5 mg/m^3), risk to life (37.5 mg/m^3), and even death (125 mg/m^3) is pleasing (Commission of the European Communities, 1990). The indoor study's TVOC means (0.05 mg/m^3) and standard deviations (0.09) differed significantly from those of Lee et al. 2018 (Korea: 230.7±1.7 µg/m^3), Mełciarová et al. 2017 (Slovak: 28-2393 µg/m^3), Wang et al. 2008 (Taiwan: 1.960 µg/m^3), and Park et al. 2010 (Korea: 120 to 328 µg/m^3). The age of our study locations may be the cause of the discrepancies. The Biochemistry Laboratory reported the highest level of HCHO; this could be because formaldehyde was used to preserve the specimen. Due to the students' use of perfume, the male student residence had the highest TVOC level. Due to student activity during the time of evaluations, higher PM_1, $PM_{2.5}$, and PM_{10} levels were recorded in the cafeteria, remote sensing lab, and chemistry lab.

ISSN: 3043–6087. Science and Education Development Inst., Nigeria

Pollutant Ratio

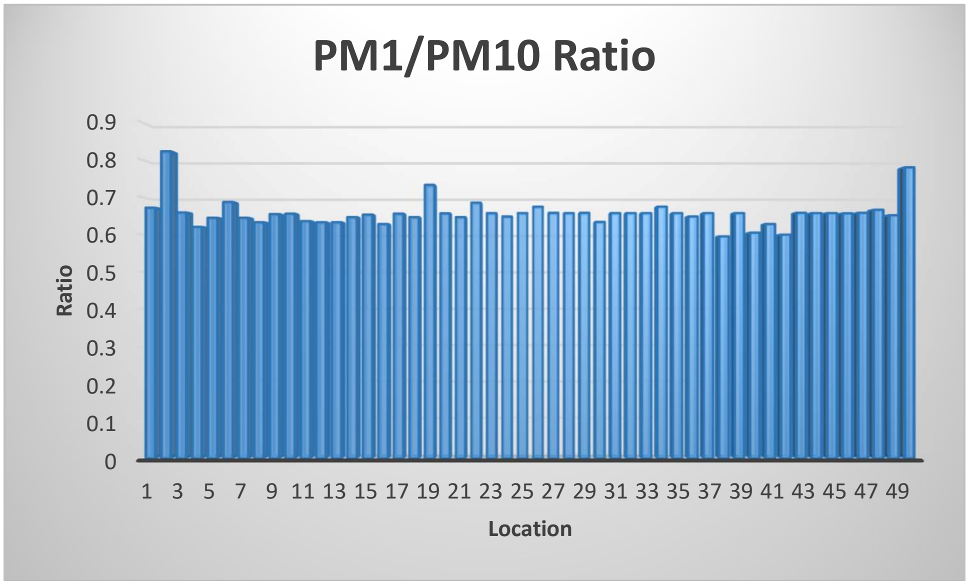


(a)



(b)

ISSN: 3043–6087. Science and Education Development Inst., Nigeria



(c)

Figure 5 (a-c): The particulate matter ratios of the contaminants

The study's average $PM_1/PM_{2.5}$, $PM_{2.5}/PM_{10}$, and PM_1/PM_{10} ratio values were 0.63-0.95, 0.84-0.95, and 0.59-0.82, respectively (Figure 5 (a-c)). Ho et al. (2003) discovered that Poly U (0.61) and KT (0.78) had higher mean $PM_{2.5}/PM_{10}$ ratios than HT (0.53) at three monitoring locations in Hong Kong. Furthermore, lower ratios of 0.29-0.51 were reported by Filonchyk et al. (2016). According to the findings of earlier research, dust storms with high PM_{10} contents and comparatively low $PM_{2.5}$ contents because of the invasion of big particles are PM indicators (Zhang et al., 1998). It should be mentioned that one important metric for identifying the origins of dust is the $PM_{2.5}/PM_{10}$ ratio. Consistent with our findings, Xu et al. (2017) found $PM_{2.5}/PM_{10}$ ratios above 0.7 in 19 Chinese cities, but below 0.5 in the other cities they looked at. Unpaved roads and farms are potential sources of emissions, as evidenced by the low variations in PM concentrations and the high $PM_{2.5}/PM_{10}$ ratios found in this study.

Toxicity Potential

Table 2: Table showing the TP of the contaminants obtained from the locations

	HCHO	$PM_{2.5}$	PM_{10}
N	50	50	50
Mean	0.07	6.28	2.40
SE Mean	0.03	0.18	0.07
StDev.	0.03	1.25	0.47
CoefVar.	33.07	19.86	19.82
Minimum	0.00	0.11	0.04
Maximum	1.60	8.80	3.40
Q1	0.00	5.60	2.13
Q3	0.05	6.85	2.67

Using the WHO's yearly norm, the TP range for HCHO, $PM_{2.5}$, and PM_{10} was calculated (Tables 2). Due to the lack of WHO criteria, the TP of PM_1 and TVOC was not calculated. The TP were 0.04-3.40 (PM_{10}), 0.11-8.80 ($PM_{2.5}$), and 0.00-1.60 (HCHO). Sonibare et al. (2005) found that the TP ranged from 0.33 to 7.72 in a Total Solid Particulates research at an enamelware manufacturing industry. The operations (spraying, pickling, milling, etc.) that occurred during the research period may have contributed to the high concentration found in their study, but in ours, there was very little vehicle activity. HCHO is carcinogenic at low concentrations; the study's upper limit of 1.60 mg/m^3 is higher than the WHO's acceptable indoor air standard, suggesting both acute and long-term health hazards. This is a high maximum limit for $PM_{2.5}$. Deep penetration into the bloodstream and lungs, which are connected to asthma, heart disease, and early death, is a possibility. Lastly, coughing, discomfort, and decreased lung function may result from the maximum TP (3.40) of PM_{10}. The air quality is dangerous, as shown by this maximum TP.

Conclusion

The assessment of pollutants indoor was carried out within seven days in Bosso, Minna using a multifunctional air detector. The results revealed that Formaldehyde (HCHO) was minimal in all the locations which could have been due to the old age of the buildings and materials therein. In comparison with standard limits its results were far below the limits. TVOC was also detected at very low concentrations. There were significant differences when compared with indoors in Korea. The PM at diameters 1, 2.5, and 10 was low compared to the 24hr indoor limit recommended by WHO. The PM ratios were below unity. The coefficient of correlation and matrix plots depicted strong correlations between PM, HCHO, and TVOC. The report showed that there were significant effects of weather on the pollutants, especially temperature. The TP report showed that the potential of the indoor inhabitants is low, but the probability of human health effects exists due to the activities within and outside the different locations. Finally, it is recommended that constant monitoring of the locations assessed should be enforced.

Conflict of interest statement

Authors certify that they have no conflict of interest concerning the subject matter or materials discussed in the manuscript.

Acknowledgments

The authors thank HODs, Deans, Technologists, Principal of FUT Secondary, and the Headmistress who allowed us to use their premises and Dr. Cynthia Onyefulu, an Associate Professor and Vice-Dean in the Faculty of Education and Liberal Studies at the University of Technology, Jamaica, for providing funds for the purchase of the multipurpose air detector.

References

Afolabi, O. T., Awopeju, O.F., Aluko, O.O., Deji, S.A., Olaniyan, B.B, Agbakwuru, L.C, Oyedele, O.O., Oni, K.R., Ojo, B.O. (2016). Awareness of indoor air pollution and the prevalence of respiratory symptoms in an urban community in South West Nigeria. Niger J Health Sci., 16:33-8.

Akpofure Rim-Rukeh (2015). An Assessment of Indoor Air Quality in Selected Households in Squatter Settlements Warri, Nigeria, Advances in Life Sciences, Vol. 5 (1) 1-11. doi: 10.5923/j.als.20150501.01.

Ayodele C.O., Fakinle B.S., Jimoda L.A., and Sonibare J.A (2016). Investigation on the ambient air quality in a hospital environment. Cogent Environmental Science, 2: 1215281.

Chen Y. Sung F., Chen M., Mao I., and Lu C. (2016). Indoor Air Quality in the Metro System in North Taiwan. Int. J. Environ. Res. Public Health, 13, 1200; doi:10.3390/ijerph13121200

Commission of the European Communities (1990). Indoor air quality and its impact on man. Environment and quality of life. Indoor air pollution by formaldehyde in European countries. Report No. 7. Pp 1-2.

Ezezue, A.M., Diogu, J.O. (2017) Investigation of Indoor Air Quality of Residential Buildings in Enugu, Nigeria. J ArchitEng Tech 6: 206. doi: 10.4172/2168-9717.1000206.

Fanger A (2006). What is IAQ? Indoor Air. 2;16(5):328-34.

Filonchyk, M., Yan H., Yang S., and Hurynovich V. (2016). A study of $PM_{2.5}$ and PM_{10} concentrations in the atmosphere of large cities in Gansu Province, China, in summer period. J. Earth Syst. Sci., DOI 10.1007/s12040-016-0722-x, 125(6), 1175–1187.

Goyal R. and Khare M. (2010). Indoor air quality modeling for PM_{10}, $PM_{2.5}$, and $PM_{1.0}$ in naturally ventilated classrooms of an urban Indian school building. Environ Monit Assess DOI 10.1007/s10661-010-1600-7.

Hassanvand M.S., Naddafi K., Faridi S., Arhami M., Nabizadeh R., Sowlat M. H., Pourpak Z., Rastkari N., Momeniha F., Kashani H., Gholampour A., Nazmara S., Alimohammadi M., Goudarzi G., and Yunesian M. (2014). Indoor/outdoor relationships of PM_{10}, $PM_{2.5}$, and PM_1 mass concentrations and their water-soluble ions in a retirement home and a school dormitory. Atmospheric Environment. 82, 375-382.

Jiao, W., Hagler, G.S.W., Williams, R.W., Sharpe, R.N., Weinstock, L., Rice, J., (2015). Field assessment of the village green project: an autonomous community air quality monitoring system. Environ. Sci. Technol. 49 (10), 6085–6092.

Lee K, Choi J-H, Lee S, Park H-J, Oh Y-J, Kim G-B, et al.(2018). Indoor levels of volatile organic compounds and formaldehyde from emission sources at elderly care centers in Korea. PLoSONE 13(6):e0197495. https://doi.org/10.1371/journal.pone.0197495.

Li, M., Shao, M., Li, L. Y., Lu, S. H., Chen, W. T., and Wang, C. (2014). Quantifying the ambient formaldehyde sources utilizing tracers, Chin. Chem. Lett., 25, 1489 1491,doi:10.1016/j.cclet.2014.07.001.

Ma Y., Diano Y., Zhang B., Wang W., Ren X., Yang D., Wang M., Shi X., and Zheng J (2016). Detection of formaldehyde emissions from an industrial zone in the Yangtze River Delta region of China using a proton transferreaction ion-drift chemical ionization mass spectrometer. Atmos. Meas. Tech., 9, 6101–6116.

Meˇciarová L., Vilˇceková S., Burdová E. K., and Kiselák J. (2017). Factors Effecting the Total Volatile Organic Compound (TVOC) Concentrations in Slovak Households. Int. J. Environ. Res. Public Health 2017, 14, 1443; doi:10.3390/ijerph14121443.

Oluibukun G. Ajayi, Joseph O. Odumosu, Hassan A. Samaila-Ija, Nanpon Zitta, Ekundayo A. Adesina, Olaniyi J. Olanrewaju. (2015). Dynamic Road Segmentation of Part of Bosso Local Government Area, Niger State, *American Journal of Geographic Information System*, Vol. 4 No. 2, pp. 64-75. doi: 10.5923/j.ajgis.20150402.02.

Park H, Oh Y, Lee H, Woo W, Sohn J. A study of indoor air quality of public facilities in Incheon city. J Korean Soc Environ Admin. 2010; 16(2):53–61.

Petry T., Vitale D., Joachim F.J., Smith B., Cruse L., Mascarenhas R., Schneider S., Singal M. (2014). Human health risk evaluation of selected VOC, SVOC and particulate emissions from scented candles. Regulatory Toxicology and Pharmacology 69, 55–7.

Shi L., Wang Y, Xu L., Liu Y., Jia Y., Yao D., and Li X. (2016). Evaluation of Purification Effect of Intelligent Air Purifier in the Pathology Department. J Med Surg Pathol., 1(4): 138. DOI: 10.4172/2472-4971.1000138.

Sonibare, J. A., Akeredolu, F. A., Osibanjo, O., and Latinwo, I. (2005). ED-XRF analysis of total suspended particulates from enamelware manufacturing industry. American Journal of Applied Science, 2, 573–578.

U.S. Consumer Product Safety Commission (CPSC). 2012. Statement of Policy or Interpretation; Enforcement Policy for Art Materials. Consumer Product Safety Commission [FR Doc 95-3450 Filed 2-10-95 Available from: https://www.cpsc.gov/PageFiles/77793/027.txt.

Van den Bossche, J., Peters, J., Verwaeren, J., Botteldooren, D., Theunis, J., De Baets, B. (2015). Mobile monitoring for mapping spatial variation in urban air quality: development and validation of a methodology based on an extensive dataset. Atmos. Environ. 105, 148–161.

Walgraeve C, Demeestere K, Dewulf J, VanHuffel K, Van Langenhove H. (2011). Diffusive sampling of 25 volatile organic compounds in indoor air: Uptake rate determination and application in Flemish homes for the elderly. Atmospheric Environment. 45 (32):5828-36.

Wang H., Tseng C., Hsieh T (2008). Developing an indoor air quality index system based on the health risk assessment. Indoor Air 2008, 17-22, Copenhagen, Denmark - Paper ID: 749.

Xu L, Batterman S., Hen F., Li J., Zhong X., Feng Y., Rao Q., and Chen F. (2017). Spatiotemporal characteristics of $PM_{2.5}$ and PM_{10} at urban and corresponding background sites in 23 cities in China. Sci Total Environ. 599-600: 2074–2084.

Zhang X Y, Arimoto R, Zhu G H, Chen T and Zhang G Y. (1998). Concentration, size distribution and deposition of mineral aerosol over Chinese desert regions; Tellus B. 50(4) 317 330.

Zikova, N., Hopke, P.K., Ferro, A.R., (2017). Evaluation of new low-cost particle monitors for $PM_{2.5}$ concentrations measurements. J. Aerosol Sci. 105, 24–34.

ISSN: 3043–6087. Science and Education Development Inst., Nigeria