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Indoor Air Quality ($PM_{2.5}$ and PM_{10}) and Toxicity Potential at a Commercial Environment in Akure, Nigeria †

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Abstract: According to studies, indoor air quality is a major concern because of the health risks it poses. In Nigeria, little is done to improve indoor air quality and the toxicity potentials (TP) of $PM_{2.5}$ and PM_{10}. We assessed the levels of $PM_{2.5}$, PM_{10}, the $PM_{2.5}/PM_{10}$ ratio, and the toxicity potential of a commercial area in Akure, Ondo State, Nigeria, in this study. For the three-month assessment of the study area (March to May 2022), a low-cost sensor (Canāree A1) was used. The results depict the following: 73.23 ± 53.94 µg/m^3 ($PM_{2.5}$), 68.58 ± 50.64 µg/m^3 (PM_{10}), 0.93 ± 0.02 ($PM_{2.5}/PM_{10}$ ratio), and toxicity potentials ($PM_{2.5}$—2.74 ± 0.04 and PM_{10}—1.47 ± 0.02). Both PM values exceed the WHO standard limits. The PM values differ significantly. The average ratio value indicates that anthropogenic activities in the area contribute significantly to the high $PM_{2.5}$ levels. It should be noted that TP greater than 1 indicates a potential health risk. The TP values obtained in this study are greater than 1, indicating that the environment may be harmful to the vulnerable. Based on these findings, efforts should be directed toward continuous monitoring of this study area and Akure as a whole.

Keywords: indoor; health risks; low-cost sensor; WHO standard; Nigeria

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1. Introduction

In general, neither developing nor developed countries take the effects of air pollution for granted. Attempts are being made to reduce or entirely eliminate it. Pollutant gases (O_3, NO_2, SO_2, and CO) and particulate matter (PM—PM_{10} and $PM_{2.5}$) are the main culprits of air pollution. The size of particles in PM is directly related to their likelihood of triggering health problems [1] Small particles less than 10 µm in diameter cause the most issues because they can penetrate deep into lungs and, in some cases, enter into the bloodstream. Exposure to such particles can harm the lungs and the heart. Various studies have shown the connection of particle pollution exposure to a variety of health problems, including premature death in people with heart or lung disease, nonfatal heart attacks, irregular heartbeat, aggravated asthma, decreased lung function, and increased respiratory symptoms, such as airway irritation, coughing, or difficulty breathing. Particle pollution exposure is most likely to affect vulnerable people (the sick, children, and the elderly).

Researchers have discovered that human activity is a major source of heavy metals and fine particulate matter contaminants in the air [2–4]. Industrial activities in both developed and developing nations are documented to contribute significantly to human-induced air pollution, with particulate matter and gaseous pollutants being produced at mostly undesirable levels. Heavy metal air pollution is a worldwide issue because most metals are inextinguishable and can endanger human health, plants, animals, ecosystems, or other media [4]. The studies on pollutant toxicity potential have been motivated by growing human health concerns about PM inhalation [3]. Particulate matter toxicities are known to pose serious health risks, and a calculated toxicity potential value that exceeds unity when using the threshold limits is concerning. The objective of this study was to assess the levels of $PM_{2.5}$, PM_{10}, the $PM_{2.5}/PM_{10}$ ratio, and the toxicity potential of a commercial area in Akure, Ondo State, Nigeria.

2. Materials and Methods

Akure is the capital city of Nigeria's Ondo state. Every year, the city experiences dry (November to March) and wet (April to October) seasons. The dry season (harmattan) is typically cold (9–16 °C), with dusty northeasterly trade winds from the Sahara desert transporting large amounts of dust for several days. The season is typically distinguished by high solar radiation and clear skies, moderate air temperatures, and no precipitation. Between April and mid-October, southwesterly winds from the Atlantic Ocean predominate. The research was carried out at the Federal College of Agriculture, Akure, REC campus commercial area (5°14′23.94″ E 7°5′49.34″ N). There are motorcycle mechanics, shoe-making workshops, and a commercial shop (typing, bookbinding, etc.) in the campus commercial area. A lot of generator usage occurs in these places. A low-cost Canāree A1 sensor an Intelligent Particle Sensor was used for the three-month monitoring (March to May 2022) of PM_{10} and $PM_{2.5}$ in the study for 6 h each day. The manufacturer's standard protocols were strictly followed. The generated data were statistically manipulated using Minitab and Excel 2013 software, producing basic summary reports and a bar chart, respectively.

Toxicity Potential

Toxicity potential (TP) is the ratio of evaluated ambient PM mass to the standard limit of ambient concentration [5]. It is useful in determining the harmful effects of pollutants on human health. It was calculated using Equation (1), in consideration of the World Health Organization 2021 Guidelines for PM_{10} and $PM_{2.5}$ ambient air quality standards: PM_{10} (24 h-45 μg/m^3 and Annual-15 μg/m^3) $PM_{2.5}$ (24 h-5 μg/m^3 and Annual-5 μg/m^3) [6].

$$\text{Toxicity Potential} = \frac{MPM}{SPM} \quad (1)$$

where *MPM* is the measured particulate matter, and *SPM* is the guideline limit set for PM_{10} and $PM_{2.5}$.

3. Results and Discussion

Figure 1 depicts the summary reports for PM_{10}, $PM_{2.5}$, and their respective ratios. The recorded $PM_{2.5}$ and PM_{10} levels for the study periods ranged from 1.26 to 469.80 μg/m^3, $PM_{2.5}$—1.26 to 419.13 μg/m^3, and their ratios were observed as 0.49 and 1.00. It should be noted that the WHO 2021 guidelines assert that annual average $PM_{2.5}$ and PM_{10} concentrations must not exceed 5 and 15 μg/m^3, respectively, while 24-h average risks must not surpass 15 and 45 μg/m^3, respectively. The majority of the 24-h PM_{10} and $PM_{2.5}$ values in the commercial area were discovered to be greater than the WHO recommendations in this study. Figure 1 depicts the summary reports for PM_{10}, $PM_{2.5}$, and their respective ratios. The high Particulate matter levels are expected due to the many anthropogenic activities within the study area, including the use of perfumes by people (customers and shop owners) within the surroundings, generator fumes, and the center's proximity to a high-traffic location, i.e., vehicular movements on the airport road. During this time, there were also many land preparations for the start of the new planting season. There was a lot of bush burning and soil dust movement.

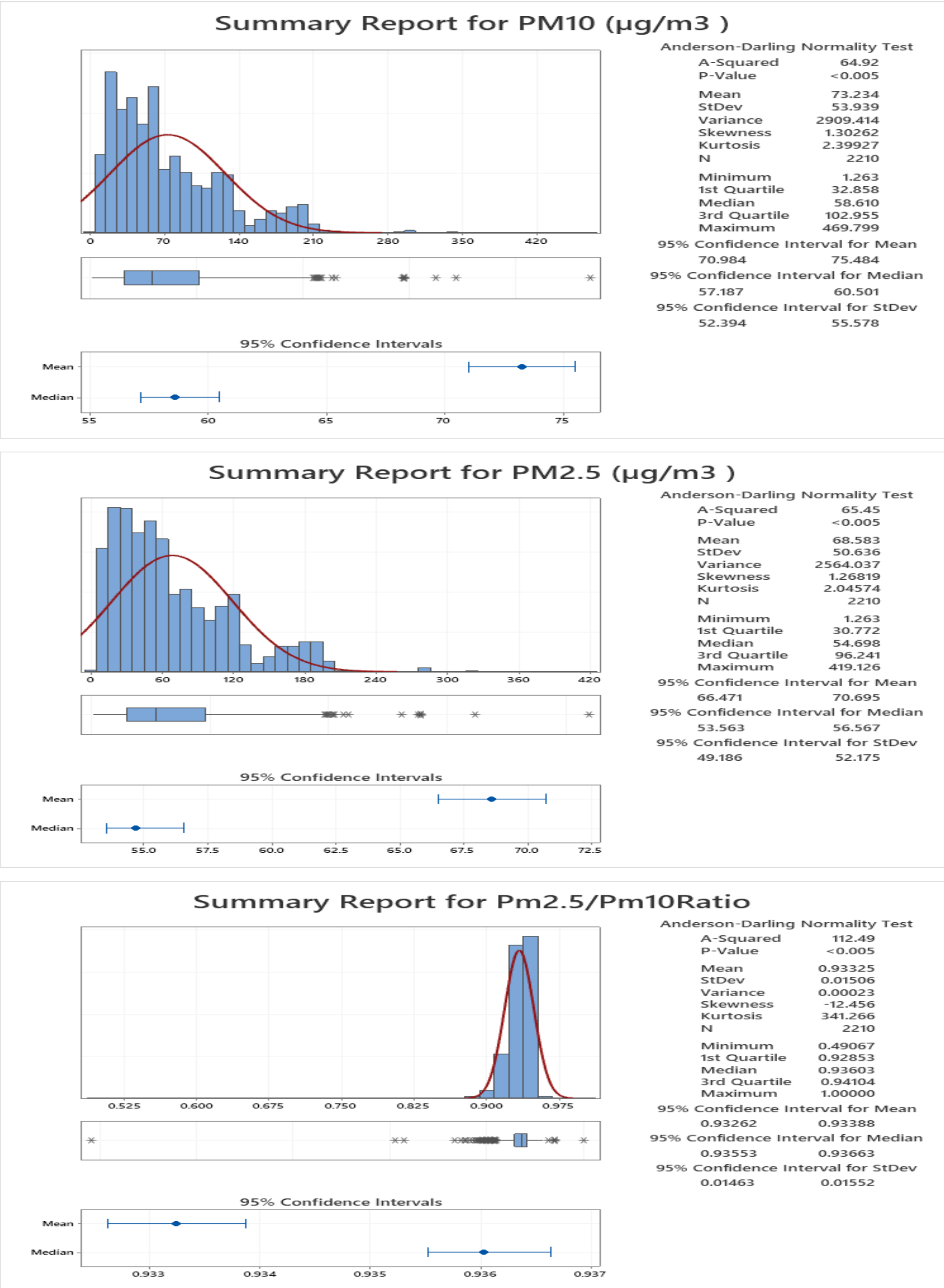

Figure 1. The Summary Report of PM_{10}, $PM_{2.5}$, and Their Ratios.

In addition, forest fires could also have contributed to mass concentrations during this time period. Table 1 compares our findings to previous research in Nigeria and other countries. Figure 1 depicts the summary reports for PM_{10}, $PM_{2.5}$, and their respective ratios. The average $PM_{2.5}/PM_{10}$ ratios in other countries were consistent with our studies, which range from 0.3 to 0.85 in the winter, spring, and summer seasons. The consistency could be explained by the fact that traffic-related sources are dominated by particle emissions and the constituents of $PM_{2.5}$ and PM_{10}.

Table 1. Comparison of the results of our study with previous ones in Nigeria and Other countries.

S/N	Location	PM_{10} (µg/m^3)	$PM_{2.5}$ (µg/m^3)	$PM_{2.5}/PM_{10}$	Toxicity Potential	References
1.	FECA, Akure, Nigeria	73.23 ± 53.94	68.58 ± 50.64	0.93 ± 0.02	PM_{10}—1.47 $PM_{2.5}$—2.74	This Study
2.	Kano, Nigeria	22.70–57.00	11.71–25.30	-	PM_{10}: 0.45–1.14 $PM_{2.5}$: 0.45–1.08	Ayua et al. [7]
3.	Chelyabinsk, Russia	6 and 64	5 to 56	0.85	-	Krupnova et al. [8]
4.	Helsinki and Stockholm	-		0.30–0.80	-	Adães and Pires [9]
5.	Tianjin, China	40.09 to 746	13.03 to 309	Average 0.41 ± 0.22 (Spring) – 0.43 ± 0.19 (winter),	-	Zhang et al. [10]
6.	China mainland	74.37–85.13	38.08–48.63	0.54–0.57	-	Fan et al. [11]
7.	Omu-Aran, Nigeria	59.32–473.52	11.42–32.40	-	PM_{10}: 0.13–0.36, $PM_{2.5}$: 0.33–2.64	Fakinle et al. [12]
8.	Idiroko Road, Nigeria	-	43.0 ± 1.0 to 91.0 ± 5.0 (day) 42.0 ± 2.0 to 53.0 ± 3.0 (evening)	-	$PM_{2.5}$: 1.36–3.64	Oghenovo et al. [13]

Figure 2 depicts the mean values of PM_{10} and $PM_{2.5}$ Toxicity Potentials 1.47 and 1.47 and 2.74. Our results were similar to those of Fakinle et al. [12]—$PM_{2.5}$: 0.13–0.36, and PM_{10}: 0.33–2.64—but Oghenovo et al. [13] obtained a higher maximum level (3.64). The similarities in TP results revealed that the sources of particulate matter may not differ between locations. A TP value greater than one indicates that PM_{10} and $PM_{2.5}$ in a location pose a health risk to people in the area. Several epidemiologic studies and toxicity research studies have found that a variety of chemical components and sources can have a negative impact on people's health. It is crucial to mention that the area surrounding this study is healthy, but good tracking of the environment in terms of PM should be done on a regular basis.

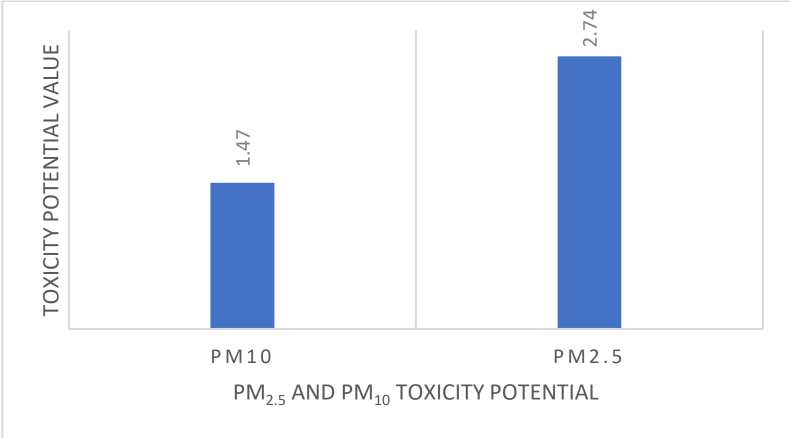

Figure 2. The PM_{10} and $PM_{2.5}$ Toxicity Potentials.

4. Conclusions

The $PM_{2.5}$, PM_{10}, $PM_{2.5}/PM_{10}$ ratios, and TP of a commercial area in Akure, Ondo State, Nigeria were measured for three months using a Canāree A1 low-cost sensor. The findings revealed that the WHO 2021 guidelines were exceeded. The $PM_{2.5}/PM_{10}$ ratios revealed that the presence of PM could be attributed to fumes from the generator and vehicles in the study area. A TP greater than one is a health concern, especially for the vulnerable (the sick, children, and the elderly). Constant monitoring is advised.

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References

1. Ndamitso, M.M.; Iyaka, Y.A.; Abdulkadir, A.; Abulude, F.O. Evaluation of Atmospheric PM10 in the Southwest Region of Nigeria. *Curr. Appl. Sci. Technol.* **2021**, *21*, 215–223.
2. Zhang, M.-K.; Liu, Z.-Y.; Wang, H. Use of Single Extraction Methods to Predict Bioavailability of Heavy Metals in Polluted Soils to Rice. *Commun. Soil Sci. Plant Anal.* **2010**, *41*, 820–831. [CrossRef]
3. Fakinle, B.S.; Sonibare, J.A.; Akeredolu, F.A.; Okedere, O.B.; Jimoda, L.A. Toxicity Potential of Particulates in the Airshed of Haulage Vehicle Park. *Glob. NEST J.* **2013**, *15*, 466–473.
4. Abah, J.; Mashebe, P.; Onjefu, S.A. Heavy Metals Pollution Status of the Katima Mulilo Urban Open Land Wastewater Disposal Centre and the Immediate Vicinity. *Cogent Environ. Sci.* **2020**, *6*, 1726093. [CrossRef]
5. Sonibare, J.A.; Akeredolu, F.A.; Osibanjo, O.; Latinwo, I. ED-XRF Analysis of Total Suspended Particulates from Enamelware Manufacturing Industry. *Am. J. Appl. Sci.* **2005**, *2*, 573–578. [CrossRef]
6. WHO. *WHO Global Air Quality Guidelines: Particulate Matter (PM2.5 and PM10), Ozone, Nitrogen Dioxide, Sulfur Dioxide and Carbon Monoxide*; World Health Organization: Geneva, Switzerland, 2021. Available online: https://apps.who.int/iris/handle/10665/345329 (accessed on 10 April 2022).
7. Ayua, T.; Tyovenda, A.; Sombo, T.; Tikyaa, E.; Igbawua, T. Fine Particulate Matter and Heavy Metals Pollution Status in Ambient Air of Some Selected Industrial Sites in Northern Nigeria. *J. Geosci. Environ. Prot.* **2020**, *8*, 1–13. [CrossRef]

8. Krupnova, T.G.; Rakova, O.V.; Bondarenko, K.A.; Saifullin, A.F.; Popova, D.A.; Potgieter-Vermaak, S.; Godoi, R.H.M. Elemental Composition of $PM_{2.5}$ and PM_{10} and Health Risks Assessment in the Industrial Districts of Chelyabinsk, South Ural Region, Russia. *Int. J. Environ. Res. Public Health* **2021**, *18*, 12354. [CrossRef] [PubMed]
9. Adães, J.; Pires, J.C.M. Analysis and Modelling of $PM_{2.5}$ Temporal and Spatial Behaviors in European Cities. *Sustainability* **2019**, *11*, 6019. [CrossRef]
10. Zhang, J.; Wu, L.; Fang, X.; Li, F.; Yang, Z.; Wang, T.; Mao, H.; Wei, E. Elemental Composition and Health Risk Assessment of PM_{10} and $PM_{2.5}$ in the Roadside Microenvironment in Tianjin, China. *Aerosol Air Qual. Res.* **2018**, *18*, 1817–1827. [CrossRef]
11. Fan, H.; Zhao, C.; Yang, Y.; Yang, X. Spatio-Temporal Variations of the $PM_{2.5}/PM_{10}$ Ratios and Its Application to Air Pollution Type Classification in China. *Front. Environ. Sci.* **2021**, *9*, 692440. [CrossRef]
12. Fakinle, B.S.; Adebayo, B.M.; Aremu, C.O.; Sonibare, J.A. Toxicity potential of particulate in the airshed of a university farm. *IOP Conf. Series: Earth Environ. Sci.* **2020**, *445*, 012036. [CrossRef]
13. Oghenovo, I.; Benson, N.; Adedapo, A.; Ahmadu, O.F. Assessment of Particulate Matter ($PM_{2.5}$) in Residential Staff Quarters of Covenant University, Nigeria. *J. Phys. Conf. Ser.* **2019**, *1299*, 012101. [CrossRef]