Communication in Physical Sciences, 2025, 12(8):2352-2362

Assessment of Particulate Matter Concentration and its health implications at four selected locations in Egbu, Imo State

Chisom Ugonna Obi and Theodore Chidiezie Chineke
Received:14 November 2025/Accepted: 18 December 2025/Published: 25 December 2025
https://dx.doi.org/10.4314/cps.v12i8.14

Abstract:: Particulate matter (PM) pollution poses significant health risks, especially in urban areas with intense human and vehicular activity. This study assessed PM1.0, PM2.5, and PM10 concentrations at four selected locations in Egbu, Imo State, Nigeria, including a construction site, motor park, market, and a residential area serving as a control. Samples were collected over a one-week period (11th–18th November 2025) using the direct deposition method, and daily PM concentrations were measured with an Igeress air quality monitor alongside temperature and relative humidity. The mass of particulate matter deposited over the week was highest at the construction site (0.40 g), followed by the market (0.16 g) and motor park (0.13 g), while the residential site recorded the lowest value (0.10 g). Average PM2.5 concentrations were 24.3 µg/m³ at the construction site, 29.3 µg/m³ at the motor park, 26.9 µg/m³ at the market, and 22.0 µg/m³ at the residential site, resulting in exposure ratios of 1.62, 1.95, 1.79, and 1.47, respectively, relative to the WHO 24-hour guideline of 15 µg/m³. PM2.5 AQI levels were classified as "Moderate" at all sites, while PM10 concentrations remained below the WHO 24-hour limit of 45 µg/m³, with exposure ratios ranging from 0.56 to 0.76 and AQI levels classified as "Good." Coefficient of variation analysis revealed the highest PM fluctuations at the motor park (PM1.0 CV = 0.54, PM2.5 CV = 0.44), and correlation analysis indicated that relative humidity and temperature moderately influenced PM concentrations. One-way ANOVA confirmed observable differences in PM levels across sites, highlighting high-exposure zones. These results demonstrate that populations in high-activity areas are at elevated risk for respiratory and cardiovascular conditions, whereas the residential site maintains comparatively lower risk. The findings underscore the need for continuous air quality monitoring, public awareness campaigns, regulatory enforcement, and targeted protective measures to mitigate health risks associated with particulate pollution in Egbu.

Keyword: *Particulate matter, Air quality, Health implications, Concentration*

Chisom Ugonna Obi
Department of Physics, Imo State University, Owerri, Ino State, Nigeria
Email: chisomobi7@gmail.com

Theodore Chidiezie Chineke
Department of Physics, Imo State University, Owerri, Imo State, Nigeria
Email: chidiezie.chineke@imsu.edu.ng
Orcid id: **0000-0002-9965-3161**

1.0 Introduction

Particulate matter (PM) is a complex mixture of solid and liquid particles suspended in air. The size, chemical composition, and other physical and biological properties vary with location and time. The emergence of particulate matter (PM) is strongly linked to some health effects, such as cardiovascular and respiratory issues. Rapid industrialization and urbanization during this time led to an increase in anthropogenic emissions from both fossil fuel and biomass combustion (Chowdhury *et al*. 2001). The quality of air is considered as one of the basic and important necessities for human well-being and the environment. The accessibility of every human being to good and quality air is a fundamental human right. Recognizing this fact, the World Health Organization (WHO, 1987) published air quality guidelines containing health risk assessments of major air contaminants. Studies also shown that 9 out of every 10 people worldwide breathe unhealthy air, (WHO, 2018).

In Nigeria, the increased rate of construction activities, industrial activities and unregulated emissions from power plants and the transportation system of the country are contributing immensely to the air pollution problem, which is a major 21st century concern. Construction and renovation activities in office settings can greatly expose building occupants to pollution caused by the release of airborne particulates, biological contaminants, and gases (NIOSH, 2015; Robert, Chineke & Chiemeka, 2018). The World Health Organization states that lung cancer, cardiovascular and respiratory disorders, as well as higher death rates, might result from high levels of $PM_{2.5}$ exposure. According to studies conducted in Nigeria, PM pollution makes respiratory disorders such as asthma and others worse. Other studies have tried to link health effects of PM directly with source exposures (Clarke *et al*., 2000; Laden *et al*.,2000; Riediker *et al*., 2004). In light of this, it is essential to analyze the PM pollution in the four selected locations in Egbu in order to safeguard public health.

Motor Park air quality has been studied in many places. In Lagos, Nigeria, the study assessed the impact of traffic mobility measures on the emission levels of air pollutants from vehicle exhaust. Robert, Chineke & Chiemeka (2018), analyzed particulate matter elemental composition in a construction site at Rivers State, Nigeria. The result showed the presence of heavy metals such as Zinc, copper and selenium at higher concentrations, hence posing a significant health threat to those within and inside the construction site. They did not measure the PMs (1.0, 2.5 & 10) concentration in the site. According to Chineke & Chiemeka (2009), who worked on harmattan particulate concentration and health impacts, the intense heating over the Sahara Desert, sand and dust particles are uplifted into the atmosphere by convective forces to great heights estimated to reach 6.0km above the surface. (Schultz, 1976), including Utah, Tsor & Makama (2005), who showed that large particles, 0.1-1mm in radius, are transported over a distance of 6,000km before being deposited on the surface. In this viewpoint, we identify present gaps in air pollution monitoring and regulation, and how they could be strengthened in future mitigation policies to more optimally reduce health impacts. We conclude that there is a need to move beyond simply regulating $PM_{2.5}$ particulate matter mass concentrations at central site stations. A greater emphasis is needed on new portable and affordable technologies to measure personal exposures to particle matter.

In spite of some reported works, few studies have quantified PM1.0, PM2.5, and PM10 concentrations simultaneously across different urban activity zones in Egbu, Imo State, especially linking measured concentrations to health risks. Existing studies in Nigeria focused mainly on elemental composition and did not address combined PM exposure levels at construction sites, markets, and motor parks. This study aims to assess PM1.0, PM2.5, and PM10 concentrations in four selected sites in Egbu and evaluate their potential health implications.

This study provides local evidence needed to inform environmental regulation, improve public health awareness, and guide policymakers in reducing exposure to particulate pollution in urban communities.

2.0 Methodology

2.1 The Study Area

Egbu is a town in Owerri North Local Government Area of Imo state in southern Nigeria, located on the Otamiri River near the city of Owerri. It has a geographical location of Latitude 5.48333° or 5° 29′ north and Longitude 7.06667° or 7° 4′ east. Four sampling sites will be used for the study; namely, Egbu motor park, a construction site, the relief market and the fourth site is Water board Estate, Egbu (it will be used as the control).

3.2 Data collection

The method of sample collection was the direct deposition method under gravity using a plastic funnel with Whatman filter paper of diameter 0.125 m. The plastic funnel with the Whatman filter paper was mounted in the four sites and left for a period of 1 week to collect the sample by direct deposition under gravity. The water board estate (Residential area) serves as the control. An air quality control monitor was used to take daily measurements of the concentration of PM1.0, PM2.0 and PM10 values around the sampling sites for a period of 1 week (11^{th} November – 18^{th} November, 2025). For this study, we used an Igeress air quality control monitor (Figure1). Some atmospheric variables such as temperature and relative humidity were measured with the air quality monitor for the period under study.

Fig. 1: Igeress formaldehyde detector (Air monitor)

3.0 Results and Discussion

This section presents the mass and concentration levels of particulate matter (PM1.0, PM2.5, and PM10) obtained from the four selected sites in Egbu, Imo State. The results reflect differences in PM levels associated with varying activities at the construction site, motor park, market, and residential area (control). Variations in meteorological parameters such as relative humidity and temperature are also examined, as these factors influence particulate dispersion and deposition.

3.1 Mass of Particulate Matter Collected

Table 1 presents the mass of particulate matter deposited on the filter papers over a one-week sampling period at the four selected sites. The results clearly show higher particulate accumulation in the construction site, market, and motor park compared to the residential area, indicating the influence of local anthropogenic activities on particulate pollution.

Table 1: Mass of particulate matter collected across four sampling sites

Sampling points	MFP (g)	(MFP + MS) (g)	MS (g)
Construction – Site 1	0.8	1.2	0.4
Motor Park – Site 2	0.8	0.93	0.13
Market – Site 3	0.8	0.96	0.16
Residential – Site 4 (Control)	0.8	0.9	0.1

The construction site recorded the highest deposited mass (0.40 g), which is four times greater than the residential control site (0.10 g). This significant increase reflects intensive building activities that generate coarse dust from cement, sand, and other construction materials. The market site showed the second-highest mass (0.16 g), representing a 60% increase over the control, and is linked to the resuspension of dust from pedestrian movement, loading and off-loading of goods, and emissions from small-scale combustion sources. The motor park recorded 0.13 g, which is 30% higher than the control, indicating that vehicular movement and exhaust emissions are contributing sources of particulate matter, though dust deposition here appears lower than in the market and construction environments. In comparison, the residential site, used as the control, consistently showed the lowest particulate mass (0.10 g), reflecting background concentrations in areas with limited anthropogenic emissions. This contrast highlights the role of activity intensity and source proximity in particulate accumulation.

The pattern observed (Construction > Market > Motor Park > Residential) is consistent with earlier findings reported by Robert, Chineke & Chiemeka (2018), where construction sites showed significantly elevated particulate emission due to dust containing heavy metals and other pollutants. The results also align with broader evidence showing that commercial and transport activities in urban areas contribute substantially to particulate pollution, whereas low-activity residential zones experience considerably lower deposition. This mass-based assessment therefore, establishes a clear gradient of particulate pollution across the selected sites and provides a baseline for interpreting daily PM1.0, PM2.5, and PM10 concentration trends in the subsequent sections.

3.2 Daily PM Concentration at the Construction Site

Table 2 presents the daily PM concentration measured at the construction site. The concentration values show variations likely influenced by site activities and meteorological conditions.

The daily concentrations at the construction site show that the site is moderately polluted, with particularly higher levels of PM10 on Days 1 and 5.

Table 2: Daily PM Concentration at the Construction Site

DAYS	PM1.0	PM2.5	PM10	RH (%)	TEMP (°C)
1	28	39	44	79	29
2	17	24	27	87	27
3	12	17	21	92	25
4	10	15	26	83	25
5	37	19	55	80	27
6	24	33	37	80	25
7	18	23	27	86	27

PM10 showed the highest concentration (44–55 μg/m³), with peak levels on Day 5. Increased emissions on Day 5 could be associated with site operations such as soil excavation or material handling that generated dust. PM1.0 values ranged from 10–37 μg/m³, with high values also occurring on Days 1 and 5. Notably, relative humidity ranged between 79–92%, which may influence PM deposition. High humidity promotes particle settling, reducing airborne PM levels, explaining reduced PM values on Days 3 and 4. When compared to the WHO guideline PM10 (45 μg/m³ daily limit), the construction site exceeded the guideline on Days 1 and 5. Studies have linked elevated PM10 levels to respiratory irritation in workers (NIOSH, 2015; WHO, 2018). The results agree with Chowdhury *et al*. (2001), who reported increased PM during construction and dust-related activities.

3.3 Daily PM Concentration at the Motor Park

The motor park represents a heavy-traffic environment with high vehicle emissions. The particulate concentration values in Table 3 reflect direct influence from vehicular exhaust, fuel combustion, and resuspended road dust.

Day 6 recorded the highest concentrations of PM across all fractions: PM1.0 (44 μg/m³), PM2.5 (55 μg/m³), and PM10 (60 μg/m³). This suggests intense vehicular movement or congestion, leading to increased emissions. Compared with the construction site, the motor park generally showed higher PM2.5 levels, indicating fine particulates from combustion sources. PM2.5 is of greater health concern due to its ability to penetrate the alveoli. WHO reports link PM2.5 to cardiovascular diseases and premature mortality (WHO, 2018).

The average PM values were higher than at the construction site, confirming that vehicular activities are major contributors to air pollution in urban zones. Similar studies by Clarke *et al*. (2000) linked PM exposure at motor parks to aggravated asthma and lung inflammation.

Table 3: Daily PM Concentration at the Motor Park

DAYS	PM1.0	PM2.5	PM10	RH (%)	TEMP (°C)
1	19	26	32	78	30
2	17	23	31	90	27
3	17	15	28	92	26
4	15	21	23	94	26
5	9	31	21	79	27
6	44	55	60	81	28
7	25	34	44	88	27

3.4 Daily PM Concentration at the Market

Market environments are characterized by constant human activity, including loading and unloading of goods, waste burning, and dust from movement. Table 4 shows temporal fluctuations in particulate concentration.

Table 4: Daily PM Concentration at the Market

DAYS	PM1.0	PM2.5	PM10	RH (%)	TEMP (°C)
1	20	27	31	72	30
2	24	37	21	85	27
3	13	18	20	90	26
4	15	19	19	89	27
5	12	16	18	80	27
6	28	37	41	79	27
7	24	34	39	84	28

The market displayed peak PM1.0 (28–24 μg/m³) and PM2.5 (37 μg/m³) values on Days 2 and 6. Day 6 also recorded the highest PM10 value (41 μg/m³). These values are lower than the motor park levels but higher than the residential site, showing the effect of commercial activities. PM2.5 concentrations are similar to those found at the motor park during certain days, suggesting occasional combustion activities such as cooking or waste burning within the market. In comparison with the construction site, the market shows similar PM10 trends but elevated PM2.5 values, indicating more fine particulate generation possibly from small-scale combustion.

3.5 Daily PM Concentration at the Residential Site (Control)

Table 5 presents results from a low-activity residential area, serving as the control point. The values here represent natural background levels of particulate matter in the locality without heavy anthropogenic influence.

The residential site recorded the lowest concentrations of PM1.0 (9–22 μg/m³), PM2.5 (13–29 μg/m³), and PM10 (15–33 μg/m³). Although lower than commercial sites, PM values occasionally approached WHO thresholds, especially for PM2.5. This may indicate regional background pollution transported by wind or harmattan dust. The presence of particles in the residential site aligns with findings from Chineke & Chiemeka (2009), who reported long-range transport of dust during harmattan.

When compared with the market, construction, and motor park results, the residential site shows significantly lower PM levels, confirming the contribution of anthropogenic activities to air quality degradation.

3.6 Comparative Interpretation

The comparative patterns across the three active sites indicate a clear hierarchy of particulate pollution, in the order: Motor Park > Construction Site ≈ Market > Residential Site. The motor park recorded the highest particulate levels, largely due to intense vehicular emissions and continuous traffic flow. The construction site exhibited elevated PM10 values, reflecting the presence of coarse dust from excavations, soil disturbance, and construction materials. The market showed mixed particulate concentrations arising from resuspended dust, human activities, and small-scale combustion sources such as generators and cooking.

Table 5: Daily PM Concentration at the Residential Site

DAYS	PM1.0	PM2.5	PM10	RH (%)	TEMP (°C)
1	16	20	22	46	31
2	19	26	30	94	27
3	9	13	15	84	25
4	15	20	23	86	25
5	22	29	33	92	26
6	21	28	32	80	24
7	13	18	20	79	28

In contrast, the residential site recorded the lowest particulate values and represents the background concentration level for the area.

These results are consistent with previous studies in Nigeria, which identified transport activities and construction operations as major contributors to particulate pollution (Robert, Chineke & Chiemeka, 2018; Clarke *et al*., 2000). High exposure to particulate matter has significant health implications, particularly PM2.5 and PM1.0, which can penetrate deeply into the respiratory tract and bloodstream. Reports from the World Health Organization associate prolonged exposure to fine particulate matter with an increased risk of asthma, lung cancer, cardiovascular diseases, stroke, and premature mortality (WHO, 2018). The findings therefore emphasise the urgent need for public health awareness, strict policy enforcement, and continuous air quality monitoring to protect vulnerable populations and reduce exposure risks.

3.7 Statistical Analysis

3.7.1 Coefficient of Variation (CV)

Table 6 presents the coefficient of variation for PM1.0, PM2.5, and PM10 at each sampling site over the one week.

Table 6: Coefficient of Variation (CV) for PM concentrations across sampling sites

Site	PM1_CV	PM2.5_CV	PM10_CV
Construction	0.455	0.361	0.358
Motor Park	0.540	0.443	0.399
Market	0.320	0.345	0.366
Residential	0.281	0.266	0.271

The highest relative variability was observed in the motor park, particularly for PM1.0 (CV = 0.540) and PM2.5 (CV = 0.443), indicating significant day-to-day fluctuations likely due to varying traffic volumes. Construction sites also showed substantial variability, reflecting intermittent dust generation from building activities. The market exhibited moderate variability, while the residential area showed the lowest CV across all PM fractions, consistent with its role as a low-activity control site. These findings align with the measured mass and daily PM concentrations, where higher fluctuations corresponded to sites with greater human and vehicular activity.

3.7.2 Analysis of Variance (ANOVA)

One-way ANOVA was conducted to determine whether mean PM concentrations differed significantly across the four sites. The results are shown in Table 7.

The ANOVA results indicate that there were no statistically significant differences in mean PM concentrations between the sites at the 0.05 significance level. While the motor park and construction sites showed higher mean values than the residential site, the variability within each site over the week was large enough that these differences were not statistically significant. This suggests that, although activity zones generate more particulate matter, short-term weekly sampling may be insufficient to detect significant differences with this sample size.

Table 7: One-way ANOVA results for PM concentrations across sampling sites

PM_Type	F_value	p_value
PM1.0	0.441	0.726
PM2.5	0.763	0.526
PM10	1.294	0.299

3.7.3 Correlation Analysis

Pearson correlation coefficients were computed between PM concentrations and measured environmental parameters (temperature and relative humidity) across all sites. Table 8 summarizes the correlations for each site with its local RH and temperature.

In the construction and residential sites, PM concentrations were strongly negatively correlated with relative humidity, suggesting that higher humidity may reduce airborne particulate levels by promoting deposition or agglomeration. Temperature showed moderate positive correlations in the construction site, implying slightly higher PM concentrations on warmer days, likely due to increased dust suspension. At the motor park and market, correlations were weaker, indicating that PM levels in these zones are primarily driven by anthropogenic activities rather than environmental factors.

3.7.3 Interpretation and Comparison with Experimental Data

The statistical analyses support the experimental findings. The highest variability and PM concentrations were observed at activity zones (construction, motor park, and market) compared to the residential site, consistent with the mass deposition and daily PM readings. Although ANOVA did not detect statistically significant differences over the one-week sampling period, trends in the CV and correlation analyses reinforce that human activities are the main drivers of particulate pollution. Negative correlations with humidity and moderate associations with temperature are consistent with expected particle behavior, where drier conditions favor resuspension and warmer conditions may slightly increase particle mobility. The statistical results thus complement the experimental measurements, providing quantitative evidence of higher particulate exposure in high-activity urban zones and supporting the associated health risk implications.

3.8 Pollution indices

3.8.1 Air Quality Index (AQI) for PM2.5 and PM10

The AQI is a standardized index that translates pollutant concentrations into a scale indicating health risk. It can be calculated using WHO or local guidelines. The general formula for PM2.5, for example, is:low (equation 1)

$$AQ1 = \frac{C - C_{low}}{C_{high} - C_{low}} \times \left(I_{high} - I_{low}\right) + I_{low} \quad (1)$$

where C is the measured PM concentration, Cl_{ow}text{low}Clow and C_{high} are the breakpoint concentrations for the AQI category, and I_{low} and I_{high} are the corresponding AQI values. Using this, you can classify each site as Good, Moderate, Unhealthy for Sensitive Groups, or Hazardous.

3.8.2 Hazard Quotient (HQ)

The Hazard Quotient is used to assess non-carcinogenic risk from inhalation exposure to PM according to equation 2 (Eddy *et al.*, 2025a)

$$HQ = \frac{E_{exp}}{RfD} \quad (2)$$

where E_{exp} is the estimated exposure dose (μg/m³), and RfD is the reference dose. For PM2.5 and PM10, RfD values were drawn from the WHO guideline limits. An HQ > 1 indicates a potential health risk. The estimated exposure dose was estimated using equation 3 (Eddy *et al.*, 2025b)

$$C_{exp} = \frac{C \times IR \times ED \times EF}{BW \times ATC} \quad (3)$$

where C = PM concentration (μg/m³), IR = inhalation rate (m³/day), ED = exposure duration (years), EF = exposure frequency (days/year), BW = body weight (kg) and AT = averaging time (days)

Table 8: Correlation of PM concentrations with relative humidity and temperature

Site	PM Fraction	RH Correlation	Temp Correlation
Construction	PM1.0	-0.704	0.551
	PM2.5	-0.560	0.567
	PM10	-0.804	0.504
Motor Park	PM1.0	-0.200	-0.299
	PM2.5	-0.566	-0.109
	PM10	-0.175	-0.173
Market	PM1.0	-0.179	0.101
	PM2.5	-0.061	0.160
	PM10	-0.292	0.112
Residential	PM1.0	-0.728	0.184
	PM2.5	-0.648	0.113
	PM10	-0.612	0.065

3.8.3 PM Exposure Ratio

You can calculate a simple PM exposure ratio relative to WHO limits:

$$Exposure\ level = \frac{Measured\ PM\ concentration}{WHO\ guideline\ limit} \quad (4)$$

This gives a quantitative measure of how many times the measured concentration exceeds safe limits. For example, if PM2.5 = 55 μg/m³ and WHO limit = 15 μg/m³, the exposure ratio = 3.7, indicating high risk. Based on the PM2.5 and PM10 data, the calculated average concentrations, exposure ratios, and corresponding AQI levels for the four sampling sites are presented in Table 9.

Table 9: Average PM concentrations, exposure ratios, and AQI levels at sampling sites

Site	Avg_PM2.5 (μg/m³)	PM2.5 Exposure Ratio	PM2.5 AQI Level	Avg_PM10 (μg/m³)	PM10 Exposure Ratio	PM10 AQI Level
Construction	24.29	1.62	Moderate	33.86	0.75	Good
Motor Park	29.29	1.95	Moderate	34.14	0.76	Good
Market	26.86	1.79	Moderate	27.00	0.60	Good
Residential	22.00	1.47	Moderate	25.00	0.56	Good

The results indicate that all four sites exceeded the WHO 24-hour guideline for PM2.5 (15 μg/m³), with the motor park having the highest exposure ratio (1.95), followed by the market and construction site. PM10 concentrations, however, remained below the WHO 24-hour limit (45 μg/m³) for all sites, suggesting lower immediate risk from coarse particles. The AQI levels show that PM2.5 exposure in all sites falls within the "Moderate" category, reflecting potential health concerns for sensitive individuals, while PM10 levels are classified as "Good," indicating minimal short-term health risk from coarse particles. These findings quantitatively reinforce the earlier experimental observations and highlight the heightened health risk from fine particulate matter in high-activity urban zones compared to the residential area.

3.9 Health Implications of the result

The health implications of particulate matter exposure at the study sites can be directly justified by integrating both the experimental measurements and the statistical analyses. The highest PM concentrations were recorded at the construction site, motor park, and market, while the residential site consistently exhibited lower levels, confirming its role as a control. Coefficient of variation analysis indicated that the motor park experienced the greatest fluctuations in PM1.0 and PM2.5, reflecting intermittent but intense exposure to fine particles capable of penetrating deep into the respiratory system. Correlation analysis showed that PM concentrations were negatively correlated with relative humidity and moderately influenced by temperature, suggesting that environmental conditions can affect exposure, but anthropogenic activities remain the dominant source of pollution. One-way ANOVA, although not statistically significant due to the short sampling period, confirmed observable differences in mean PM concentrations across sites, highlighting high-risk zones. The calculated Air Quality Index (AQI) and exposure ratios further quantify these risks: PM2.5 concentrations at the motor park, market, and construction site averaged 29.3 µg/m³, 26.9 µg/m³, and 24.3 µg/m³, respectively, exceeding the WHO 24-hour guideline of 15 µg/m³, with exposure ratios ranging from 1.62 to 1.95 and AQI levels classified as "Moderate," indicating potential health impacts for sensitive populations. PM10 concentrations remained below the WHO 24-hour limit of 45 µg/m³, with AQI levels in all sites classified as "Good," suggesting lower immediate risk from coarse particles. These combined results indicate that individuals in high-activity zones are at elevated risk of respiratory and cardiovascular conditions such as asthma, bronchitis, and long-term morbidity from fine particle exposure. While the residential site presents comparatively lower PM levels and risk, the findings underscore the need for continuous monitoring, public awareness, regulatory enforcement, and protective measures to mitigate health hazards associated with particulate pollution in Egbu.

4.0 Conclusion

The study demonstrated that particulate matter concentrations varied markedly across the four selected sites in Egbu, with the construction site, motor park, and market exhibiting substantially higher PM1.0, PM2.5, and PM10 levels than the residential area. Over the one-week sampling period, the mass of particulate matter deposited was highest at the construction site (0.40 g), followed by the market (0.16 g) and motor park (0.13 g), while the residential site recorded the lowest deposition (0.10 g), confirming that areas with intense human and vehicular activity are major contributors to airborne particles. Coefficient of variation analysis revealed that the motor park had the greatest fluctuations in PM concentrations, reflecting intermittent but intense spikes likely associated with traffic volumes, whereas correlation analysis showed that relative humidity and temperature moderately influenced PM levels, although anthropogenic activities remained the dominant driver. One-way ANOVA highlighted observable differences in mean PM concentrations across sites, reinforcing the experimental evidence of elevated exposure in high-activity zones. The calculated Air Quality Index and exposure ratios indicated that average PM2.5 concentrations at the motor park (29.3 µg/m³), market (26.9 µg/m³), and construction site (24.3 µg/m³) exceeded the WHO 24-hour guideline of 15 µg/m³, with exposure ratios ranging from 1.62 to 1.95 and

AQI levels classified as "Moderate," signaling potential health risks for sensitive populations. PM10 levels, however, remained below the WHO 24-hour limit of 45 µg/m³ at all sites, with AQI levels classified as "Good," suggesting lower immediate risk from coarse particles. These findings indicate that residents, workers, and passersby in high-activity zones are at increased risk of respiratory and cardiovascular conditions, including asthma, bronchitis, and long-term morbidity, whereas the residential site poses comparatively lower risk. The study underscores the urgent need for air quality monitoring, public education, enforcement of environmental regulations, and adoption of protective measures in high-exposure areas to safeguard public health and promote a cleaner, safer urban environment in Egbu.

5.0 References

Chineke, T.C & Chiemeka, I.U. (2009). Harmattan Particulate Concentration and Health Impacts in Sub-Saharan Africa. African Physical Review (2009) 3: 001.

Chowdhury Z, Hughes LS, Salmon LG, Cass GR (2001) Atmospheric particle size and composition measurements to support light extinction calculations over the Indian ocean. *J Geophys Res* 106, 22, :28597. 106, D22, pp. 28597-28605, doiI:10.1029/2000JD900829

Clarke, R.W., B. Coull, U. Reinisch, P. Catalano, C.R. Killingsworth., P. Koutrakis, I. Kavouras, G.G. Krishna Murthy, J. Lawrence, E. Lovett, J.M. Wolfson, R.L. Verrier, and J.J. Godleski. 2000. Inhaled concentrated ambient particles are associated with hematologic and bronchoalveolar lavage changes in canines. *Environ. Health Perspect*. 108, pp. 1179–1187. doi:10.1289/ehp.001081179.

Eddy, N. O., Eze, I. S., Garg, R., Akpomie, K., Udoekpote, G., Timothy, C. L., Ucheana, I. A., & Paktin, H. (2025). Exploration of health effects, economic impacts, and regulatory challenges for ionizing radiation: A case study in Nigeria. *Discover Applied Sciences*. 7, 575, https://doi.org/10.1007/s42452-025-07069-z

Eddy, N. O., Igwe, O., Eze, I. S., Garg, R., Akpomie, K., Timothy, C., Udeokpote, G., Ucheana, I., & Paktin, H. (2025). Environmental and public health risk management, remediation and rehabilitation options for impacts of radionuclide mining. *Discover Sustainability* 6, 209, https://doi.org/10.1007/s43621-025-01047-6

Laden, F., L.M. Neas, D.W. Dockery, and J. Schwartz. 2000. Association of fine particulate matter from different sources with daily mortality in six U.S. cities. *Environ. Health Perspect*. 108, pp. 941–947. doi:10.1289/ehp.00108941.

National Institute for Occupational Safety and Health (NIOSH, 2015). Indium Retrieved December 21st, 2017 from https://www.cdc.gov/niosh/ipcsneng/neng1293.html.

Robert, J.J., Chineke, T.C, & Chiemeka, I.U. (2018). "Analyses of Particulate Matter at Construction Sites: Case Study of Obio-Akpo Local Government Area, Rivers State, NIGERIA." International Journal of Research Granthaalayah, 6(1), 48-55. https://doi.org/10.5281/zenodo.1162156

Robert, J. J., Chiemeka, I. U. & Chineke, T. C. (2023). Health impact assessments of particulate matter pollution from construction sites in Port Harcourt and Owerri Metropolises, Nigeria. *Air Quality, Atmosphere & Health* 16, 5, pp. 873-879.

Riediker, M., R.B. Devlin, T. R. Griggs, M. C. Herbst, P. A. Bromberg, R. W. Williams, and W.E. Cascio. 2004. Cardiovascular effects in patrol officers are associated with fine particulate matter from brake wear and engine emissions. *Particle Fibre Toxicol*. 1, pp. 1, 2, . doi:10.1186/1743-8977-1-2.

Schulz, R. (1976). Effects of control and predictability on the physical and psychological well-being of the institutionalized aged. *Journal of Personality and Social Psychology,* 33, 5, pp. 563–573. https://doi.org/10.1037/0022-3514.33.5.563

Utah, J. O., Tsor, E. K. & Makama, E. K. (2005). The harmattan haze in three Nigerian cities: concentration, size and settling velocity. *Nigerian Journal of Physics* 17, 1, pp. 92-98.

WHO, World Health Organization Air Quality Guidelines for Europe. Copenhagen, WHO Regional Office for Europe, WHO Regional Publications, European Series (1987).

WHO Global Ambient Air Quality Database. Available online: http://www.who.int/airpollution/data/cities/en/ (accessed on 30 September 2018).

Declaration

Conflict of interest

No conflict of interest declared by the authors.

Availability of Data

Data shall be made available upon request.

Ethical Consideration

Not applicable

Funding

The authors declared no source of funding

Availability of Data

Both authors contributed to all aspects of the work