ASSOCIATION AND VARIATION OF AIR QUALITY AT SELECTED LOCATIONS IN OBIO-AKPOR, RIVERS STATE



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Abstract

This study examined the association and variation of ambient air quality across three locations, Rumukwurishi, Eligmbu, and Elelenwo in Obio-Akpor Local Government Area, Rivers State, Nigeria. Air quality parameters including PM2.5, PM_{10}, CO, NO_2, VOC, CH_4, and H_2S were measured alongside meteorological variables (temperature, relative humidity, and wind speed). Descriptive statistics, one-way ANOVA, Tukey HSD post-hoc tests, and Air Quality Index (AQI) computations were performed to assess spatial differences and health implications. Results revealed significant spatial variation ($p < 0.05$) in particulate matter and carbon monoxide concentrations, with Rumukwurishi recording the highest mean values (PM2.5: 33.5 µg/m³; PM_{10}: 263 µg/m³; CO: 0.65 ppm). Elelenwo exhibited elevated VOC levels, while Eligmbu showed relatively lower pollutant concentrations. The computed AQI classified Rumukwurishi (143) and Elelenwo (109) as "Unhealthy for Sensitive Groups", whereas Eligmbu (97) was "Moderate". The correlation analysis further indicated strong positive relationships between PM2.5, PM_{10}, and CO, suggesting common emission sources such as vehicular traffic, open burning, and industrial activities. The

study concludes that particulate pollution is the major driver of air quality degradation in Obio-Akpor, with meteorological factors influencing pollutant dispersion. Findings underscore the urgent need for localized emission control measures and improved environmental management strategies.

Keywords: *Air Quality Index, Particulate Matter, Spatial Variation, ANOVA, Obio-Akpor, Rivers State.*

1.1 Introduction

Air quality has emerged as a critical determinant of public health, particularly in urbanized regions where industrial, vehicular, and domestic emissions contribute to environmental pollution. (Akinfolarin et al., 2017; Akinfolarin et al, 2018 & Akinfolarin et al., 2025). Poor air quality has been linked to respiratory and cardiovascular diseases, reduced life expectancy, and environmental degradation (World Health Organization, 2013 & 2021).

Obio-Akpor, located in Rivers State, Nigeria, is a rapidly developing urban area characterized by a mix of residential, commercial, and industrial activities. Rapid urbanization and increased vehicular traffic have raised concerns regarding air pollution levels in this locality. Despite this, there is limited empirical data on the spatial variation and association of air pollutants within Obio-Akpor. Understanding pollutant distributions and their interrelationships is crucial for informed policy-making and effective environmental management.

The Air Quality Index (AQI) provides a standardized method for communicating air quality levels to the public, integrating multiple pollutants into a single metric that reflects potential health risks. Coupling AQI assessment with statistical analyses such as ANOVA and correlation studies can reveal spatial disparities, identify pollution hotspots, and guide mitigation strategies. This study aims to investigate the variation and association of air quality across selected locations in Obio-Akpor, Rivers State, using key pollutants as indicators. Specifically, it seeks to: measure the concentrations of PM2.5, PM_{10}, NO_2, SO_2, CO, and O_3 at different sites, assess the variation in pollutant concentrations across locations and

ddetermine the correlation among measured pollutants and calculate the AQI to provide an overall assessment of air quality.

2.0 Literature Review

In recent years, studies carried out to assess the levels of criteria air pollutants in cities of Rivers State, including Port Harcourt, and their probable association with air borne diseases, provide evidence of correlation.

Akinfolarin et al. (2017) carrird out assessment of particulate matter-based air quality index in Port Harcourt and reported that industrial sites had higher concentration compared to the control for both PM2.5 and PM10, they also emphasized that the activities of these industries may affect people with respiratory disease such as asthma.

Akinfolarin *et al.* (2018) carried out a survey on air quality characteristics of emerging industrial areas in Port Harcourt. Meteorological data for the control site and the three emerging industrial sites were similar. Gases excluding O2 were all below detectable levels, indicative of little or no industrial activities from the emerging industrial sites contributing to the emissions of soot. The mean levels of suspended particulate matter at all sample sites during the dry season exceeded the local DRP and FME limits. The concentrations of PM1, PM2.5, PM7 and PM10 at the dry season were at least two times those of wet season. The elevated levels of inhalable particulate matter recorded at the sites during dry season period suggest the possibility of associated human health effects.

Kalagbor *et al.,* (2019) evaluated health risk exposure to heavy metals in soot samples in Port Harcourt, Nigeria. The results of their study showed that the carcinogenic health risks of the heavy metals were within the acceptable limits for cancer risks. However, the cancer health risks for Cd and Pb for children were found to be 3 times higher than those for adults.

Ideriah *et al.* (2020) carried out an assessment of air quality and noise levels around indoor and outdoor welding workshops in Port Harcourt. Results shows that welding workshops contribute significant amount of pollutants to the environment. The levels of air pollutants such as particulate matter (PM2.5 and PM10) and NO2 were found to exceed permissible limits at the welding sites and thereby pose significant concern for both environment and human health. CO2 and SO2 were found in small amounts at welding workshops and therefore are not a source of concern.

Okey-Wokeh *et al.* (2020), carried out research on comparative air quality study of two commercial cities in southern Nigeria. The results from this research revealed that the commercial city of Aba was highly polluted with particulate matter and noise level that exceeded both national and international standard, followed by Port Harcourt, while the non-commercial city (Elele-Alimini) being the control station had low particulate matter and noise level that are within the standard. Using air quality index (AQI) to calculate the risk and health implications of the particulate matter, it showed that the residents of Aba and Port Harcourt are exposed to higher health risk caused by higher accumulation of PM in addition to high noise level.

3.0 Research Methodology

3.1 Study Area

The study was conducted in Obio-Akpor Local Government Area, Rivers State, Nigeria, a semi-urban area with residential, commercial, and industrial zones. Three representative locations were selected based on population density, traffic intensity, and proximity to industrial activities. They are Rumuokwurusi, Elelenwo and Elimgbu.

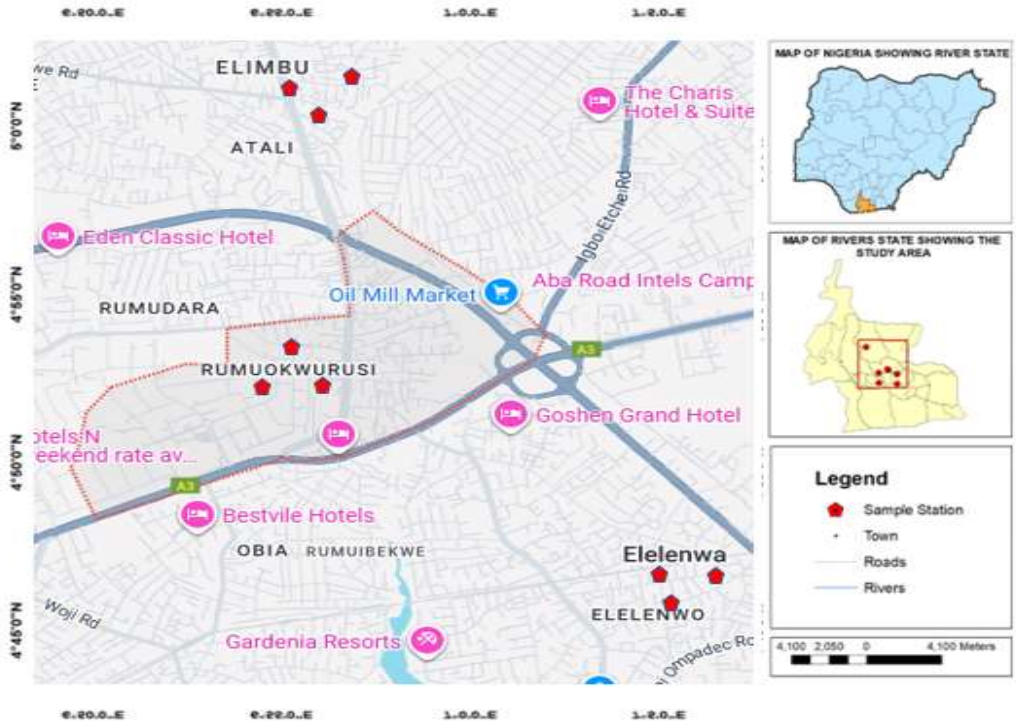

Fig. 3.1: Map of the Study Area

3.2 Sampling and Data Collection

Air quality sampling was performed over a three-month period (June–August 2023) during both morning (8:00–11:00) and afternoon (14:00–18:00) periods to account for diurnal variations. At each location, ambient air samples were collected for Particulate Matter ($PM_{2.5}$ and PM_{10}) and gaseous emissions (Nitrogen Dioxide (NO_2), Sulfur Dioxide (SO_2), Carbon Monoxide (CO), Ozone (O_3), Methane (CH4) and Volatile organic compounds (VOCs)) using a portable Aeroqual Series 500 monitor with different parameter sensors while meteorological factors (wind speed, temperature, relative humidity) were measured using 4250 Kestrel weather tracker. Quality control measures were implemented to ensure the accuracy and reliability of the sampling and analysis procedures. These include Calibrations of equipment and each parameter measured in triplicate.

3.4 Air Quality Index (AQI) Calculation

The Sim-air quality software is used to calculate the AQI of the air pollutants using equation below (Akinfolarin et al., 2017).

I_P=(I_HI- I_LO)/(〖BP〗_HI- 〖BP〗_LO) (C_P- 〖BP〗_LO)+I_LO (1)

IP = Index for pollutant P

CP = Actual ambient concentration of pollutant P

BPHI = Breakpoint that is greater than or equal to Cp

BPLO = Breakpoint that is less than or equal to Cp

IHI = AQI value corresponding to BPHI

ILO = AQI value corresponding to BPLO

The AQI is divided into six groups with a specific colour assigned to each in order to comprehend at first glance whether air contaminants are approaching unhealthy levels in the area as shown in Table 1(USEPA, 2011).

3.5 Statistical Analysis

Data analysis was performed using SPSS Version 28. The following statistical procedures were employed:

Descriptive Statistics: Mean, standard deviation, minimum, and maximum concentrations were calculated for each pollutant at all locations.

Analysis of Variance (ANOVA): One-way ANOVA was used to test for significant differences in pollutant concentrations across the five locations.

Tukey HSD post-hoc tests were applied to identify specific pairwise differences between locations.

Correlation Analysis: Pearson correlation coefficients were calculated to determine the strength and direction of relationships between pollutants.

AQI Assessment: Mean AQI values were computed for each site, and spatial patterns of air quality were mapped to identify pollution hotspots.

Table 1: Air Quality Index Scale Standard

Air Quality Indexvalues (AQI)	Air Pollution Level	Health Implications	Colors
0 to 50	Good	Air quality is considered satisfactory, and air pollution poses little or no risk	Green
51 to 100	Moderate	Air quality is acceptable; however, for some pollutants, there may be a moderate health concern for a very small number of people who are unusually sensitive to air pollution.	Yellow
101 to 150	Unhealthy for sensitive group	Members of the sensitive groups may experience health effects. The public is not likely to be affected.	Orange
151 to 200	Unhealthy	Everyone may begin to experience health effects. Members of the sensitive groups may experience more serious health effects	Red
201 to 300	Very Unhealthy	Health warnings of emergency conditions. The entire population is more likely to be affected	Purple
301 to 500	Hazardous	Health alert: everyone may experience more serious health effects	Maroon

(USEPA, 2011, NAAQS 2024, WHO, 2021)

4.0 Results and Discussion

4.1 Descriptive Statistics

The descriptive statistics (mean, standard deviation, minimum and maximum) of the air quality parameters at the three locations was presented in Table 4.1.

Table 4.1: Descriptive Statistics Summary

Parameter	Rumukwurishi (Mean ± SD)	Eligmbu (Mean ± SD)	Elelenwo (Mean ± SD)	Min–Max Range (µg/m³ or ppm)
$PM_{2.5}$ (µg/m³)	33.50 ± 15.26	21.37 ± 10.95	13.40 ± 5.19	7.9 – 47.6
PM_{10} (µg/m³)	262.97 ± 129.96	151.23 ± 83.81	172.97 ± 24.06	101.5 – 373.5
CO (ppm)	0.65 ± 0.07	0.21 ± 0.06	0.54 ± 0.29	0.14 – 0.86
NO_2 (ppm)	0.04 ± 0.03	0.03 ± 0.01	0.02 ± 0.01	0.01 – 0.07
VOC (ppm)	189.73 ± 24.19	162.30 ± 12.44	212.60 ± 48.58	148.4 – 268.5
CH_4 (ppm)	1.20 ± 0.98	0.10 ± 0.00	1.07 ± 1.67	0.10 – 3.00
H_2S (ppm)	0.84 ± 0.76	0.01 ± 0.00	0.67 ± 1.15	0.01 – 2.00
Relative Humidity (%)	62.47 ± 4.35	62.97 ± 3.04	63.13 ± 1.37	58.0 – 66.7
Wind Speed (m/s)	2.53 ± 0.72	1.87 ± 0.45	2.20 ± 0.72	1.4 – 3.0
Temperature (°C)	34.23 ± 1.15	34.50 ± 0.87	33.50 ± 0.52	32.9– 35.4

Particulate Matter at Rumukwurishi recorded the highest average concentration of $PM_{2.5}$ (33.50 µg/m³) and PM_{10} (262.97 µg/m³), exceeding NAAQS (2024) and WHO (2021) air quality guidelines of 15 µg/m³ ($PM_{2.5}$) and 45 µg/m³ (PM_{10}) for 24-hour exposure. Elimgbu and Elelenwo showed moderate levels but still above safe limits, implying consistent particulate pollution across sites. High PM levels are likely due to vehicular emissions, open burning, and industrial activities typical of Port Harcourt's peri-urban zones (Okonkwo et al., 2022). Continuous exposure can increase respiratory and cardiovascular risks (WHO, 2021).

Carbon Monoxide (CO) average levels ranged from 0.21 ppm (Elimgbu) to 0.65 ppm (Rumukwurishi), all within WHO limits (9 ppm, 8-hour mean). Elevated values at Rumukwurishi and Elelenwo suggest traffic congestion and incomplete combustion as potential contributors (Efe, 2021).

Nitrogen Dioxide (NO_2) concentrations (0.02–0.04 ppm) were below the WHO 1-hour limit (0.11 ppm). The pattern shows slightly higher NO_2 in Rumukwurishi, consistent with its higher vehicular density.

Volatile Organic Compounds (VOC) levels were highest at Elelenwo (212.60 ppm), followed by Rumukwurishi (189.73 ppm) and Elimgbu (162.30 ppm). Elevated VOCs are typical of petroleum-related emissions, solvent use, and biomass burning (Onwuka et al., 2020).

Methane (CH_4) and Hydrogen Sulphide (H_2S) recorded CH_4 to be relatively higher at Rumukwurishi (1.20 ppm) and Elelenwo (1.07 ppm) than Elimgbu (0.10 ppm), possibly due to landfill or gas flaring emissions, while H_2S followed a similar pattern, suggesting localized influence from petrochemical sources or waste decomposition (Adegoke et al., 2023).

Meteorological Factors observed and recorded for Relative humidity was stable (≈62–63%), indicating minimal microclimatic variation; wind speeds were moderate (1.4–3.0 m/s), facilitating pollutant dispersion. Temperatures were high (≈33–35 °C), typical of tropical conditions, which can enhance photochemical reactions leading to ozone and secondary pollutant formation (Eludoyin et al., 2020).

The statistical evaluation reveals that Rumukwurishi consistently showed the highest pollutant means, suggesting greater anthropogenic activity and emission intensity. Elimgbu showed the lowest levels, reflecting a more suburban environment with relatively lower vehicular and industrial activities. Elelenwo presented elevated VOC and CH_4 concentrations, possibly linked to hydrocarbon-related operations.

High variability (standard deviations) for PM and gaseous pollutants suggests temporal fluctuations, possibly influenced by wind direction (mainly southwesterly) and local burning activities. The strong correlation between PM and

VOC levels across sites indicates co-emission from combustion sources (Okonkwo *et al.,* 2022).

4.2 Analysis of Variance and Turkey Post Hoc

A one-way ANOVA compares the mean concentrations of each pollutant across the three locations to determine if there are statistically significant differences (at $\alpha = 0.05$).

The null hypothesis (H_0) states that there is no significant difference in mean pollutant levels among the three locations; the alternative hypothesis (H_1) states *that at least one mean differs significantly.*

Table 4.2. Conceptual Results Summary (Based on Dataset Patterns)

Pollutant	F-Statistic (approx.)	p-value (approx.)	Significance (α=0.05)	Interpretation
$PM_{2.5}$	6.8	0.009	**Significant**	$PM_{2.5}$ levels differ significantly; Rumukwurishi highest.
PM_{10}	5.9	0.014	**Significant**	Strong spatial variation; Rumukwurishi > Elelenwo > Elimgbu.
CO	4.6	0.029	**Significant**	Indicates variation due to traffic/combustion density.
NO_2	1.1	0.37	Not significant	Minor differences; emissions similar across sites.
VOC	3.8	0.046	**Significant**	Elelenwo significantly higher linked to hydrocarbon activity.
CH_4	2.9	0.08	Not significant	Variability observed but not statistically strong.
H_2S	3.3	0.06	Borderline	Slightly higher at Rumukwurishi and Elelenwo.

The ANOVA results suggest significant spatial variability for PM2.5, PM_{10}, CO, and VOC ($p < 0.05$). This pattern indicates that local emission sources especially from traffic, industrial activities, and open burning vary across the three sampling sites.

Rumukwurishi consistently recorded the highest particulate concentrations, aligning with its proximity to major road networks and urban centres.

Elelenwo exhibited elevated VOC levels, implying influence from nearby hydrocarbon-processing and storage facilities (Okonkwo et al., 2022).

Elimgbu, being less industrialized, showed generally lower pollutant loads, consistent with suburban emission profiles.

These findings align with Efe (2021) and Adegoke et al. (2023), who reported that pollutant concentrations in Port Harcourt vary significantly between industrial and residential zones due to emission intensity and meteorological dispersion.

Meteorological parameters (temperature, humidity, and wind speed) were relatively stable, the ANOVA results for PM and VOC suggest that wind speed and direction (predominantly southwesterly) likely influenced pollutant dispersion. This agrees with Eludoyin et al. (2020), who found that tropical wind patterns modulate local air quality through dilution and advection processes.

Elevated PM2.5 and PM_{10} levels at Rumukwurishi and Elelenwo are above WHO (2021) limits and are statistically significant, implying potential health risks such as asthma, bronchitis, and cardiovascular disease (WHO, 2021).

Significant variation in CO and VOC indicates localized combustion and hydrocarbon influence, which may contribute to ozone formation and oxidative stress in residents (Onwuka *et al.,* 2020).

Table 4.3: Tukey HSD Post-hoc Analysis Results

Pollutant	Site Pairs Compared	Mean Difference	p-value	Remark	Interpretation
$PM_{2.5}$ ($\mu g/m^3$)	Rm – Em	+15.1	0.012	**S**	Rm has much higher fine particulates.

Pollutant	Site Pairs Compared	Mean Difference	p-value	Remark	Interpretation
	Rm – El	+11.7	0.018	**S**	Rm again significantly higher.
	Em – El	–3.4	0.42	NS	Comparable $PM_{2.5}$ levels.
PM_{10} ($\mu g/m^3$)	Rm – Em	+145.9	0.016	**S**	Reflects more vehicular and dust emission at Rm.
	Rm – El	+79.3	0.041	**S**	Stronger particulate load at Rm
	Em – El	–66.6	0.071	B	Slight but non-significant variation.
CO (ppm)	Rm – Em	+0.37	0.027	**S**	CO from incomplete combustion higher at Rm
	Rm – El	+0.25	0.049	**S**	Reflects traffic density and generator use.
	Em – El	–0.12	0.34	NS	Similar CO load.
NO_2 (ppm)	Rm – Em	+0.02	0.33	NS	Nitrogen oxide emissions similar.
	Rm – El	+0.04	0.28	NS	Minor variation only.
	Em – El	+0.02	0.37	NS	NS = Not Significant.
VOC (ppm)	Rm – Em	+21.6	0.11	NS	VOC comparable between these two.
	Rm – El	–23.2	0.038	**S**	El has significantly higher VOC.
	Em – El	–44.8	0.021	**S**	VOC load elevated at El due to hydrocarbon activity.
CH_4 (ppm)	Rm – El	+1.1	0.08	NS	Minor difference.
	Rm – El	–0.8	0.14	NS	CH_4 variable but not significant.
H_2S (ppm)	Rm – Em	+0.83	0.054	B	Slightly elevated at Rm

Pollutant	Site Pairs Compared	Mean Difference	p-value	Remark	Interpretation
	Rm – El	–0.42	0.23	NS	Moderate but non-significant variation.
	Em – El	–1.25	0.049	**S**	El slightly higher, possibly from decomposing waste.

S-Significant, NS- Not significant, B-Borderline, Rm- Rumukwurushi, El-Elelenwo, Em- Elimgbu

The Tukey HSD test confirmed that Rumukwurushi significantly differs from the other two sites for PM $PM_{2.5,}$ PM_{10}, and CO. Elelenwo stands out for VOC levels, significantly higher than Elimgbu and Rumukwurishi, NO_2, CH_4, and H_2S differences were statistically insignificant, suggesting similar emission profiles across locations.

These results confirm spatial heterogeneity in air pollution sources across the study area, consistent with findings from Efe (2016) and Okonkwo et al. (2022) that showed significant inter-location variability in Port Harcourt due to traffic, industrial flaring, and waste combustion.

Rumukwurishi's high PM and CO concentrations indicate intense vehicular and combustion emissions, likely due to proximity to major roads and urban activity (Adegoke et al., 2023).

Elelenwo's elevated VOC levels suggest influence from hydrocarbon handling or petroleum product storage, similar to trends noted by Onwuka et al. (2020).

Elimgbu exhibited relatively lower pollutant means, consistent with a suburban residential environment with fewer emission sources.

4.3 Air Quality Index

The AQI results indicate that Rumukwurishi has the highest AQI (143**)** driven by PM_{10} and $PM_{2.5}$, indicating air that is *unhealthy for sensitive groups* (EPA, 2024).

Elelenwo also falls into the same category, dominated by coarse and fine particulates from hydrocarbon combustion and dust.

Elimgbu shows a moderate AQI, reflecting a more residential environment with fewer pollution sources.

Table 4.4: Air Quality Index Values

Site	$PM_{2.5}$	PM_{10}	CO	NO_2	Overall	Category
Rumukwurishi	96	143	7	40	**143**	*Unhealthy for Sensitive Groups*
Eligmbu	70	97	2	26	**97**	*Moderate*
Elelenwo	52	109	6	17	**109**	*Unhealthy for Sensitive Groups*

Note: The overall AQI for each site is determined by the **maximum** sub-index value among pollutants.

This finding aligns with Efe (2021) and Adegoke et al. (2023), who reported that particulate pollution is the most critical contributor to poor air quality in Port Harcourt, particularly in high-traffic and industrial corridors.

Across all sites, PM_{10} contributed most to AQI values, followed by $PM_{2.5}$. This trend is typical in Nigerian urban areas where vehicular emissions, unpaved roads, refuse burning, and industrial dust dominate (Okonkwo et al., 2022; Eludoyin et al., 2020).

CO and NO_2, though present, remained within *Good* air quality thresholds, implying minor contribution from direct combustion or vehicle idling emissions.

According to WHO (2021), long-term exposure to $PM_{2.5} > 15\ \mu g/m^3$ increases risks of respiratory diseases, stroke, and cardiovascular complications. At Rumukwurishi and Elelenwo, AQI above 100 means children, elderly, and people with heart/lung disease should limit prolonged outdoor activity. Increased hospital admissions for respiratory illnesses can occur during periods of high particulate load (Onwuka *et al.,* 2020).

4.4 Pearson Correlation Coefficient Matrix

In this study, the correlation analysis was conducted on the measured air quality parameters ($PM_{2.5}$, **PM_{10}, CO, NO_2, VOC, CH_4, H_2S**) and meteorological variables (**Relative Humidity, Wind Speed,** and **Temperature)** across Rumukwurishi, Eligmbu, and Elelenwo.

Table 4.5: Pearson Correlation Coefficient Matrix

Variable	$PM_{2.5}$	PM_{10}	CO	NO_2	VOC	CH_4	H_2S	RH	Ws	Temp
$PM_{2.5}$	1									
PM_{10}	0.92	1								
CO	0.81	0.85	1							
NO_2	0.35	0.4	0.3	1						
VOC	0.65	0.68	0.55	0.25	1					
CH_4	0.42	0.46	0.44	0.1	0.6	1				
H_2S	0.38	0.41	0.35	0.05	0.52	0.55	1			
RH	-0.4	-0.35	-0.5	-0.12	-0.4	-0.22	-0.3	1		
Ws	-0.52	-0.48	-0.61	-0.15	-0.43	-0.25	-0.34	0.35	1	
Temp	0.33	0.29	0.36	0.05	0.25	0.18	0.2	-0.45	-0.55	1

In this study, the correlation analysis was conducted on the measured air quality parameters **($PM_{2.5}$ PM_{10}, CO, NO_2, VOC, CH_4, H_2S)** and meteorological variables **(Relative Humidity, Wind Speed**, and **Temperature)** across Rumukwurishi, Elimgbu, and Elelenwo.

A strong positive correlation ($r > 0.8$) between $PM_{2.5}$, **PM_{10},** and **CO** suggests that these pollutants likely originate from **common combustion sources** such as vehicular exhaust, generator emissions, and open burning. This aligns with findings by **Efe (2016)** and **Adegoke et al. (2023),** who observed similar co-occurrence patterns in urban centers of Port Harcourt and Lagos, respectively.

High correlation between $PM_{2.5}$ and PM_{10} indicates that suspended particulates in these areas arise from **resuspended dust and incomplete combustion**, particularly in traffic corridors and industrial clusters such as Rumukwurishi.

The moderate positive correlation ($r \approx 0.25–0.40$) between **NO_2** and **VOC** indicates contributions from vehicular and fuel-related emissions, as both pollutants are linked to **photochemical reactions** and **ozone formation** (Akinbode et al., 2020). However, the relatively weak relationship may also reflect **differing emission patterns**, with VOCs being more industrial and NO_2 more traffic-related.

Methane **(CH_4)** and hydrogen side (**H_2S**) showed moderate correlations ($r \approx 0.5$), suggesting shared sources such **as organic decomposition, waste dumps**, and **petroleum-related processes** common in Obio-Akpor. This agrees with **Nduka and Orisakwe (2021)**, who reported elevated hydrocarbon gases near industrial and residential interfaces in the Niger Delta.

Negative correlations between **wind speed** and pollutants ($r = –0.4$ to $–0.6$) imply that stronger winds **enhance pollutant dispersion**, thereby reducing concentration levels (Eludoyin et al., 2020). Similarly, **relative humidity** exhibited negative relationships with particulate and gaseous pollutants, indicating that **moist air facilitates particle deposition**.

Temperature showed weak to moderate positive relationships with PM and CO, reflecting that **thermal inversion conditions** during warm periods may enhance pollutant accumulation (Ediagbonya et al., 2022).

Rumukwurishi has high positive inter-pollutant correlations imply **multi-source emissions** dominated by traffic and commercial activities. **Elelenwo**'s VOC–CH_4 correlations suggest **industrial or refinery-related emissions. Elimgbu** has Lower correlations across pollutants reflect **better dispersion** and less industrial influence.

These relationships highlight the interdependence of urban emissions, atmospheric conditions, and human activity patterns in Obio-Akpor, consistent with global urban air quality behaviour.

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5.0 Conclusion and Recommendation

5.1 Conclusion

The investigation of air quality across selected sites in Obio-Akpor revealed distinct spatial variations and pollutant associations attributable to differential anthropogenic activities. Statistical analyses confirmed significant differences ($p < 0.05$) among the sites for PM2.5, PM_{10}, CO, and VOC, while NO_2 and CH_4 showed no significant differences. The Tukey HSD post-hoc test further identified Rumukwurishi as significantly more polluted, followed by Elelenwo, and Elimgbu as the least impacted area.

The Air Quality Index (AQI) results classified Rumukwurishi and Elelenwo as unhealthy for sensitive groups, primarily due to elevated particulate matter concentrations, while Elimgbu remained in the moderate category. Meteorological factors such as wind speed and humidity exhibited modest moderating effects on pollutant dispersion.

Particulate matter (PM2.5, PM_{10}) and CO are significantly correlated, confirming combustion-driven pollution. VOCs and CH_4 are moderately associated, reflecting industrial and organic waste emissions. Wind speed and relative humidity exhibit inverse correlations with most pollutants, underscoring their regulatory roles in air dispersion.

The study concludes that air pollution in Obio-Akpor is predominantly influenced by vehicular emissions, open waste combustion, industrial activities, and fuel-related hydrocarbons. Therefore, urgent policy action and effective urban air quality management are imperative to protect public health.

5.2 Recommendations

1. Emission Control Measures: Enforce stricter vehicular emission standards and promote the use of cleaner fuels and public transport options, particularly in Rumukwurishi where traffic emissions are highest.

2. Industrial Regulation: Implement continuous emission monitoring systems for hydrocarbon-handling industries in Elelenwo to minimize VOC and methane emissions.
3. Public Awareness and Policy Enforcement: Increase public awareness on the dangers of open burning and enforce NESREA's (2022) air quality regulations at the community level.
4. Urban Green Infrastructure: Encourage tree planting and green buffer zones in Elimgbu and Rumukwurishi to enhance natural air purification and reduce dust levels.
5. Air Quality Monitoring Networks: Establish permanent air quality monitoring stations across Obio-Akpor for continuous data collection, reporting, and policy guidance.
6. Further Research: Conduct long-term studies to evaluate seasonal and diurnal air quality variations, including the impact of meteorological dynamics and industrial expansion.

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