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Human-related activities in Akpanandem Market, Uyo during the dry andwet seasons and their related impact on the air quality and human health

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Abstract: The pollution of air environment by anthropogenic activities is becoming a serious problem for human health and the environment globally. A bibliometric analysis is conducted using Scopus data from 1996 to 2025 and VOSviewer. This research examined the levels of air pollutants released by the commercial activities at Akpanandem Market in Uyo, Akwa Ibom State during the dry and wet seasons. The concentrations of nitrogen (IV) oxide (NO_2), sulphur (IV) oxide (SO_2), hydrogen sulphide (H_2S), total volatile organic compounds (TVOCs), and air particulate matters ($PM_{2.5}$ and PM_{10}) were determined in air environment within the market during the dry and wet seasons using portable air monitors. These air parameters were also monitored at E-Line Ewet Housing, Uyo (Control) during the dry and wet seasons. The air quality index (AQI) of the air pollutants recorded for the both seasons were also computed using standard method. The mean concentrations of NO_2, SO_2, H_2S, TVOCs, $PM_{2.5}$, and PM_{10} recorded during the dry season were 0.30±0.03 ppm, 0.39±0.01 ppm, 0.72±0.02 ppm, 0.468±0.003 mg/m^3, 75.8±4.45 µg/m^3, and 134.3±3.09 µg/m^3, respectively. During the wet season, the average values of NO_2, SO_2, H_2S, TVOCs, $PM_{2.5}$, and PM_{10} obtained were 0.19±0.02 ppm, 0.29±0.03 ppm, 0.43±0.03 ppm, 0.436±0.01 mg/m^3, 60.6±1.76 µg/m^3, and 112.4±5.20 µg/m^3, respectively. The mean concentrations reported for both seasons exceeded their safe limits by World Health Organization (WHO) and United Nation Environmental Protection Agency (USEPA). The concentrations of these pollutants were significantly higher in the dry than in wet season at $p < 0.05$. The AQI for all the air pollutants except TVOCs recorded for the both seasons were in the hazardous category. Consequently, constant exposure to these air parameters may have severe health problems in both seasons however; the risks could be more severe during the dry season. The multivariate analyses identified human activities as the major source of these air pollutants in the air environment within the studied market. Air pollution control strategies should be adopted for the management of the market to mitigate the related negative implications on human health and the environment.

1. Introduction

The introduction of foreign bodies into the atmosphere, either by biological, chemical, or physical mechanisms that modify its natural compositions and affect the ecosystem, climate, or human health is known as air pollution. Air pollutants can be gaseous, liquid, or solid that is released into the atmosphere from natural or anthropogenic sources (Chetouani *et al*., 2017; Nowzari, 2023). Market is a place where buyers and sellers meet to substitute goods and services with a price decided by the interaction of demand and supply. Studies have shown that in urban environment the levels of air contaminants are relatively higher than in the rural settings due to elevated population and human activities (Khan *et al*., 2025; Kurata *et al*., 2025; Tsekeri *et al*., 2025). Hence, air environment within

urban markets is more contaminated than their rural counterparts. The major contaminants released by the activities in urban markets include air particulate matters ($PM_{2.5}$ and PM_{10}), sulphur (IV) oxide (SO_2), Nitrogen oxides (NOx), carbon (II) oxide (CO), volatile organic compounds (VOCs), and ground-level ozone (O_3) (Sicard *et al*., 2023; Ovenseri, 2025). These air pollutants often emanate from the anthropogenic activities such as poor waste management, high traffic density, and energy utilization within the market areas. The sources of air contaminants in Akpanandem Market include transportation, burning of fossil fuel and biomass, improper waste management methods, food processing activities, construction of offices and shops (Ebong *et al*., 2023a; Ebong *et al*., 2025). These sources, alongside the meteorological parameters of the area may impact negatively on the environment and human health (Wang *et al*., 2025). The implications of air pollution on human health are numerous and it included cardiovascular diseases, respiratory problems, and neurological disorders (Chen *et al*., 2024). Prolonged exposure to air pollutants may result in both cancer and non-cancer human health risks (De Guzman and Schiller, 2025; Ji *et al*., 2026).
It has also been established that air pollution has significant negative impacts on the aquatic organisms including fish (Gokul *et al*., 2023; Mustafa *et al*., 2024). The presence of high levels of air pollutants in air can cause acid rain and climate change. Basically, the burning of fossil fuels results in the formation of acid rain by the release of high amounts of SO_2 and NO_2 into the atmosphere, while CO_2 causes climate change (Siddiqi and Farsi, 2019; Panchakarla*et al*., 2024). Studies have indicated that acid rain has the potentials of modifying the chemistry of soil environment significantly (Zheng *et al*., 2022; Zhang *et al*., 2023). Literature has also documented that climate change has devastating effects on the environment and human health as well. These effects include severe extreme weather, ocean acidification, and loss of biodiversity, food insecurity, and scarcity of water, severe human health problems, difficult human survival and livelihood (Teshome, 2024; Abdul-Nabi *et al*., 2025). According to Mahala (2024), air pollution affects all facets of life including air, soil, and water. Hence, the associated problems are enormous and should be properly handled to forestall these negative implications.

Recently, studies have been undertaken to monitor the air pollution status of Uyo based on several sources of air pollutants however; the contributions of commercial activities in Akpanandem Market have never been examined (Ebong *et al*., 2023a & b; Nicholas and Ukoha, 2023; Abai *et al*., 2025; Ebong *et al*., 2025). Consequently, this study was carried out to identify and establish the level of air pollutants released from the commercial activities in Akpanandem Market into the surrounding air environment. The outcome of this study will reveal the level of human exposure to toxic substances in the air environment around the market and the associated negative impacts on the environment. Accordingly, based on the results obtained possible recommendations will be made on the proper management methods of air pollution in the market to forestall the related negative impacts of the pollutants on human health and the environment.

2. Materials and methods

2.1 Bibliometric analysis

The bibliometric analysis was carried out on urban air pollution studies using Scopus tool that contributed the analysis data and the VOS viewer (Bulto *et al*., 2024; Wen *et al*., 2024; Dilanjani *et al*., 2025; Hammouti *et al*., 2025; Kachbou *et al*., 2025). The device produces scientific literature, important authors, citations, and competently identify research trends (N'diaye *et al*., 2022; Muloudi *et al*., 2023; Kumar *et al*., 2023; Passas, 2024). The major VOS indicators are node size, node colour, and distance between nodes, label size, and line thickness. These indicators provide the frequency of occurrence, stronger citation links, highly cited materials, sub fields etc (Kirby, 2023; Laita *et al*., 2024; Bukar *et al*., 2025; Merzouki *et al*., 2025).

2.2. Study Area

This work studied the impact of commercial activities in and around Akpanadem Market in Uyo, Akwa Ibom State, Nigeria. Akpanadem Market is an Urban Market located in Uyo the capital of Akwa Ibom State. The market is mostly patronized by people from Uyo, IbesikpoAsutan, Uruan, Itu, Ibiono Ibom, Abak, Nsit Ibom, Etinan, and Ikono local governments, however; the people from Igbo land also patronize the market effectively. Akpanadem Market is located between latitude 05° 01ꞌ03.65ꞌꞌ E and longitude 07° 55ꞌ28.02ꞌꞌ N. The market is bounded by Ndiya Street, Udo Umana Street, Johnson Street, and Aka Road. The sources of air contaminants within and around the market are automobile emissions, biodegradable wastes from food processing, burning of fossil fuel, abattoir etc. Uyo is a state in the Niger Delta Region of Nigeria, hence; the population and the volume of wastes generated within the area are high. The high levels of commercial activities coupled with the crude oil activities have highly contaminated the studied environment. In the research, E-Line Ewet Housing Estate in Uyo where there was minimal level of commercial activities was chosen as the control site.

2.3. Analytical procedures

The work was carried out for six months between October, 2024 and March, 2025 covering the dry and wet seasons of the area. The concentrations of the air contaminants were determined at four locations within the vicinity of the market namely: Ndiya Street, Udo Umana Street, Johnson Street, and Aka Road using portable air monitors shown in Table 1. The air parameters examined were nitrogen (IV) oxide (NO_2), sulphur (IV) oxide (SO_2), Hydrogen sulphide (H_2S), total volatile organic compounds (TVOCs), and particulate matters ($PM_{2.5}$ and PM_{10}). At each of the locations, the portable air monitor was positioned in an open space, adjusted to the TEST point and maintained for two minutes. The monitor was then regulated to the GAS position and the concentrations of the air contaminants shown on the LCD were recorded (Caselles *et al*., 2025; Oluwagbayide and Ogunlade, 2025). This procedure was performed in triplicates and the average values were recorded for the discussions of results. The portable monitors were standardized regularly for accuracy and reliability of results. The data collection was done in the early hours of each day as reported by Oyareme and Osaji (2022). The various portable monitors employed for the determination of air pollutants are shown in Table 1. The air quality index (AQI) of the air pollutants recorded in the studied market was computed with Eqn. 1 following the procedures of USEPA (2014).

$$AQI = \frac{Concentration of Air Contaminant}{Recommended Limit} \times 100 \qquad \textbf{Eqn. 1}$$

The AQI of the contaminants expresses the human health consequences associated with the prolonged exposure to these contaminants in the market. According to Longinus *et al*. (2016), there are six major classes of AQI and their related human health implications as shown in Table 6.

Table 1: Air Parameters and the Air Monitors Used

Air Pollutant	Equipment Used
Sulphur dioxide (SO_2)	SO_2 Crowcon Gasman S/N: 19648H
Nitrogen dioxide (NO_2)	NO_2 Crowcon Gasman S/N: 19831N
Hydrogen sulphide (H_2S)	H_2S Crowcon Gasman S/N: 19502H
$PM_{2.5}$	$PM_{2.5}$ gas monitor Gasman Model Air Ae Steward air quality monitor
PM_{10}	PM_{10} gas monitor Gasman Model Air Ae Steward air quality monitor

2.4: Statistical Analysis of Data

The statistical analysis of data was done using IBM SPSS Statistic version 29.0.2.0 (20) Software. The minimum, maximum, and mean values as well as standard deviation were obtained directly from the software. Factor analysis was performed on the data obtained with Varimax Rotation Technique and values from 0.662 and above were considered significant. The Cluster analysis performed on the data obtained to categorize the air pollutants into their related groups was done with Dendrograms. Each analysis was done three times to establish the reliability of the results obtained.

3.0 Results and Discussion

3.1 Bibliometric analysis

The advancement of articles in Scopus from 1996 to 2025 has been illustrated in Figure 1. It has been documented that over 14,500 articles on air pollution are available in Scopus during this period, indicating the intensive work by policymakers and widespread investigation by researchers on air pollution and related health problems (Figure 2). The intensive research work on the urban air environment is a consequence of significant burning of fossil fuels, open burning of wastes, and general non-adherence to air pollution control measures.

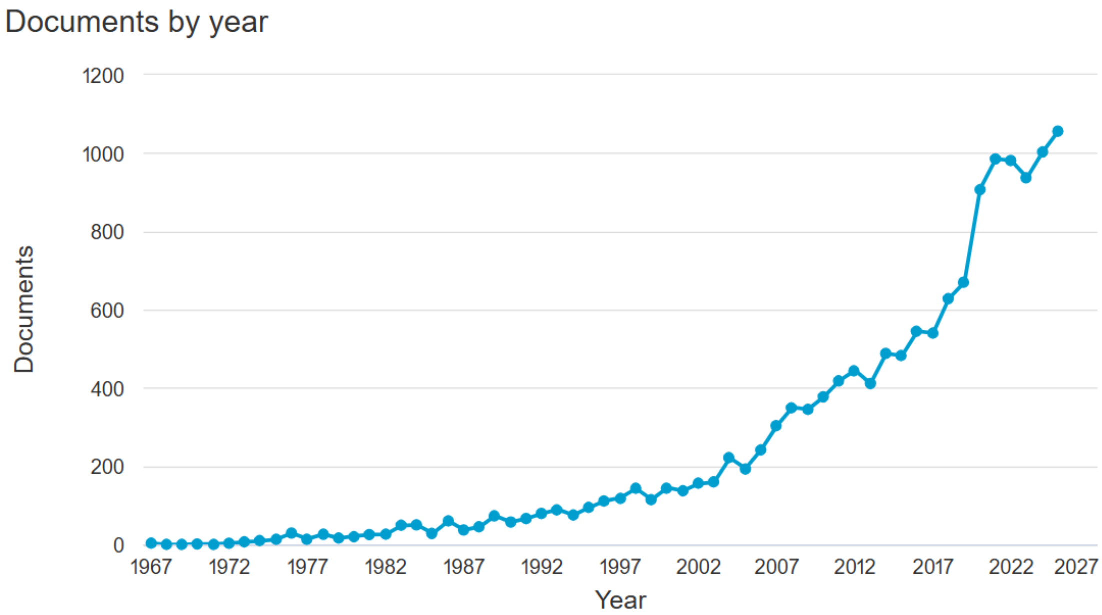

Figure 1. Evolution of article's production from 1996 to 2025

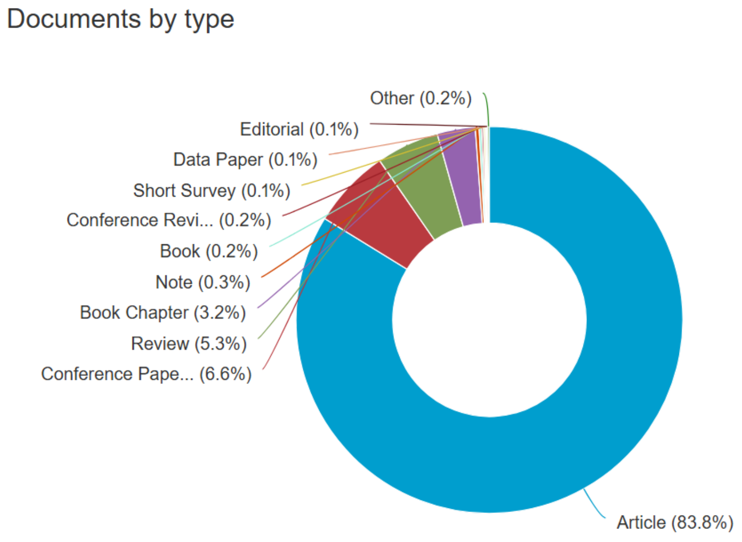

Figure 2. Production by type of publication from 1996 to 2025

Consequently, the world is now experiencing global warming, high levels of greenhouse gases, rising sea level, insecurity of food, general environmental degradation, and air pollution related human health problems globally (Abdul-Nabi *et al*., 2025; Ofremu *et al*., 2025). Figures 3 gathered the most published authors in this topic. The top profiler one is Wang S. (Laboratory of Sources and Control of Air Pollution Complex, Beijing, China) with about one hundred articles in this thematic, but his Scopus profile indicates more than 600 articles, an H-index of 103 and over 38,000 citations. The second position occupied by the Spanish Querol X. (University of Huelva, Huelva) contributing 84 articles and his Scopus profile is most prestigious with 827 articles (H=126 and >61,000 citations). More information about the other authors listed in Figure 3 can be consulted on Scopus.

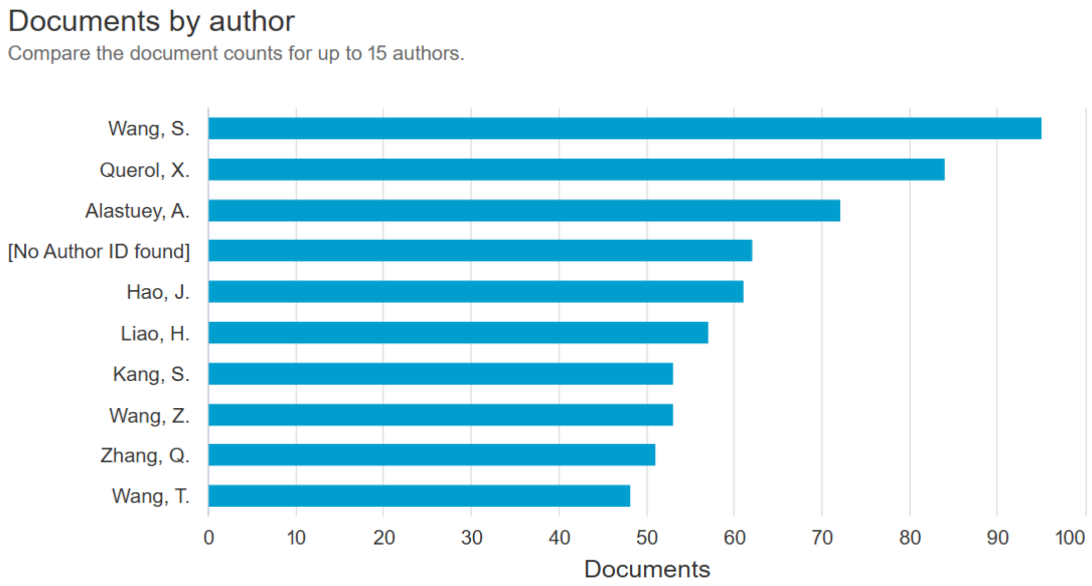

Figure 3. Production of documents by author from 1996 to 2025

The Scopus analysis provides also the top countries interesting by this field (Figure 4). China and USA are the most profilers with more than 3500 articles. Based on the current bibliometric analyses with the VOSviewer tool on air pollution, about 172 countries are contributing significantly to research on anthropogenic air pollution and the associated human health problems. As indicated in Figures 5 and 6, about 91 countries have published at least 10 articles each on the global air pollution and the related environmental and human health problems, with China having the highest number followed by USA (Manisalidis *et al*., 2020).

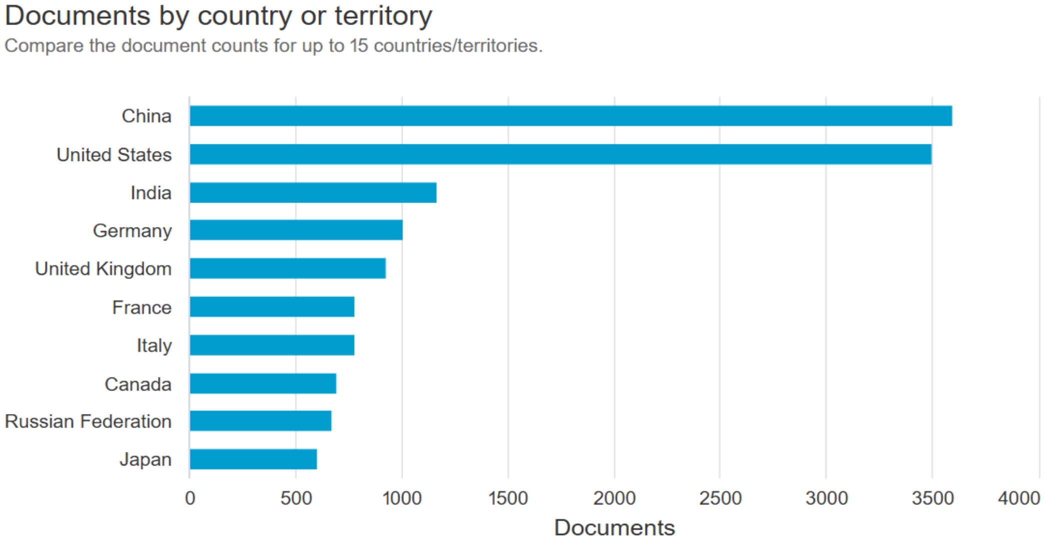

Figure 4. Countries' production from 1996 to 2025

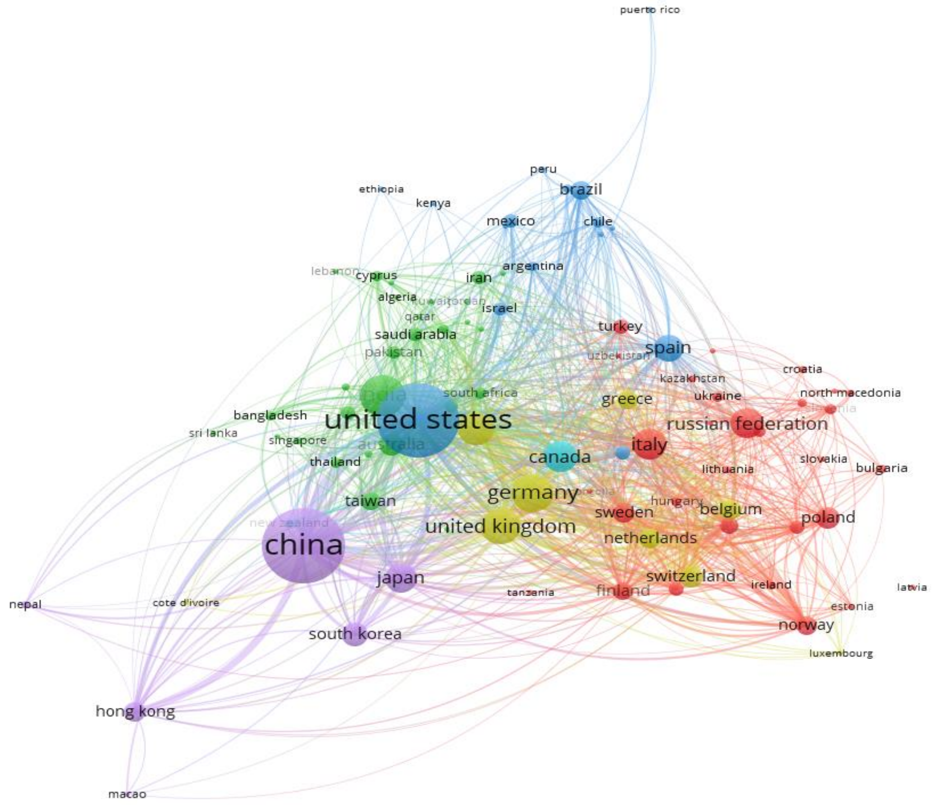

Figure 5. Network visualization of the authors from 2010 to 2025 (VOS viewer)

China indicated by the largest purple circle called also node, followed by the US (blue node) and India at the third position (green node) behind that of the US as presented in the Network visualization

(Figure 5). In the overlay visualization of VOSviewer, the production in linked to time. The recent contribution is visualized by yellow as shown China and India; the contribution published before 2012 are indicated dark purple (Figure 6).

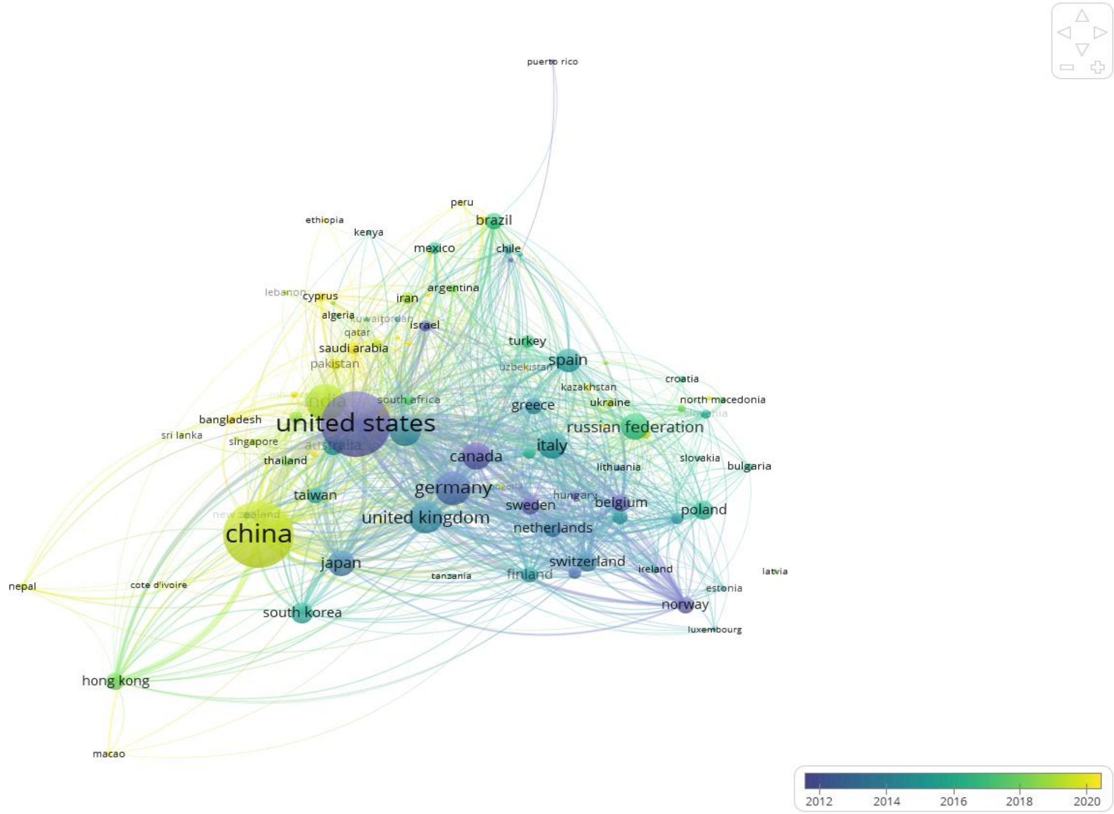

Figure 6. Overlay visualization of the authors from 2010 to 2024 (VOS viewer)

The results for the concentrations of the air pollutants recorded in the studied Akpanadem Market during the dry season are shown in Table 2. The concentrations (ppm) of NO_2, SO_2, and H_2S varied as follows 0.26-0.34, 0.37-0.42, and 0.68-0.75, respectively. Whereas the levels of TVOC, $PM_{2.5}$, and PM_{10} obtained in the dry season ranged as follows: 0.464-0.472 mg/m^3, 70.0-82.0 µg/m^3, and 129.0-138.0 µg/m^3, respectively. During the dry season, the average concentrations of NO_2, SO_2, H_2S, and TVOC were 0.30±0.03 ppm, 0.39±0.01 ppm, 0.72±0.02 ppm, and 0.468±0.003 mg/m^3, respectively. While the respective mean concentrations of $PM_{2.5}$ and PM_{10} reported during the same regime were 75.8±4.45 µg/m^3 and 134.3±3.09 µg/m^3, respectively. The mean concentrations of NO_2, SO_2, H_2S, TVOC, $PM_{2.5}$, and PM_{10} recorded at the control site during the same season were 0.14±0.05 ppm, 0.17±0.03 ppm, 0.38±0.03 ppm, 0.266±0.02 mg/m^3, 45.3±2.08 µg/m^3, and 71.5±3.33 µg/m^3, respectively. Hence, the mean concentrations of the air pollutants reported for the control site during the period were relatively lower than their respective levels in the market as reported by Amesho *et al.* (2021) & Agan and Adelekan (2025). The results corroborated the findings obtained during the wet season. Consequently, commercial activities carried out within the market area may have released high levels of air pollutants into the surrounding air environment (Amesho *et al.*, 2021). It was also inferred from the results that the highest level of all the parameters were obtained in February, 2025, while the lowest levels were obtained in December, 2024 during the dry season. Obviously, there could be a significant buildup of air contaminants in the atmosphere during the dry season (Emekwuru and Ejohwomu, 2023; Abai *et al.*, 2025).

Table 2: Statistical analysis of the results of air contaminants in the dry season

	NO_2 (ppm)	SO_2 (ppm)	H_2S (ppm)	TVOC mg/m^3	$PM_{2.5}$ $\mu g/m^3$	PM_{10} $\mu g/m^3$
S1	0.29	0.39	0.71	0.467	76.0	134.0
S2	0.30	0.39	0.72	0.468	76.3	134.3
S3	0.30	0.38	0.72	0.469	75.0	134.7
S4	0.31	0.40	0.72	0.468	75.7	134.3
Min	0.26	0.37	0.68	0.464	70.0	129.0
Max	0.34	0.42	0.75	0.472	82.0	138.0
Mean	0.30	0.39	0.72	0.468	75.8	134.3
SD	0.03	0.01	0.02	0.003	4.45	3.09
CTL	0.14 ±0.05	0.17 ±0.03	0.38 ±0.03	0.266 ±0.02	45.3 ±2.08	71.5 ±3.33

The distribution of air pollutants determined within the studied Akpanandem Market during the wet season is indicated in Table 3. The results showed that NO_2, SO_2, H_2S, and TVOC varied as follows: 0.16-0.23 ppm, 0.26-0.34 ppm, 0.38-0.48 ppm, and 0.423-0.454 mg/m^3, respectively. While the concentrations of $PM_{2.5}$ and PM_{10} recorded in the same period ranged from 58.0 to 63.5 $\mu g/m^3$ and 105.0 to 119.0 $\mu g/m^3$, respectively. The respective mean concentrations of NO_2, SO_2, H_2S, TVOC, $PM_{2.5}$ and PM_{10} were 0.19±0.02 ppm, 0.29±0.03 ppm, 0.43±0.03 ppm, 0.436±0.01 mg/m^3, 60.0±1.76 $\mu g/m^3$, and 112.4±5.20 $\mu g/m^3$. The mean concentrations of NO_2, SO_2, H_2S, TVOC, $PM_{2.5}$ and PM_{10} obtained at the control site in the wet season were 0.09±0.03 ppm, 0.14±0.03 ppm, 0.16±0.02 ppm, 0.212±0.05 mg/m^3, 25.5±1.76 $\mu g/m^3$, and 52.2±4.30 $\mu g/m^3$, respectively.

Table 3: Statistical analysis of the results of air contaminants in the wet season

	NO_2 (ppm)	SO_2 (ppm)	H_2S (ppm)	TVOC mg/m^3	$PM_{2.5}$ $\mu g/m^3$	PM_{10} $\mu g/m^3$
S1	0.20	0.30	0.44	0.437	60.7	113.7
S2	0.19	0.29	0.43	0.436	60.7	110.7
S3	0.18	0.28	0.43	0.435	61.3	111.7
S4	0.19	0.30	0.43	0.435	59.8	113.7
Min	0.16	0.26	0.38	0.423	58.0	105.0
Max	0.23	0.34	0.48	0.454	63.5	119.0
Mean	0.19	0.29	0.43	0.436	60.6	112.4
SD	0.02	0.03	0.03	0.01	1.76	5.20
CTL	0.09 ±0.03	0.14 ±0.03	0.16 ±0.02	0.212 ±0.05	25.5 ±1.76	52.2 ±4.30

Thus, the mean concentrations of these parameters were also higher in the studied market than at the control site during the wet season. This is similar with the results obtained from a related study by Ipeaiyeda and Adegboyega (2017). This is an indication that the commercial activities at the studied market might have released some levels of these air pollutants into the air environment around the studied market during the wet season as reported by Amesho *et al*. (2021). The results of the air pollutants recorded during the wet season revealed that the highest concentrations of all the parameters were obtained in August, 2024, while their lowest levels were recorded in October, 2024. Consequently, rainfall can reduce the concentration of air pollutants in a contaminated air environment as opined by Tian *et al*. (2021).

Generally, the study revealed that the dry season results were significantly higher than the wet season at $p < 0.05$. This is consistent with the findings byYavuz (2024) and Ogbuagu *et al*. (2025) from related studies. It was also observed that the mean values of all the air pollutants obtained during the wet and dry seasons were higher than their recommended limits in an unpolluted air by WHO (2005), USEPA (2014), and WHO (2018). Accordingly, persistent exposure to these air pollutantsin both seasons might result in severe human health problems (Atuyambe *et al*., 2024; Chen *et al*., 2024).

Multivariate analysis of the Air Pollutants in Akpanandem Market during the dry and wet seasons.

The Principal Component Analysis (PCA) of air pollutants in the studied Akpanadem Market during the dry season are shown in Table 4. The PCA used for the identification of the source(s) of the air pollutants in the studied environment revealed two factors each for the dry and wet seasons. During the dry season, the first factor (F1) with Eigen value 3.73 had a total and a cumulative variance of 62.2 %. Factor (F1) indicated considerable loadings on H_2S, TVOC, $PM_{2.5}$, and PM_{10}. This could be the effects of anthropogenic and natural activities in the studied market area as opined by Manisalidis *et al*. (2020) and Farid *et al*. (2023). The second factor (F2) identified during the dry season had Eigen value of 1.81, total variance 30.2 %, and a cumulative variance of 92.4 %. It showed strong loadings on NO_2 and SO_2 only, this might be the influence of human induced activities specifically as reported by Edo *et al*. (2024). The PCA results of the air pollutants recorded during the wet season indicated two significant factors (F1 and F2).

Table 4: Principal component analysis of the air pollutants

	DRY SEASON		WET SEASON	
Air Pollutant	**F1**	**F2**	**F1**	**F2**
NO_2	0.566	0.812	0.964	0.162
SO_2	-0.428	0.873	0.916	-0.374
H_2S	0.823	0.484	0.819	0.511
TVOC	0.994	-0.061	0.727	0.650
$PM_{2.5}$	-0.766	0.356	-0.498	0.833
PM_{10}	0.987	-0.153	0.749	-0.387
% Total Variance	62.2	30.2	62.9	28.2
% Cumulative Variance	62.2	92.4	62.9	91.1
Eigen Value	3.73	1.81	3.78	1.69

The first factor (F1) had Eigen value of 3.78, a total and cumulative variance of 62.9 %. The factor showed strong loadings on NO_2, SO_2, H_2S, TVOC, and PM_{10}. This could be the negative impact of human activities on the quality of the air during the wet season. The second factor (F2) with Eigen value of 1.69 had a total and cumulative variance of 28.2 % and 91.1 %, respectively. This might be the natural and anthropogenic impacts on the air quality of the studied market during the wet season (Mečiarová *et al*., 2017; Zhang *et al*., 2025).

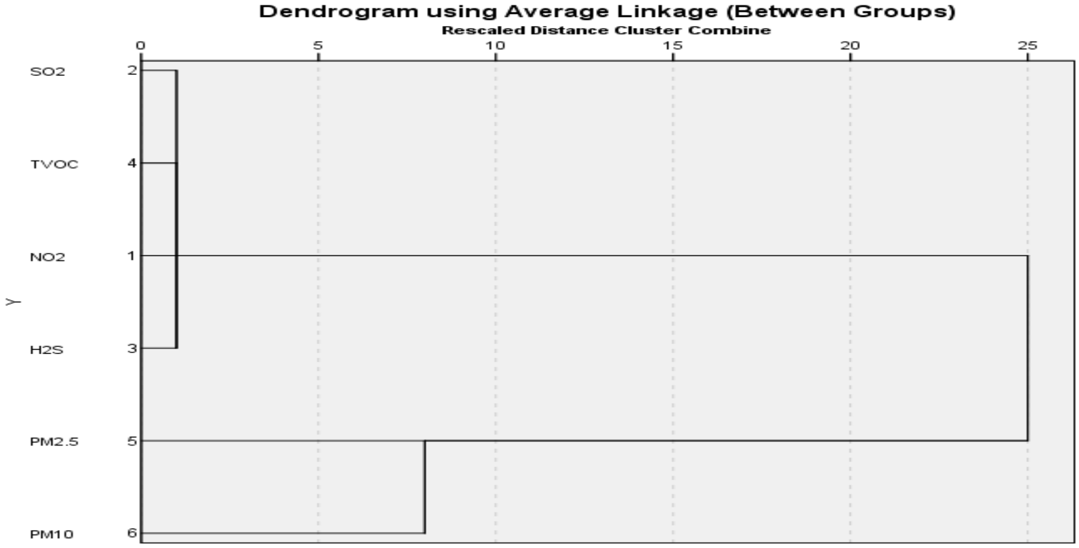

Figure 7: Hierarchical Clusters of air pollutants obtained at Akpanandem Market during the dry and wet seasons

The Hierarchical Cluster Analysis (HCA) of the air pollutants measured at the studied Akpanandem Market in the dry and wet seasons is shown in Figure 7. The HCA is commonly used for the classification of air pollutants released from a related source (Nannaparaju and Rao, 2023). The analysis revealed two main clusters for the air parameters obtained at the studied location during the dry and wet seasons. As shown in Figure 1, one of the clusters joins NO_2, SO_2, H_2S, and TVOC together, while the second one correlates $PM_{2.5}$ and PM_{10}together. Consequently, the source of air particulates ($PM_{2.5}$ and PM_{10}) could have been different from that of NO_2, SO_2, H_2S, and TVOC. The results also revealed that apart from the air particulates, the other air pollutants might have been released from a familiar source (Bodor *et al*., 2022). The AQI of the air pollutants determined at Akpanandem Market during the dry and wet seasons are shown in Table 5, while the human health implications of the respective class of AQI of the pollutants are indicated in Table 6.

Table 5: Air Quality Index (AQI) of Air parameters determined during the wetand dry seasons

	Mean Concentration		Air Quality Index (AQI)	
	Wet	Dry	Wet	Dry
NO_2	0.19	0.30	317.0	500.0
SO_2	0.29	0.39	483.0	650.0
H_2S	0.43	0.72	717.0	1,200.0
TVOC	0.436	0.468	87.2	94.0
$PM_{2.5}$	60.6	75.8	1,212.0	1,516.0
PM_{10}	112.4	134.3	749.3	895.3

According to Horn and Dasgupta (2024), air quality index (AQI) is a model that indicates the real contamination status of the air environment within a given location. Hence, AQI was used to identify the actual contamination status of the air environment within the studied Akpanandem Market. According to Horn and Dasgupta (2024), air quality index (AQI) is a model that indicates the real contamination status of the air environment within a given location. Hence, AQI was used to identify the actual contamination status of the air environment within the studied Akpanandem Market. The AQI of all the air pollutants determined during both seasons except TVOCs were in the F (hazardous) category (Table 6).

Table 6: Classifications of Air quality Index and their related human health problems

AQI Range	AQI Rating	Health status	Related health risk
0 - 50	A	Good	The air quality is acceptable, and may have negligible or no risk
51 – 100	B	Moderate	The air quality is acceptable, but; the Sensitive class may be affected
101 – 150	C	Unhealthy for sensitive groups	Negative health problems may be experienced by the Sensitive class
151 – 200	D	Unhealthy	Both the sensitive and non-sensitive classes may be affected negatively, however; it could be severe for the sensitive class
201 – 300	E	Very Unhealthy	Both the sensitive and non-sensitive classes may have negative health problems
>300	F	Hazardous	This is an emergency health alert level, both classes will be impacted severely

Despite the lower concentrations of the air pollutants reported at the studied market in the wet season, the related human health problems for the period were in the hazardous class. Accordingly, the levels of NO_2, SO_2, H_2S, $PM_{2.5}$, and PM_{10} reported at the studied market during the dry and wet seasons could affect the health of both the members of sensitive and non-sensitive classes severely (Chen *et al*., 2023; Odubanjo *et al*., 2024). As indicated in Table 5, the AQI of TVOCs recorded during the dry and wet seasons at the studied market belongs to the B (moderate) class. Thus, the levels of TVOCs reported at the studied market might have negative health implications on the members of the sensitive class (Zaib *et al*., 2022). The results obtained also indicated higher AQI values for the air pollutants at Akpanandem Market during the dry than in wet season as reported by Nwaerema *et al*. (2022). Hence, the vulnerable ones were more exposed to health problems associated with these air pollutants during the dry than in the wet season.

Recommendations

Based on the results obtained, the following recommendations are made to forestall the negative impacts associated with improper management on human health and environment:

i. Emissions standards for vehicles should be implemented.
ii. Planting of green plants around the market should adopted
iii. Open burning of wastes should be discouraged, recycling of wastes and proper waste disposal methods should be adopted.
iv. Some days in the market should be set aside for sanitation exercise and education on the implication of poor management of wastes.
v. Offenders of environmental laws in the market should be prosecuted to serve as deterrent to others.

Conclusion

Based on the outcome of the study on the effects of commercial activities in Akpanandem Market during the dry and wet seasons on human and environmental health it could be concluded that, the activities in the market might have released high levels of air pollutants into the surrounding air environment. The concentrations of air pollutants recorded in the studied market during the dry and wet seasons were hazardous to both human health and the environment. It could also be inferred from the study that the negative impacts of these pollutants were higher in the dry than in wet season. The research revealed that rainfall has the tendency to mitigate the environmental and human health problems associated with these air contaminants. The study indicated that improper wastes management and burning of fossil fuels were the principal sources of air pollutants in the market.

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