



Assessment of Air Quality Using the Plume Air Quality Index Indicator (PAQI): Reference to Five Towns in Nigeria

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ABSTRACT

Air quality is an important issue worldwide due to the health implications on man and livestock. For this reason, different countries constructed the air quality index (AQI) which depicts pollution levels and the impact on health. PAQI is an example of an air quality index built by Plume Labs, Paris, France. It has seven levels (Low, Moderate, High, Very High, Excessive, Extreme, and Airpocalypse) of pollution which are linked to the World Health Organization (WHO) limits. This study aimed to assess the AQI of five different towns in Nigeria using the satellite model data released by Plumes Labs. Daily data of the towns were recorded between 9 am and 7 pm for 60 days and statistically analyzed. The air quality index was determined by whatever pollutant was measuring the highest. It was observed that PM_{2.5} and O₃ (>30 and >40 respectively) had the highest concentration levels most times. The results were compared with the PAQI indicator. The air quality of the towns has reached high levels of pollution above the maximum limit for 24 hours established by WHO.

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1. INTRODUCTION

Air pollution is becoming more serious as society progresses and the level of industrialization continues to rise. It is hazardous to human health and has evolved into a worldwide environmental crisis that is either hard to address or irrevocable (Xu et al., 2020).

According to the WHO report, air pollution killed up to one million people more than AIDS, malaria, and tuberculosis merged in the same year. Approximately 91 percent of the world's population now lives in areas where air quality exceeds WHO limits for particulate matter (PM_{2.5} and PM₁₀), ozone (O₃), nitrogen dioxide (NO₂), and sulfur dioxide (SO₂) as foremost pollutants of greatest public health significance. Cohen et al. (2017) indicated that of the 4.2 million documented premature deaths each year, ambient PM_{2.5} (particulate matter less than 2.5 micrometers in diameter) is present in up to 16.5 percent, with an estimated 1.7 million lung cancer-related deaths (Cohen et al. 2017; Wambebe and Duan, 2020).

Policymakers use the Air Quality Index (AQI) to inform the people about how polluted the air is present as well as provide short-term and long-term effects of air pollution on the healthcare system. The development of ambient air quality standards can provide a foundation for and assure ambient air quality administration to protect the public, sustain ecological environmental safety, and promote harmonious, sustainable development that keeps us safe, society, and nature. There is evidence of avoidance behavior in response to air quality alerts in both vulnerable populations and individuals with no underlying health conditions, according to the existing literature (Ward and Beatty, 2016; Cromar et al., 2020).

Many cities around the world continually evaluate pollution levels using sensor networks utilized to determine and document air pollutant concentrations at various points deemed to depict population awareness of these pollutants (Kanchan & Pramila, 2015). Governments all over the world have begun to use real-time access to advanced database management software to provide their people with access to site-specific air quality/air pollution indexes and their potential health implications. As a result, a more advanced tool for conveying the health risk of ambient levels using air pollution index (API) or air quality index (AQI) has been devised (AQI). Kanchan et al. (2015) conducted a critical review of the various categories of AQI, which include the AQI system of U.S. EPA, common Air Quality Index (cAQI), oak ridge Air Quality Index (orAQI), new Air Quality Index (nAQI), Pollution Index (PI), Air Quality depreciation Index (AQDI), integral Air Pollution Index (IAPI), Aggregate Air Quality Index (AQI), The Aggregate risk Index (Ari), AQI Based on PCA-neural network Model, fuzzy Air Quality Index, Air Pollution Indexing system in South Africa, Air Quality Health Index, and Air Pollution Indexing system in china.

The majority of AQIs are tied to local laws and regulations. Because policies and laws differ across countries and regions, a large number of AQIs are required to measure air pollution and enforce specific laws. Furthermore, most countries' AQIs are computed using the following thresholds, different pollutants, various analytical approaches, and a different number of categories. There is a European AQI, a Chinese AQI, a Canadian AQI, a US AQI, and others.

PAQI is one of them. As far as we know, the tool has not seen much use in this part of the world, particularly in Nigeria. As a result, we used the Plume Air Quality Index Indicator to assess the air quality (AQI, PM_{2.5}, PM₁₀, NO₂, and O₃) of five Nigerian towns (Ibadan, Abeokuta, Ado-Ekiti, Akure, and Osogbo).

2. METHODS

Nigeria one of the countries in Africa has 36 states including Federal Capital Territory (Abuja). The Southwest region of Nigeria was chosen for pollution data collection. Lagos, Ogun, Oyo, Osun, Ekiti, and Ondo are the states in the southwest (**Figure 1**). The South West region's population is estimated to be 32.5 million people. The region's population is predominantly Christian, with 352 people belonging to the Yoruba ethnic group, which accounts for approximately 21 percent of the national population.

The overall Plume AQI is determined by the pollutant with the highest measurement. For example, if you have 10 VOCs, 25 PM_{2.5}, 30 PM₁₀, and 50 NO₂, your Plume AQI will be 50. Plume Labs defines the Plume AQI and its seven associated categories using World Health Organization (WHO) guidelines, international standards developed by the United States Environmental Protection Agency (EPA), and other scientific studies. The AQI is calculated by taking the average of all pollutant levels measured over a full hour, 8 hours, or day. They average at least 90 measured data points of pollution concentration from a full hour (e.g., between 9:00 AM and 10:00 AM) to calculate an hourly air quality.

PAQI (powered by Plume Labs, Paris, France) is a low-cost global citizen-based PM sensor network. Plume Labs provides contaminant measurements using satellite images (AQI, PM_{2.5}, PM₁₀, NO₂, and O₃). Measurements of hourly pollutants (6-9 am and 6-9 pm) were used in this analysis for 30 days. In this study, available data on AQI and pollutants were computed and statistically analyzed for Ibadan (Oyo State), Abeokuta (Ogun State), Akure (Ondo State), Osogbo (Osun State), and Ado-Ekiti (Ekiti State) using Minitab software version 16 (Descriptive) and Excel 2013. (Contributions of each pollutant).



Figure 1. Map of Southwest Nigeria where satellite monitored (Abegunrin and Sangodoyin, 2016).

3. RESULTS AND DISCUSSION

The morning AQI mean values are as follows: Ibadan (82), Abeokuta (46), Ado-Ekiti (23), Akure (26), and Osogbo (31), but 53, 39, 38, 35, and 42 for the evening period, respectively. The health risks to which the public is exposed as a result of the pollutants' AQI were investigated in the study. The AQI data for the study areas were provided in **Table 1** for the morning (6-9 a.m.) and evening sections (6-9 pm). The health consequences for the various locations ranged from moderate to severe. This means that people living in vicinities with moderate PAQI values will have acceptable air quality in the morning and evening, but people with specific sensitivities may face health challenges.

This study contradicts the findings of [Akinfolarin et al. \(2017\)](#) and [Abulude et al. \(2021\)](#), who found that Port Harcourt, Nigeria, and Lagos, Nigeria, respectively, are very unhealthy and pose hazardous situations. The high AQI values (mean, minimum, and maximum) were caused by high traffic incidences, industrial fumes, and high dust incidences caused by pedestrian and vehicular activities, particularly in Ibadan, Oyo State. People who worked long hours were more likely to suffer from severe health complications, as were other vulnerable groups such as asthmatics, children and the elderly, and people with heart or lung diseases ([Zagha & Nwaogazie, 2015](#)). Airborne particulate matter has a negative impact on health and is thought to account for between 3 and 7 million deaths per year, primarily due to the development or rapidly deteriorating of cardio-respiratory diseases ([Beelen et al., 2013](#); [Hoek et al., 2013](#)).

The mean concentration of PM_{2.5} in **Table 2** shows the mean PM_{2.5} concentrations (g/m³) for both morning and evening in all of the towns studied. The mean PM_{2.5} levels in all locations are as follows: Ibadan has 82 (morning) and 53 (evening), 46 (morning) and 39 (evening), 23 (morning) and 52 (evening), 26 (morning) and 48 (evening), and 31 (morning) and 42 (evening), respectively. The PM₁₀ values are consistently lower than the PM_{2.5} values. The majority of the PM_{2.5} findings in this analysis, both morning and evening, were above the NAAQS limit of 35 g/m³ ([Osimobi et al., 2019](#)).

In these areas of research, both living things (humans, animals, and plants) and non-living things (monuments, vehicular components, and buildings) are vulnerable to the harmful effects of particulate matter. The PM₁₀ followed the same pattern, with morning values in Ibadan and Abeokuta towns being higher than evening values. This demonstrates that the majority of anthropogenic activities in these locations occurred during the day. It should be noted that the NO₂ and O₃ levels were between 7 and 35 g/m³ in the morning and afternoon, respectively. The NO₂ values in this study are well above the Federal Ministry of Environment (FMEEnv) Nigeria maximum 1-hour mean (0.5 g/m³), but less than the recommended 24-hour WHO limit (40 g/m³). [Jayamurugan et al. \(2013\)](#) obtained 1.7 - 50.3 g/m³ for NO₂ in India, which is comparable to our results.

Figures 2 and 3 (for morning and evening, respectively) depict the pollutants' contributions to the environments of each town. According to the pictorial diagrams, PM_{2.5} contributed the most to air quality, followed by PM₁₀ in Ibadan, Abeokuta, Akure, and Osogbo (**Figure 2**), while in the evening, it was Ibadan, Akure, Ado-Ekiti, and Osogbo (**Figure 3**).

Table 1. The PAQI indicator and health implications.

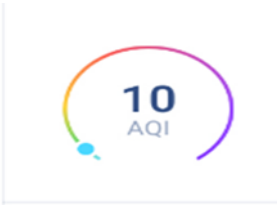
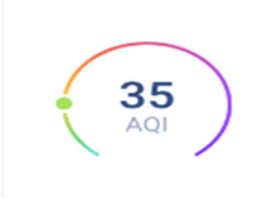
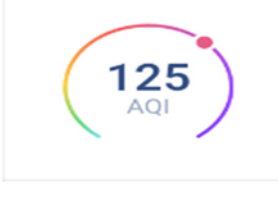
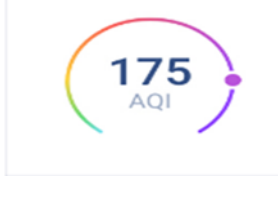
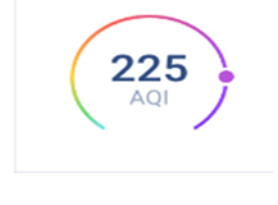
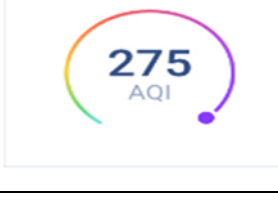
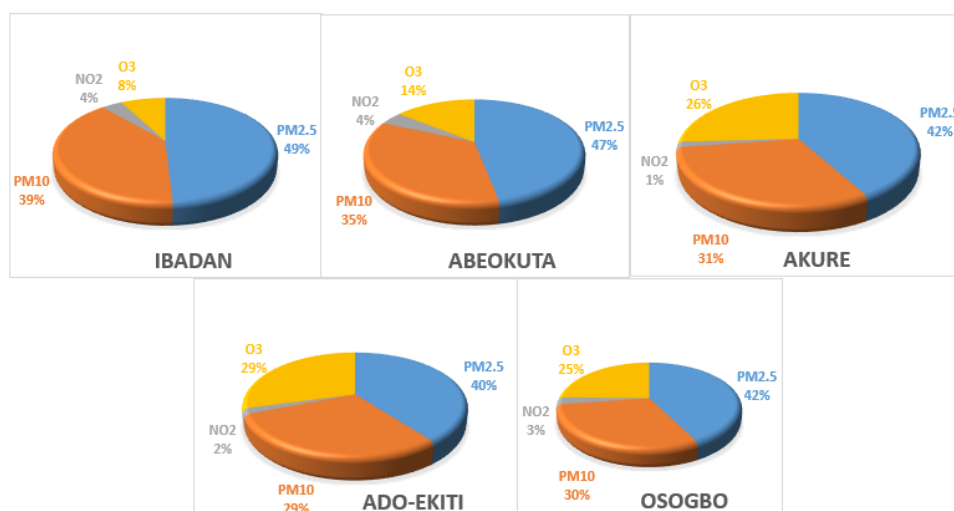
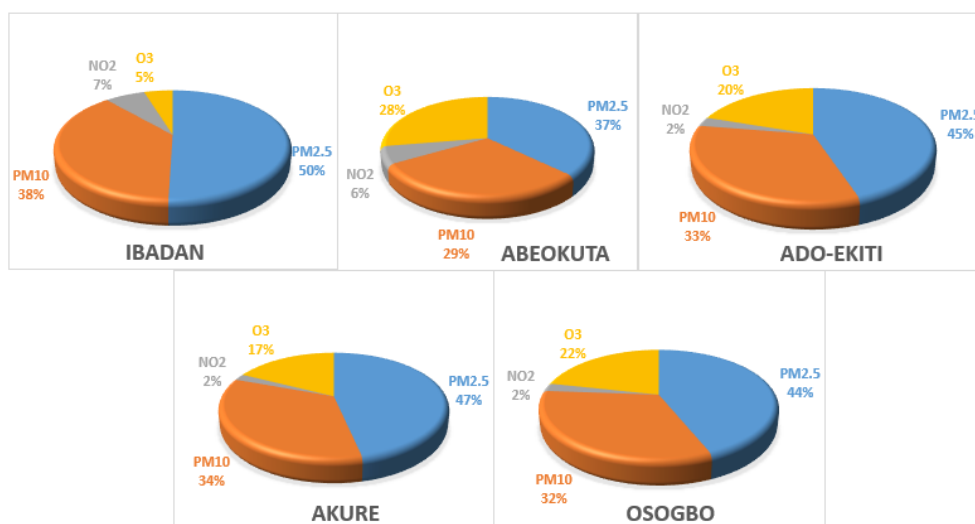
Gauge	PAQI Value	Meaning
	Low, 0 - 20	The air is clear - perfect for outdoor activities.
	Moderate, 21 - 50	Air quality is considered acceptable. However, there may be certain health Concern for people with specific sensitivities.
	High, 51 - 100	Above 50, pollution is high, and everyone may start to experience more serious health effects. Long term exposure Constitutes a real health risk.
	Very High, 101 - 150	The air has reached a very high level of pollution. Effects can be immediately felt by individuals at risk. Everybody feels the effects of prolong exposure.
	Excessive, 151 - 200	The pollution levels have reached a critical level. Individuals at risk feel immediate effects. Even healthy people may show symptoms for short exposures.
	Extreme, 201 - 250	The pollution has reached extreme levels. Immediate effects on health.
	Airpocalypse, 252+	Airpocalypse! Immediate and heavy effects on everybody

Table 2. Basic description of the AQI and pollutants for hours of 6-9 am and 6-9 pm.

Town/State		6.00 - 9:00 AM					6.00 - 9:00 PM				
		AQI	PM _{2.5}	PM ₁₀	NO ₂	O ₃	AQI	PM _{2.5}	PM ₁₀	NO ₂	O ₃
Ibadan (Oyo State)	Mean	82	82	66	6	13	53	53	40	7	35
https://air.plumelabs.com/air-quality-in-Ibadan-9Ozw	Minimum	78	78	61	4	8	43	43	32	5	28
	Maximum	110	110	76	10	15	71	71	66	8	43
Abeokuta (Ogun State)	Mean	46	46	34	4	14	39	39	31	6	29
https://air.plumelabs.com/air-quality-in-Abeokuta-9S6L	Minimum	41	41	21	2	6	28	28	26	4	25
	Maximum	98	98	54	12	18	50	50	40	8	39
Ado-Ekiti (Ekiti State)	Mean	23	23	17	1	17	52	52	38	3	23
https://air.plumelabs.com/air-quality-in-Ado-Ekiti-9RxB	Minimum	18	18	15	1	13	46	46	33	1	19
	Maximum	32	32	24	1	21	63	63	45	5	28
Akure (Ondo State)	Mean	26	26	19	1	16	48	48	35	2	18
https://air.plumelabs.com/air-quality-in-Akure-9RyN	Minimum	21	21	16	1	12	40	40	29	1	12
	Maximum	35	35	28	1		56	56	43	4	26
Osogbo (Osun State)	Mean	31	31	22	2	18	57	57	42	3	28
https://air.plumelabs.com/air-quality-in-Osogbo-9KZw	Minimum	28	28	18	2	16	49	49	35	2	20
	Maximum	40	40	35	2	24	63	63	53	5	34

**Figure 2.** Contributions of the Pollutants between the hours of 6 and 9 am.**Figure 3.** Contributions of the Pollutants between the hours of 6 and 9 pm.

4. CONCLUSION

According to the findings, the AQI values for average O₃ and NO₂ concentrations were moderate and high during the study periods. PM_{2.5} levels were higher than PM₁₀ levels in both the morning and evening.

The following are the study's key findings: The primary cause of heavy air pollution was high PM_{2.5} levels; air pollution was periodic, with daily mean NO₂, PM_{2.5}, and PM₁₀ levels significantly higher in the daytime than in the evening, particularly in Ibadan, indicating the combined impact of wood and biomass burning, cigarette smoke, vehicular emissions, soil dust sources, and unfavorable weather patterns on air pollution.

5. AUTHORS' NOTE

The authors declare that there is no conflict of interest regarding the publication of this article. Authors confirmed that the paper was free of plagiarism.

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