Air Quality Index: Case of One-day Monitoring of 253 Urban and Sub-urban Towns in Nigeria

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Abstract

Government departments use the air quality index (AQI) to inform the public about how unhealthy the air is now or may become in the future. As the AQI increases, so do the health threats. It is a daily air quality index that is used to report on air quality. In addition, a measure of how air pollution impacts one's health over a limited period of time. The AQI was created to assist people in understanding how local air quality affects their health. Therefore the aim of the study was to assess one-day air quality of 253 towns in Nigeria, thereby determining the health threat in these towns. The data was collected from the Tutiempo Network's regular data set by the Environmental Protection Agency (EPA). Data on all of the major pollutants (O_3, $PM_{2.5}$, PM_{10}, CO, NO, SO_2) was collected and statistical analysis was performed. Kura (Kano State), a town in northern Nigeria, recorded the highest level of 184, while Idiroko, a border town (Nigeria-Benin Republic) in Ogun State, had the least value of 41. Kura was portrayed as unhealthy, while Idiroko was portrayed as healthy, implying that Idiroko air poses little to no danger, while Kura air showed that certain people of the general public, as well as members of sensitive groups, could encounter more severe health effects.

Keywords: Government Department, AQI, USEPA, Tutiempo Network's Data, Nigeria

Introduction

Air pollution is a major environmental health risk. By reducing environmental impacts, nations around the world can reduce the burden of illness caused by stroke, heart disease, lung cancer, and both chronic and acute respiratory diseases, including asthma (Manisalidis et al., 2020). Nigeria one of the developing countries in Africa has urban and suburban towns rapidly growing economically, population wise, industrially, among others. As these towns are fast growing there are records of high rates of illness and premature death caused by unhealthy air. An example is a recent World Bank study in Lagos a former capital city of Nigeria, it estimates that illness and premature deaths due to ambient air pollution caused losses of $2.1 billion in 2018, representing about 2.1% of

Lagos State's GDP. In the same year, it caused an estimated 11,200 premature deaths, the highest in West Africa. Children under five were the most affected, accounting for 60 percent of total deaths while adults suffered from heart disease, lung cancer, and chronic obstructive pulmonary disease (Kemper and Chaudhuri, 2020).

Nigeria ranks 152nd (out of 180 countries) on the Environmental Performance Index for Air Quality, so there's reason to be concerned about its air quality. Furthermore, according to the most recent World Health Organization air pollution database (2016), air quality in many Nigerian cities hits dangerous to hazardous levels of $PM_{2.5}$.

The AQI is about the health effects that occur within a few hours or days of breathing polluted air. The AQI is being used by the EPA to regulate five key air pollutants under the Clean Air Act: ground-level ozone, particulate matter, carbon monoxide, sulfur dioxide, and nitrogen dioxide. To protect against negative effects, the EPA has established national air quality standards for each of these pollutants (USEPA, 2000). Data on AQI are scarce in Nigeria, particularly in remote areas. Because of the Internet of Things (IoT) and Citizen Science, low-cost sensors and satellite tracking have been used to assess the AQI in the environment of cities all over the world (Abulude et al., 2021). TuTiempo satellite data was used for a one-day assessment of AQI in this study to reduce data scarcity in Nigeria, particularly in rural areas. This will be the first time this technique is being used in this part of the world. The purpose of this initial report was to assess the air quality index, $PM_{2.5}$, PM_{10}, O_3, CO, NO, and SO_2 levels in 253 towns and villages across the country. A two years AQI monitoring will follow.

Materials and Methods

TuTiempo.net (powered by Tutiempo Network, S.L., Madrid, Spain) is a low-cost, citizen-based PM sensors network system that has been deployed globally (https://en.tutiempo.net/air-quality/ilaro.html). TuTiempo.net offers measurements of pollutants ($PM_{2.5}$, PM_{10}, CO, NO_2, SO_2, O_3), air quality index (AQI), world weather, global climate data, astronomy, and meteorological parameters (humidity, wind speed, and temperature), among other things, using satellite images. One day's worth of data from their website was used in this analysis. They have current air quality data as well as a forecast on their website. The data were presented in accordance with the Environmental Protection Agency's (EPA) standard. The available data on AQI from 253 towns was computed and statistically analyzed in this study using Minitab software version 16. (Descriptive, Pearson correlation, and Box plot).

Results and Discussion

The cumulative AQI of all locations is 117.31, with minimum and maximum values ranging from 41 to 184, respectively (Table 1). Kura (Kano State) and Idi Iroko (Ogun State) have maximum (184) and minimum (41) levels, respectively. According to the study, the ranges between 169 and 184 are obtained from the northern part of the country. According to the findings of the study, the highest AQI levels are mostly found in the country's northern regions. The high levels could be attributed to the area's intense fighting and insecurity, as well as the burning of farm waste, wood for cooking, and fossil fuels. Meteorological factors may also play a role here. There is little or no rainfall, for example, which could have washed or dissolved the pollutants. Meteorological factors may also play a role here. There is little or no rainfall, for example, which could have washed or dissolved the pollutants. But since there is little or no rain, the temperature will be high, the humidity will be low, and the wind speed will be slow, resulting in high concentrations of pollutants. Environmental (caused by human activity) characteristics may have a larger impact on air quality than meteorological conditions. (Akinwumiju et al., 2021).

Table 1: Basic Description of the AQI Results

	AQI	O_3	$PM_{2.5}$	PM_{10}	CO	NO	SO_2
Mean	117.31	44.87	117.4	66.87	5.48	6.84	6.58
Std Dev	73.33	16.32	55.95	27.4	2	6.94	6.25
Coef. Var	62.51	36.36	47.66	40.98	45.45	101.49	94.96
Minimum	41	15	41	3	2	0	0
Maximum	184	118	645	143	19	37	42
Q1	88	35	88	45	4	2	3
Q3	153	51	153	83	6	7	8
Skewness	11.21	1.8	5.02	0.69	2.22	1.89	2.33
Kurtosis	15.8	4.18	39.68	-0.19	7.76	3.07	7.11

Table 2: AQI, Levels of Concern and Description

Daily AQI Color	Levels of Concern	Values of Index	Description of Air Quality
Green	Good	0 to 50	Air quality is satisfactory, and air pollution poses little or no risk.
Yellow	Moderate	51 to 100	Air quality is acceptable. However, there may be a risk for some people, particularly those who are unusually sensitive to air pollution.
Orange	Unhealthy for Sensitive Groups	101 to 150	Members of sensitive groups may experience health effects. The general public is less likely to be affected.
Red	Unhealthy	151 to 200	Some members of the general public may experience health effects; members of sensitive groups may experience more serious health effects.
Purple	Very Unhealthy	201 to 300	Health alert: The risk of health effects is increased for everyone.
Maroon	Hazardous	301 and higher	Health warning of emergency conditions: everyone is more likely to be affected.

Based on the AQI values, there is a level of concern with regards to human health. Tables 2 is provided to categorise the levels based on the colour, concern, and values of the index. Explanations and health effects are provided. Idiroko has the least value of 41 (Southwest), while Kura (Northwest) has the highest (184). The implication is that AQI of the selected towns are between 'Good' and 'Unhealthy' because the values fall under 0 to 50 and 151 to 200 respectively. The implications are (i) All towns and villages whose values fall under 'good' has satisfactory air quality, and air pollution has little or no risk. (ii) On the other hand, some people or general public in towns and villages that fall under unhealthy may experience health issues, and members of sensitive groups may experience more serious health issues. Members of the community must be environmental conscious because any further introduction of pollutants into the environment may result in further health implications.

Table 3: Pearson Correlation Coefficient of the Pollutants

	AQI	O_3	$PM_{2.5}$	PM_{10}	CO	NO_2	SO_2
AQI	1						
O_3	0.12	1					
$PM_{2.5}$	0.36	0.29	1				
PM_{10}	0.31	0.52	0.52	1			
CO	0.25	0.46	0.49	0.55	1		
NO_2	0.21	0.66	0.45	0.66	0.69	1	
SO_2	0.15	0.6	0.31	0.59	0.3	0.61	1

The pollutants are significantly ($p > 0.01$) related (Table 1). They are either weak or strong. Weakness is defined as a value less than 0.5. There is a significant relationship between PM_{10} and O_3 (r=0.52), PM_{10} and $PM_{2.5}$ (r=0.52), CO and PM_{10} (r=0.55), NO and O_3, CO (r=0.66), SO_2 and O_3 (r=0.6), SO_2 and PM_{10} (r=0.59), and SO_2 and NO_2 (r=0.61), indicating that the pollutants originated from the same sources (e.g., vehicle and wood/coal emissions).

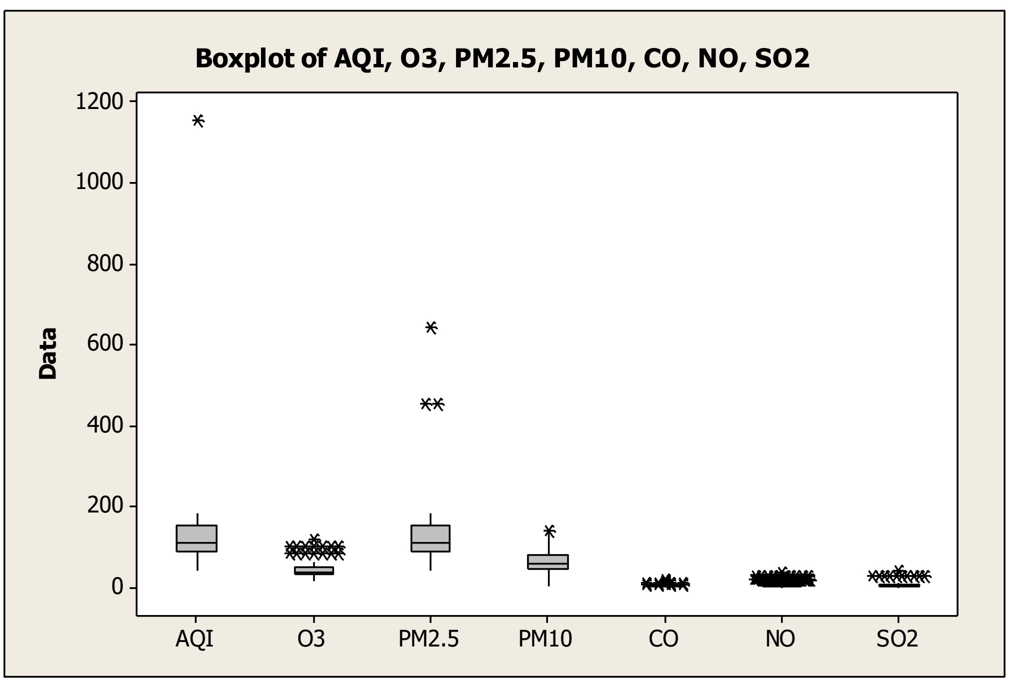

Figure 2: Boxplot of the results

Figure 2 depicts the data distribution in terms of lower quartile, upper quartile, median, minimum, and maximum in each of the five locations using box and whisker plots. This was done to demonstrate the difference in regular concentrations of air pollutants. The box plot essentially depicts a brief sketch of the distribution of the underlying data.

Conclusion

Based on one-day air pollutant concentrations from 253 urban and urban communities in Nigeria, the air quality index of pollutants (PM, O_3, NO_2, CO, and SO_2) was monitored in this study. The following are the key findings: (i) High $PM_{2.5}$ levels were the primary cause of heavy air pollution; (ii) Air pollution was regional, with daily mean CO, NO_2, $PM_{2.5}$, and PM_{10} levels significantly higher in the north than in other regions, particularly the south, indicating the combined impact of wood and biomass burning, cigarette smoke, vehicular emissions, soil dust sources, and undesirable weather patterns on air pollution.

Data Availability Statement: The data presented in this study are available on request from the corresponding author.

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Conflicts of Interest: The authors declare no conflict of interest.

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Abbreviations

The following abbreviations are used in this manuscript:

AQI	Air Quality Index
IoT	Internet of Things
WHO	World Health Organization
NGO	Nongovernmental organization

References

Abulude, F.O., Damodharan, U., Acha, S., Adamu, A., and Arifalo, K.M. (2021). Preliminary Assessment of Air Pollution Quality Levels of Lagos, Nigeria. Aerosol Science and Engineering. In Press.

Akinwumiju, A.S., Ajisafe, T. and Adelodun, A.A. Airborne Particulate Matter Pollution in Akure Metro City, Southwestern Nigeria, West Africa: Attribution and Meteorological Influence. *J geovis spat anal* **5,** 11 (2021). https://doi.org/10.1007/s41651-021-00079-6

Kemper and Chaudhuri (2020). Air pollution: A silent killer in Lagos. World Bank Blogs. Published on Africa Can End Poverty. https://blogs.worldbank.org/africacan/air-pollution-silent-killer-lagos. Assessed 23th March, 2021.

Manisalidis, I., Stavropoulou, E., Stavropoulos, A., and Bezirtzoglou, E. (2020). Environmental and Health Impacts of Air Pollution: A Review. *Frontiers in public health*, *8*, 14. **https://doi.org/10.3389/fpubh.2020.00014**

Tutiempo Network, S.L. (2021). https://www.calidadaire.net/nigeria.html. Accessed 1st May, 2021.

USEPA (2000). Air Quality Index A Guide to Air Quality and Your Health. EPA-454/R-00-005. **http://www.epa.gov**. **https://www.miamidade.gov/environment/library/brochures/air-quality-index.pdf**. Accessed 1st May, 2021.

WHO (2016) WHO Global Urban Ambient Air Pollution Database (update 2016). Public health, environmental and social determinants of health (PHE). https://www.who.int/phe/health_topics/outdoorair/databases/cities/en/. Accessed 1st May, 2021.