



# Real-Time Air Quality Index App: The Use of eWeather HDF App for Education in Monitoring of Pollutants and Meteorological Parameters in Nigeria

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## ABSTRACTS

The veracity of data derived from networks of low-cost measuring instruments is a rapidly increasing and contentious issue. For air quality monitoring, networks of low-cost devices, satellite modeling, and phone apps have risen to prominence. We used the eWeather HDF phone app to monitor the air quality (AQI, PM<sub>2.5</sub>, PM<sub>10</sub>, NO, NO<sub>2</sub>, CO, SO<sub>2</sub>, and meteorological parameters) of five Nigerian towns in this study. This app also can be used for education. The results show that the AQI of all towns is between 51 and 100. Except for Zaria, where the PM<sub>2.5</sub> levels are about 16 percent higher, all of the locations' PM<sub>2.5</sub> levels are within the World Health Organization (WHO) daily limit standard. Similarly, the PM<sub>10</sub> level in the same town was nearly three times higher than the limit. NO<sub>2</sub> (Akure > Ilorin > Ikere-Ekiti > Zaria > Ibadan), SO<sub>2</sub> (Akure > Ilorin > Ikere-Ekiti > Zaria > Ibadan), CO (Zaria > Akure > Ilorin > Ikere-Ekiti > Zaria > Ibadan), NO (Akure > Ilorin > Ikere-Ekiti > Zaria > Ibadan). Correlations with meteorological parameters are significant. Although the pollution levels in these towns are allowable, they may pose a risk to some individuals, especially those who are exceptionally sensitive to environmental changes.

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## 1. INTRODUCTION

Pollutants pose a significant threat, particularly in developing countries. To address this issue, pollutants must be quantified in the environment (both indoors and outdoors) to determine if they are within World Health Organization (WHO) standard limits. Initially, expensive equipment was used to obtain levels of pollutants (PM<sub>2.5</sub> and PM<sub>10</sub>, NO, NO<sub>2</sub>, CO, SO<sub>2</sub>, and O<sub>3</sub>), but the Internet of Things IoT and Citizen Science using low-cost sensors have come to the rescue of low-income individuals.

Air sensor networks, such as wireless distributed networks of sensors, have been designed and tested using phone apps to collect and disseminate real-time air quality data (Jiao et al., 2016). The mobile phone is an obvious choice for personal exposure monitoring because it is carried by the majority of people. However, it has not been used as a stand-alone device for this purpose to date. Several approaches to collecting and disseminating air quality data using mobile phones and pollutant sensing instruments have been reported (Brienza et al., 2015; Nyarku et al., 2018). This was accomplished by either directly connecting the sensing device to the phone or by interfacing it via Bluetooth pairing or tethering, allowing for real-time data visualization on the phone and subsequent upload to a server.

Due to the scarcity of monitoring devices in Nigeria, little is done to monitor air quality, particularly in rural areas, which means that citizens in these areas will lack critical information about the quality of air for their health. With the availability of weather apps and mobile phones, which have a wide range of applications, it is now possible to aid in risk prevention and improve the health and well-being of their owners. They have not, however, been used for comprehensive testing of individual ambient air pollution. This app also can be used for education.

Monitoring pollutants and meteorological factors using appropriate and cost-effective methods can be accomplished through the use of low-cost sensors, satellite modeling, and the use of phone apps (Abulude, 2021). One of the dependable phone apps is the eWeather HDF App. eWeather HDF displays the air quality index (AQI), air pollution, and air matters on a map and in widgets. AirNow, Copernicus, and the European Centre for Medium-Range Weather Forecasts (ECMWF) provide data on harmful substance concentrations in the atmosphere. eWeather HDF displays the air quality index (AQI) for fine particulate matter PM<sub>10</sub>, coarse particulate matter PM<sub>2.5</sub>, nitrogen oxide NO, sulfur dioxide SO<sub>2</sub>, ozone O<sub>3</sub>, and other substances. eWeather HDF makes use of many data providers. As a result, for many cities, it is possible to compare data from various sources. eWeather HDF displays current air quality values, a graph of changes over the last 24 hours, and a forecast of air quality several days in advance. The forecast is only available for a subset of data sources. The program's air quality index ranges from 0 to 500. Whereas 0 represents ideally clean air, 500 represents the most polluted air. This work aims to quantify the AQI, pollutants, and meteorological factors of four towns in Nigeria.

## 2. METHODS

The locations of monitoring in this study are Ibadan, Ilorin, Zaria, and Akure (**Table 1**). Ibadan is the capital and largest city of Oyo State, Nigeria. It is Nigeria's third-largest city by inhabitants, after Lagos and Kano, with an overall population of 3,649,000 as of 2021 and cosmopolitan inhabitants of over 6 million people. It is the country's largest city in terms of land area. 3,080 km<sup>2</sup> in size. Elevation: 230 meters. Weather: 32°C, 5 km/h SE wind, and 57 percent humidity. Ilorin is the state capital of Kwara State in Nigeria's Western region. It had a population of 777,667 as of the 2006 census, making it Nigeria's seventh-largest city by

population. Area: 765 km<sup>2</sup>. Temperature: 32°C, Wind: S at 5 km/h, Humidity: 50%. Akure is the biggest city and capital of Ondo State in southwestern Nigeria. According to the 2006 census, the city had a population of 484,798 people. 991 km<sup>2</sup> in size, 350 m in elevation. Weather: 31°C, E wind at 0 km/h, 60% humidity. Zaria is a major city in Kaduna state and a metropolis city that currently lies within four local government areas. These local government areas in Kaduna state, Nigeria, include Zaria Local Government, Sabon Gari Local Government, Giwa Local Government, and Soba Local Government. 563 km<sup>2</sup> in size. Weather: 33°C, NE wind 14 km/h, humidity 24 percent.

**Table 1.** The locations, Geopolitical Zones, and the Coordinates of this Study.

Location Name	Geopolitical Zone	Coordinate
Oyo State (Ibadan)	South West	7.3775° N, 3.9470° E
Ondo State (Akure)	South West	7.2571° N, 5.2058° E
Kaduna State (Zaria)	North West	11.0855° N, 7.7199° E
Kwara State (Ilorin)	North Central	8.4799° N, 4.5418° E

In this study, we monitored AQI, pollutants (PM<sub>2.5</sub>, PM<sub>10</sub>, CO, NO<sub>2</sub>, NO, and SO<sub>2</sub>), and meteorological parameters with a high temporal resolution for Nigeria, which was obtained from the Air Quality Monitoring Network of eWeather HDF app from 17 October 2021 to 31 October 2021 (see **Figure 1**). The weather app and widget provide accurate hourly and 10-day weather forecasts from two weather providers. The weather report from the weather forecast includes temperature, humidity, rainfall and new snowfall amount, wind speed, and dew points graphs. eWeather HDF app collects location data to display the current weather for the current location in the status bar and widgets, even when the app is closed or not in use. All app information is also available with various weather widgets and status bar notifications. All measurements were taken in triplicate and statistically analyzed in Excel 2013.



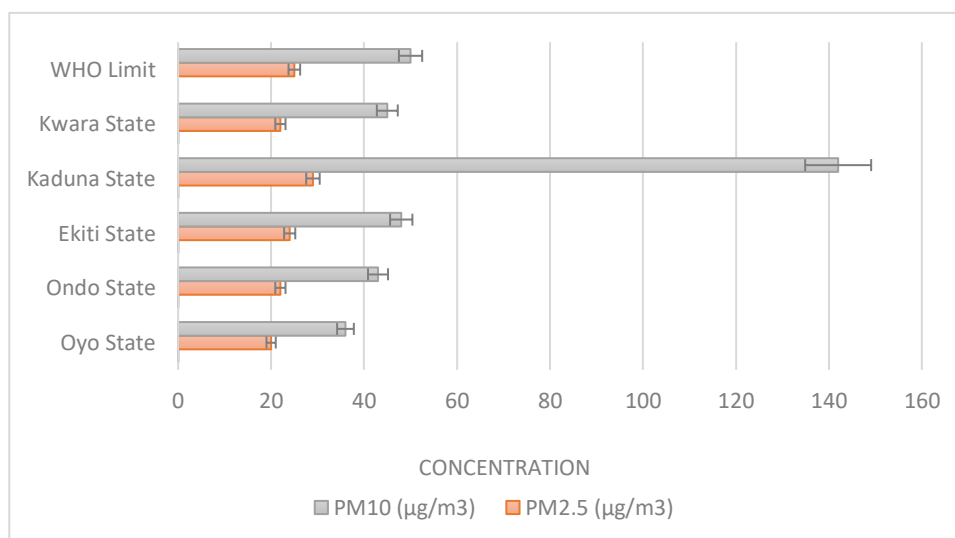
**Figure 1.** The Map of Locations of the used in this study.

### 3. RESULTS AND DISCUSSION

**Table 2** shows the results of the monitored locations. AQI of all the towns is within the values of index 51-100. As shown in **Table 3**, the level of concern is moderate depicting that the Air quality of all the locations is acceptable but, there may be a risk for some people, particularly those who are unusually sensitive to air pollution. Zaria has the highest value of 94 which means efforts should be put in place to reduce the pollutants generated. The PM<sub>2.5</sub> of the locations are within the WHO daily limit, except Zaria that is about 16% higher. Likewise, the PM<sub>10</sub> of the same town had the highest value which is almost three times more than the limit (**Figure 2**). The variations in the levels of PM might be due to wind-blown dust from roads, vehicular emissions, and burning of biomass. Outdoor air pollution and indoor smoke is serious health risk for some individuals who cook and heat their homes with biomass, kerosene fuels, and coal (see. [https://www.who.int/news-room/fact-sheets/detail/ambient-\(outdoor\)-air-quality-and-health](https://www.who.int/news-room/fact-sheets/detail/ambient-(outdoor)-air-quality-and-health)).

**Table 2.** Basic Distribution of Parameters (Pollutants and Meteorological Parameters).

Parameters	Oyo State (Ibadan)	Ondo State (Akure)	Ekiti State (Ikere-Ekiti)	Kaduna State (Zaria)	Kwara State (Ilorin)
AQI	68.000	70.000	75.000	94.000	71.000
PM <sub>2.5</sub> (µg/m <sup>3</sup> )	20.000	22.000	24.000	29.000	22.000
PM <sub>10</sub> (µg/m <sup>3</sup> )	36.000	43.000	48.000	142.000	45.000
CO (ppb)	388.000	305.000	353.000	206.000	326.000
NO <sub>2</sub> (ppb)	1.300	0.410	0.550	0.790	0.450
SO <sub>2</sub> (ppb)	0.950	0.410	0.600	0.630	0.500
NO (ppb)	0.150	0.061	0.093	0.130	0.071
Temperature (°C)	31.000	33.000	30.000	32.000	31.000
Dew Point (°C)	23.000	23.000	22.000	10.000	24.000
Precipitation (%)	20.000	30.000	0.000	0.000	0.000
Pressure (mm Hg)	738.000	726.000	721.000	703.000	734.000
Humidity (%)	64.000	59.000	66.000	26.000	69.000
Ultra Violet Index (UV)	0.000	0.000	0.000	8.000	9.000
Wind Speed (m/s)	3.000	0.000	0.000	6.000	4.000
Chance of Precipitation (%)	10.000	15.000	10.000	5.000	5.000



**Figure 2.** Comparison of PM<sub>2.5</sub> and PM<sub>10</sub> with WHO Daily Standards.

**Table 3.** The Colour Codes showing the Description of Air Quality.

Daily AQI Colour	Levels of Concern	Values of Index	Description of Air Quality
Green	Good	0 to 50	Air quality is satisfactory, and air pollution possess 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 the sensitive group 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.

The following are the other pollutant results: NO<sub>2</sub> (Akure > Ilorin > Ikere-Ekiti > Zaria > Ibadan), SO<sub>2</sub> (Akure > Ilorin > Ikere-Ekiti > Zaria > Ibadan), CO (Zaria > Akure > Ilorin > Ikere-Ekiti > Zaria > Ibadan), NO (Akure > Ilorin > Ikere-Ekiti > Zaria > Ibadan). The most significant sources of carbon monoxide exposure are the combustion of biomass fuels and tobacco smoke. Without properly functioning safety features, clogged chimneys, wood-burning fireplaces, decorative fireplaces, gas burners, and supplementary heaters could vent carbon monoxide into indoor. The primary source of NO and NO<sub>2</sub> in the atmosphere is the combustion of fuel. NO<sub>2</sub> is produced by emissions from automobiles, trucks, and buses, as well as power plants and off-road vehicles. Without a doubt, Ibadan has the highest levels of NO and NO<sub>2</sub> gas because it has more trucks and power plants than the other areas in the study.

**Table 2** displays the meteorological parameters. The UV Index of the locations ranges between 0 and 9. It is observed that the towns in the country's north show 8 (Zaria) and 9 (Ilorin). The World Health Organization's Global Solar UV Index rates UV levels from 0 - 2 (Low), 3 - 5 (moderate), 6 - 7 (high), 8 - 9 (very high), and 11+. (Extreme). When UV levels are 3 (Moderate) or higher, it indicates that sun protection is advised (see <https://www.sunsmart.com.au/uv-radiation/what-is-uv>). The phone app used in this study is an important tool for weather forecasting. It aids in planning for the unexpected. UV radiation can cause skin and eye damage, sunburn, tanning, and skin cancer if there is too much of it. A variety of factors influence UV levels, including the time of day, season, cloud cover, altitude, location, and surrounding surfaces.

Precipitation and chance of precipitation are low (0-30). This implication is that there is a low water content in the atmosphere. These are observed in the low dew content and low humidity levels obtained in the study. There was scanty rainfall during these periods of monitoring. Humidity affects the natural deposition of particulate matter in the air. With an increase in humidity, the size of the particulate matter also increases. Eventually, it becomes too heavy to remain in the air and begins to fall off. This is what is called the dry deposition of particulate matter.

Temperature range between 30 and 33 °C. The temperatures are high. It is known that Heat waves often lead to poor air quality. The extreme heat and stagnant air during a heatwave increase the amount of ozone pollution and particulate pollution.

#### 4. CONCLUSION

The eWeather HDF phone app was used in this study to monitor air quality in four towns. Except for the results from Zaria, which are higher, the results of atmospheric particulate matter (PM<sub>2.5</sub> and PM<sub>10</sub>) at the four locations show lower concentrations compared to both PM<sub>2.5</sub> and PM<sub>10</sub> WHO limits. The four towns' AQIs are in the moderate range. Although the awareness and concern are tolerable, perhaps there is a danger for some individuals, especially those who are abnormally sensitive to environmental changes. The following are the other pollutant results: NO<sub>2</sub> (Akure > Ilorin > Ikere-Ekiti > Zaria > Ibadan), SO<sub>2</sub> (Akure > Ilorin > Ikere-Ekiti > Zaria > Ibadan), CO (Zaria > Akure > Ilorin > Ikere-Ekiti > Zaria > Ibadan), NO (Akure > Ilorin > Ikere-Ekiti > Zaria > Ibadan). The UV Index of the locations ranges between 0 and 9. It is observed that the towns in the country's north show 8 (Zaria) and 9 (Ilorin). Precipitation and chance of precipitation are low (0-30). The temperatures are high (30 and 33 °C). The variations in the levels of PM in this study might be due to wind-blown dust from roads, vehicular emissions, and burning of biomass. If people with respiratory diseases, such as asthma, are exposed to particulate matter, CO, NO, NO<sub>2</sub>, and SO<sub>2</sub> at the emerging locations, they may be affected.

#### 5. ACKNOWLEDGMENT

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#### 6. 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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