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SATELLITE-BASED ASSESSMENT OF TOTAL COLUMN NITROGEN HOTSPOTS IN NIGERIA: IMPLICATIONS FOR URBAN IN-SITU MONITORING NETWORKS

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Abstract
Nitrogen Dioxide (NO_2), a criteria pollutant, serves as a primary indicator of anthropogenic combustion and a precursor to respiratory health crisis In Nigeria. The scarcity of terrestrial air quality infrastructure in the country, creates a significant "data blind spot "for environmental regulators. This study utilizes NASA Giovanni (Geo-spatial Interactive Online Visualization and Analysis Infrastructure) to conduct a comprehensive assessment of the Area-Averaged Total Column of nitrogen dioxide NO_2 across the Nigerian landmass. The research establishes a 19 year old baseline for atmospheric NO_2 loading. The analysis reveals distinct spatial clusters of elevated NO_2 over the Lagos-Ogun industrial axis, and the densely populated urban centers of Abuja. Temporal trends extracted via Giovanni time-series tools showed a consistent seasonal peak and troughs during the dry season and the rainy seasons respectively.
***K**eywords: Nitrogen Dioxide (NO_2), Air Quality, NASA Giovanni, Remote Sensing, Anthropogenic, Emissions,*

Introduction

Nigeria, a rapidly developing West African nation, faces significant environmental challenges driven by industrialization and population growth. Among the criteria pollutants, Nitrogen Dioxide (NO_2) serves as a critical indicator of air quality. Nitrogen dioxide, primarily originates. from fossil fuel combustion in vehicles, industrial plants, and domestic generators.

David -Okoro et al., (2023) in their work found that NO_2, CO and SO_2 correlated positively. This confirms they originate from the same anthropogenic sources specifically fossil fuel combustion in vehicles, power generators, and industrial plants.

While satellite remote sensing provides a "top-down" view of these emissions (East et al., 2022), there is a growing necessity for robust, ground-based (in-situ) monitoring to protect public health in fast-urbanizing cities.

Materials and Methodology

Study Site

Nigeria is located in the western part of Africa. It is bounded in the East by Cameroon, by the west by Benin Republic, and in the North by Niger republic and Chad while the southern part of the country is covered by the Atlantic Ocean. Nigeria has coordinates of (4.0 -14 N and 2.5 - 14.6 9ºE). It has an average elevation is 347 meters (Topographic map, 2024). A satellite map of Nigeria is shown in figure 1.0

Figure 1.0, A satellite map of Nigeria (Courtesy google.com)

This study utilized the NASA Giovanni platform to retrieve, Area-Averaged NO_2, total tropospheric column data (30% cloud-screened). The spatial resolution was set at 0.25 x 0.25, for a study period of January 1, 2005, to December 31, 2023. Daily observation data were retrieved from the GIOVANNI platform and subsequently aggregated to derive monthly and annual temporal resolutions to enable us identify seasonal cycles and long-term trends. A time average map was selected from the platform. A plot in Panoply using a higher-contrast color palette was chosen. The plot is shown in figure 2.0

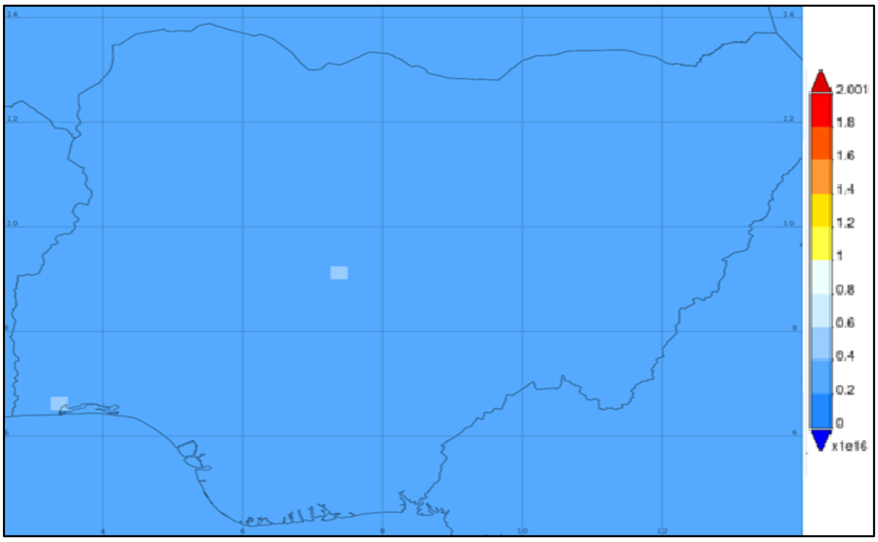

Figure 2.0 An average time map from the years 2005 to 2023 over Nigeria

Results and Discussion

Seasonal Sinusoidal Patterns

A time series data reveals a consistent sinusoidal curve in NO_2 concentrations across the 19-year period of study. The figure is as shown in figure 3.0

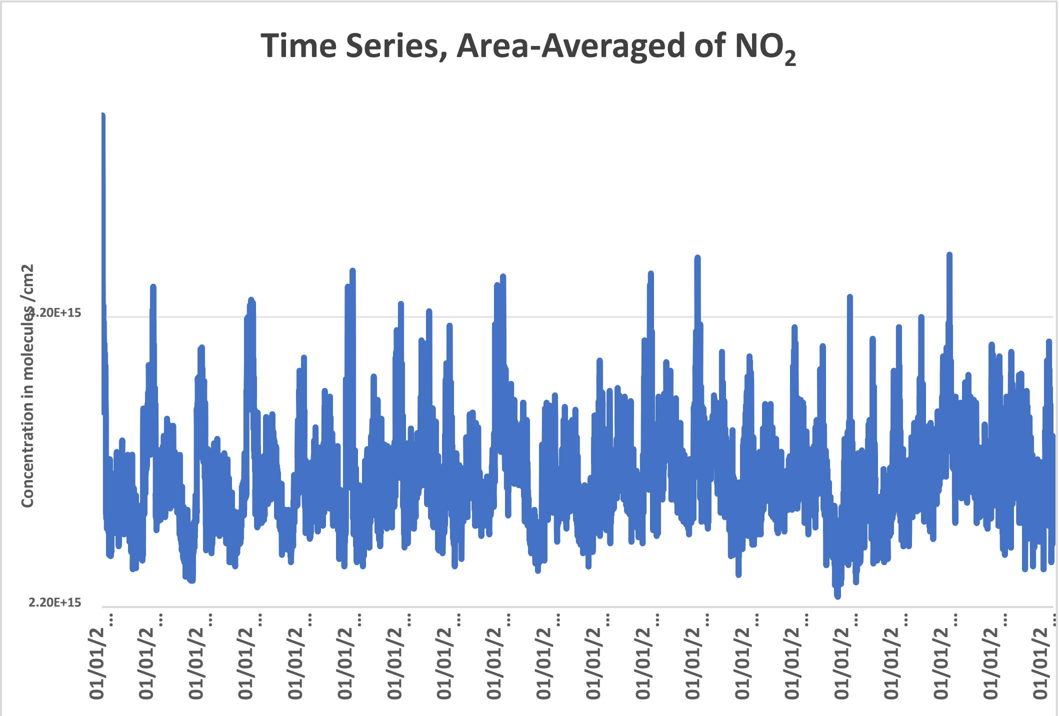

Figure 3.0, a time series area average of NO_2

The Peaks were consistently recorded during January and December. The highest values.

was retrieved in January 2005, the peak reached $4.15x10^{15}$ molecules per cm^2. These peaks coincide with the hamatan season and the peak of biomass burning, where agricultural clearing releases massive amounts of Nitrogen dioxide.

The Troughs which was witnessed around August, September, and October season recorded the lowest values, with a minimum of 2.52×10^{14} molecules per cm^2 in October. This is attributed to the West African Monsoon, where heavy rainfall facilitates the "wet deposition" or washing out of pollutants from the atmosphere.

Increased solar radiation leads to higher concentrations of the hydroxyl radical (OH) (Vieria, 2021). The hydroxyl radical accelerates the oxidation of NO_2 into nitric acid (HNO_3), and it comes down as acid rain. This is not good for our environment ñ

Long-term Trends (2005–2023)

Despite a massive increase in Nigeria's urban population, a slight decline in NO_2 concentrations was observed over almost the two decades studied. 2005 recorded the highest value for all the years studied. The slight decrease suggests a potential shift in combustion efficiency, reduced open-field burning, or changes in fuel quality standards.

Geographic Hotspots

From the study, Lagos and Abuja emerged as the primary hotspots due to lots of anthropogenic activities going on in these cities. Lagos, is an industrial and maritime hub, while Abuja, is a rapidly expanding administrative capital of the country. There is a show of high correlation between urbanization and NO_2 density.

The COVID-19 Impact (2020)

The year 2020 witnessed the lowest NO_2 values across the entire study period. The highest value of It reThis anomaly provides empirical evidence of the "anthropause" —a reduction in human-induced emissions due to national lockdowns, the reduced vehicular traffic, and slowed industrial activity during the pandemic could be the cause of the year 2020 recording the least annual value for all the years. The figure is shown in figure 4.0

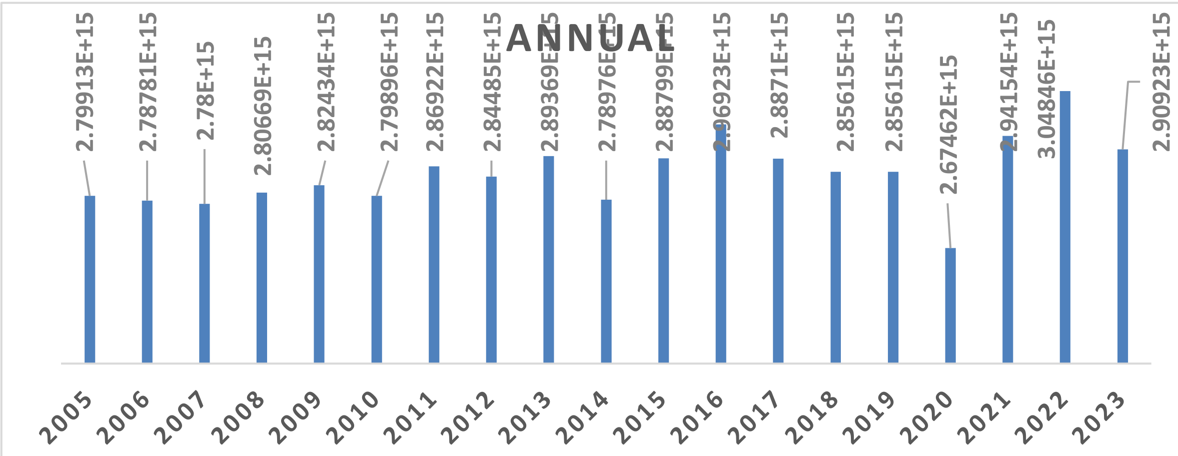

Figure 4.0 Annual value for all the years.

Implications for In-Situ Monitoring

Satellite data measures the total column of air, but humans beings, breathing are at the surface level. This implies that satellite data underestimate surface-level exposure in "street canyons" where vehicle exhaust is trapped and needs in-situ data to enhance the satellite data.

The high concentrations found in Lagos and Abuja suggest that there is the existence of Localized Data Gaps (LDG). Nigeria must transition toward obtaining a network of ground-based sensors to provide real-time Air Quality Index (AQI). Efforts should be made to place alerts for citizens especially for criteria pollutants like nitrogen dioxide (NO_2).

The places for targeted Intervention monitoring should be for high-traffic corridors and the industrial zones identified by the satellite hotspots.

Conclusion

The 19-year assessment confirms that while natural seasonal cycles dictate the rhythm of air pollution in Nigeria, anthropogenic activities in major cities are the primary drivers of dangerous peaks. The "2020 Dip" proves that policy-driven changes in anthropogenic activity can rapidly improve air quality.

To effectively manage public health in Nigeria, there must be a permanent, robust in-situ monitoring infrastructure to supplement these satellite findings.

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