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BULLETIN

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4th Quarter 2024

Air Quality Bulletin

October - December 2024

A publication of Nigerian Meteorological Agency

Our Mandate

To provide for the regulation of meteorology and for related matters

Our Vision

To be a World Class provider of Weather and Climate services for safety and sustainable national socio-economic development.

Our Mission

To observe Nigerian Weather and Climate and provide Meteorological, Hydrological, and Oceanographic Services in support of National needs and International Obligations

Who We Serve

Aviation, Agriculture, Building and Construction, Commerce, Health, Hydrology, Marine, Oil and Gas, Sports, Social Events, Power and Energy, Telecommunication and more...

EDITORIAL

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Preface

The NiMet Air Quality Quarterly Bulletin provides a detailed report and analysis of observed air pollutants, pollution levels, trends, and overall quality of air over Nigeria on quarterly basis. This is done to provide enlightenment and create public awareness about the routine assessment of air quality over the country with a view to equipping stakeholders and the general public with relevant information that will help in prevention and control practices that will minimize air pollution and unnecessary exposure of Nigerians to the adverse effects of air pollution.

In this edition, the first three chapters discuss the spatial distribution and diurnal variations of three key pollutants: PM2.5, NO2, and CO that significantly impacted air quality across Nigeria in July, August and September 2024. The atmospheric weather conditions that prevailed during the period for which air quality was monitored is also captured in these three chapters since there is relationship between weather conditions and air quality. The influences of atmospheric features, such as the Inter-Tropical Discontinuity (ITD), wind speed and direction, and mean sea level pressure, especially the Azores and St. Helena high-pressure systems over the North and South Atlantic Ocean determines the levels and extent of spread of pollutants across the country. The weather features also play important role in determining rainfall patterns across the country. Consequently, rainfall affect the levels of pollutants in the atmosphere. Chapter Four provides an overall analysis of quarterly average changes in air quality trends and levels of pollutants concentration (PM2.5, NO2, and CO) during the three-month period of July, August, and September 2024.

Air quality data utilized for the analyses in this bulletin are satellite data sourced from the Copernicus Atmospheric Monitoring System (CAMS), combined with available surface observations. This bulletin is therefore a report and guide intended for widespread use by various stakeholders, including the general public, health practitioners, research communities, environmentalists, and regulatory agencies, among others for informed decision-making. It is also a good tool in formulating policies that will enhance air quality, improve human health and reduce anthropogenic impact on climate change in the country.

Professor Charles Anosike
Director General/CEO NiMet & Permanent Representative of Nigeria with WMO

Introduction

Air pollution occurs in timescales of days to weeks affecting the quality of air across spatial scales from local to regional and continental, while climate change occurs in timescales of decades to centuries. Despite these wide differences in time scales, air pollution and climate change are interconnected as changes in one affect the other. Both climate change and air pollution have continued to affect the natural ecosystem, human health and biodiversity and carbon storage (WMO 2024). For instance, increase in concentrations of Sulfur, Nitrogen and Ozone in the atmosphere can lead to increased greenhouse effect, thereby exacerbating climate change. Effort towards combating climate change consequences should therefore be complimented with commensurate effort towards combating air pollution and ensuring clean air.

The World Meteorological Organization (WMO) reports that air pollution caused 4.5 million premature deaths annually and wreaks high economic and environmental cost (WMO 2024). A consistent and continuous monitoring of air quality contributes to the inventory of air pollution data, enhance the accuracy of forecasts and produce timely advisories. Availability of air pollution data will also help in formulation of effective policies for improved quality of air and overall health of the environment.

NiMet regularly monitors air quality over Nigeria and produces the Air Quality Bulletin on a quarterly basis. The bulletin also provides relevant information needed for action to reduce exposure to health risks due to air pollution. The information in this bulletin is also useful input for formulating regulations for controlling the emission of air pollutants in the country.

Particulate Matter (PM)

Particulate matter (PM) is made up of microscopic solid or liquid droplets with diameter of less than 10 micrometers. When suspended in the atmosphere PM causes deterioration of air quality and constitute health hazard to humans. The greatest threat to health comes from fine particles, with diameter of less than 2.5 μm (micrometers), also known as PM2.5. They are so minute that they are able to travel deeply into the respiratory tract, reaching the lungs and potentially can enter the bloodstream. Exposure to these fine particles can cause short-term health effects such as eye, nose, throat and lung irritation, coughing, sneezing, runny nose and shortness of breath. There is growing evidence of other adverse health effects of these microscopic particles. Globally, ambient PM2.5 exposure resulted in 2.9 million premature deaths in 2017, with roughly 80,000 premature deaths in West Africa. Even at relatively low concentrations, PM may produce adverse effects on health, depending on pollution sources and the duration [short-term (hours or days) or long-term (months or years)]. PM of diameter 10 m (PM10) or 2.5 m (PM2.5) or less is the most harmful air pollutant to health. Ground level ozone, nitrogen oxides, carbon monoxide and sulfur oxides are also of great health concerns as these are the main precursors of secondary PM in the atmosphere. The World Health Organization Air Quality guidelines which spell out acceptable limits of each pollutant is shown in Table.

[1] WHO (2025) World Health Organization Health Topics - Air Pollution https://www.who.int/health-topics/air-pollution#tab=tab_1

[2] WHO 2024 World Health Organization Facts Sheet – Household Air Pollution https://www.who.int/news-room/fact-sheets/detail/household-air-pollution-and-health

Table 1: World Health Organization Air Quality Guidelines (Source: World Health Organization. *Air Quality Guidelines - Update 2021)*

Pollutant	Averaging Time	2005 AQGs	2021 AQGs
$PM_{2.5}$, $\mu g/m^3$	Annual	10	5
	24-hour[a]	25	15
PM_{10}, $\mu g/m^3$	Annual	20	15
	24-hour[a]	50	45
O_3, $\mu g/m^3$	Peak season[b]	-	60
	8-hour[a]	100	100
NO_2, $\mu g/m^3$	Annual	40	10
	24-hour[a]	-	25
SO_2, $\mu g/m^3$	24-hour[a]	20	40
CO, mg/m^3	24-hour[a]	-	4

Air Quality Index (AQI)

The Air Quality Index (AQI) is a scale used to determine the quality of air based on the level of pollutant concentrations in the air and its associated health risks. The AQI has values ranging from 0 to 500 but categorized into six classes based on concentration of pollutants in the air and health risks associated with each category of the scale. The lowest category of the index (0-50) suggests clean air without threat to health while the highest category (251-500) suggests a hazardous air quality with very high health risks (Table 2). The observed AQI for the period October to December 2024 is discussed in details in Chapters One, Two and Three.

Table 2: Air Quality Index Chart

Air Quality Index	Class	Advisory
1-50	Good	The quality of the air is good, it presents no threat to anyone's health.
51-100	Moderate	The air quality is acceptable, except for unusually sensitive individuals.
101-150	Unhealthy for Sensitive group	Outdoor activity should be minimized for sensitive group such as the elderly, children, and individuals with heart and lung diseases.
151-200	Unhealthy	Everyone should avoid prolonged exposure to prevent breathing difficulties which may be more severe in sensitive populations.
201-250	Very Unhealthy	Minimize time spent outdoors. The entire populace is likely to be affected.
251-500	Hazardous	Hazardous for everyone and may prompt emergency condition alerts.

CHAPTER ONE
October 2024 Review

1.1 Position of the Inter-Tropical Discontinuity (ITD) and Rainfall Across Nigeria

The zone where the moisture laden South-westerly winds from the Atlantic Ocean meet the dry dusty North-Easterly winds from the Sahara Desert is known as the Intertropical Discontinuity (ITD). The ITD oscillates northward and southwards throughout the year. Its position at any given time determines the type of weather that will prevail over a place. Its southernmost position is attained during the dry season while its northernmost position is attained during the peak of the wet season around August. North of the ITD is usually dry and dusty but South of it is usually moisture laden impacting on agriculture and water resources. The characteristics of this moisture boundary therefore influences the distribution patterns of rainfall over the country.

In October 2024, the ITD generally oscillated between latitudes 5°N and 20.3°N tilting downwards from West to East. The ITD moved steadily Southwards from latitude 16.3°N in the first dekad to 15.5°N in the second dekad and further southward to latitude 11.2°N during the 3rd dekad of October 2024. The ITD maintained an average position of latitude 14.3°N which aligns with the climatological position when averaged. However, the observed position was more northerly than the climatological position over western Nigeria but more southerly over the eastern part. The observed position of ITD in the month favored rainfall and improved horizontal visibility especially in the Southern part of the country where total monthly rainfall of 240 to 1100mm was recorded. This resulted in an overall moderate air quality index (AQI) in most parts of the country (Figure 1.1).

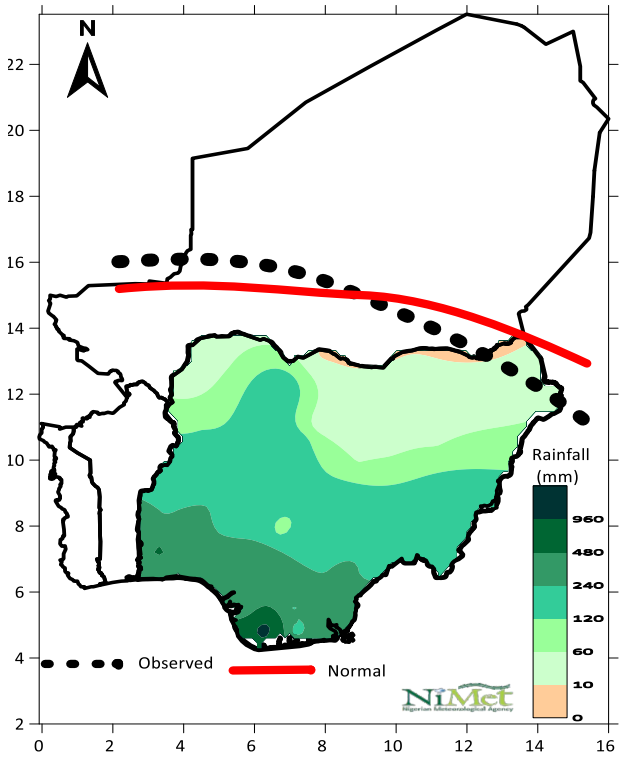


Figure 1.1: Mean Position of ITD and Rainfall Amounts across Nigeria in October 2024.

1.2 Mean Sea Level Pressure (Azores and St. Helena Highs), October 2024

The Azores and St. Helena high-pressure systems, situated around 30°N and 30°S respectively, are the two major high-pressure systems that influence weather system over the country.

The Azores experienced daily mean sea level pressure fluctuations between 1017 and 1035 hPa, and a mean center value of 1020 hPa in the month. The St. Helena high-pressure system showed similar variability, with values ranging from 1019 to 1035 hPa and an average of 1022 hPa (Figure1.2)

The average monthly position of the 1015hPa isobar, was located around 21°N in the northern hemisphere and 15°S in the southern hemisphere. Most of the southern parts of the country experienced pressure values below 1012hPa that were favorable for convective activities.

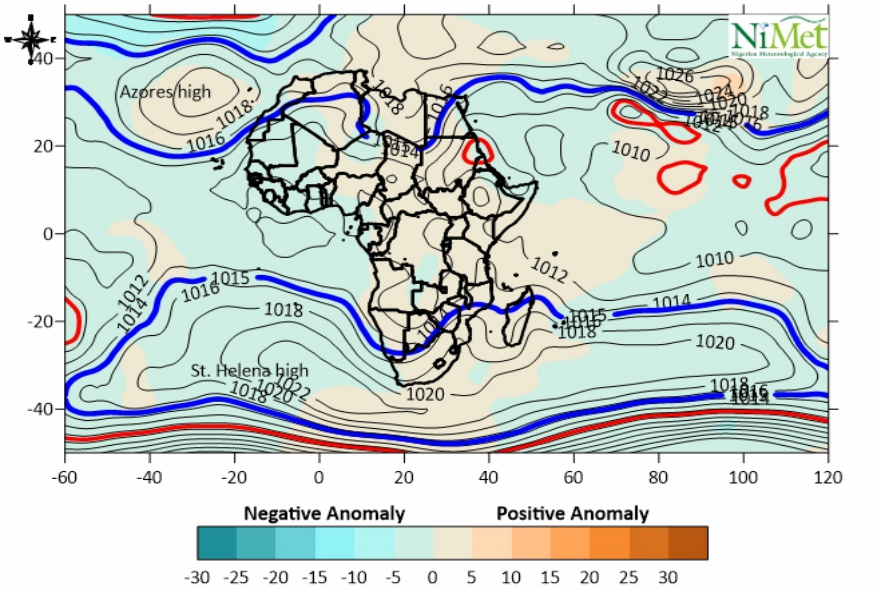


Figure 1.2: Mean Sea Level Pressure in October 2024

1.3 Winds

1.3.1 Winds at 925 hPa Level (900m above the ground level)

At this atmospheric level, moist south-westerly winds dominated the entire country during the first and second dekads of the month with speeds of 5 to 25kts. Cyclonic vortices were present at this level on some days in various parts of the country. The winds observed during the third dekad were mostly dry northeasterly harmattan winds from the Sahara Desert with speeds of 5 to 20kts dominating the northernmost parts of the country. These wind patterns sustained the prevailing

weather conditions of substantial precipitation and moderate-to-good AQI in the Northcentral and South of the country while the continental Northeasterly winds brought in some atmospheric aerosols (mostly dust) into the Northernmost parts of the country. This development negatively impacted air quality by reducing horizontal visibility to 800m, 1500m and 3000m in Nguru, Katsina and Yelwa respectively, and also reduced the air quality, making it unhealthy for sensitive group of persons living in northern Nigeria.

1.3.2 Winds at 850 hPa Level (1500m above the ground level)

The 850hPa atmospheric level was associated with occasional southwesterly winds with speeds of 5 to 20kts on the 1st, 5th, 6th and 18th of the month over the northcentral and the southwestern parts of the country. These conditions were unsustainable as the rest of the month was dominated by dry northeasterly winds with speeds of 5 to 30kts, indicative of the onset of the harmattan season over the country in October.

1.4 Particulate Matter (PM 2.5) Concentration in October, 2024.

As shown in Figure 1.3, the mean concentration of PM2.5 in October 2024, ranged from 15 µg/m3 to 49 µg/m3 across the country. During the month under review, Edo, Delta, Bayelsa, Rivers, Akwa Ibom, Cross River states, as well as eastern parts of Benue, Taraba, Adamawa, Kwara and Borno states recorded mean PM2.5 concentration between 15 µg/m3 and 25 µg/m3. Parts of Sokoto, Kebbi, Niger, Kaduna, Plateau, the FCT, Kogi, Benue, Enugu, Anambra, Imo, Gombe, Bauchi and Yobe states recorded mean PM2.5 concentrations ranging between 25 µg/m3 and 35 µg/m3, while Katsina, Jigawa, northern Kaduna and northern Bauchi observed mean PM2.5 concentration in the range of 35 µg/m3 to 45 µg/m3. The highest mean PM2.5 concentration of 49 µg/m3 was observed over Kano state.

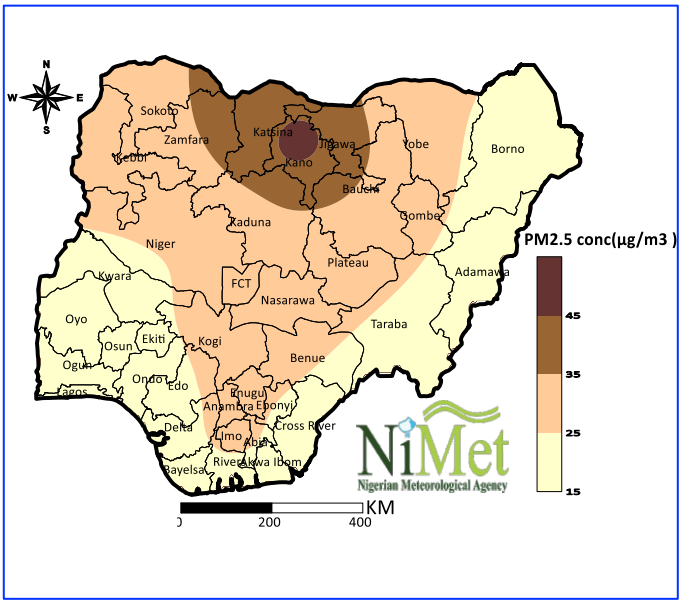


Figure 1.3: Mean Concentration of Particulate Matter (PM2.5) Across Nigeria in October, 2024.

1.5: Horizontal Visibility in October, 2024.

Horizontal visibility is the maximum distance at which an observer can see and identify an object situated in essentially the same horizontal plane. Visibility is a practical index of air quality, as studies have directly related air pollution to visibility. Horizontal visibility is influenced by many factors, among which are meteorological conditions such as wind speed, relative humidity, precipitation. Others are the amount/quantity of pollutants and airborne particles (particulate matter), urbanization, industrialization and anthropogenic activities. Particulate matter vary greatly in shape, size and chemical composition, and are constituent of a variety of natural and man-made sources. Some haze-causing particles are directly emitted into the atmosphere during windblown dust, anthropogenic activities and soot. The finer particles, generally characterized as PM2.5 used in this review are believed to be primarily responsible for the scattering of visible light and a cause of deterioration of visibility.

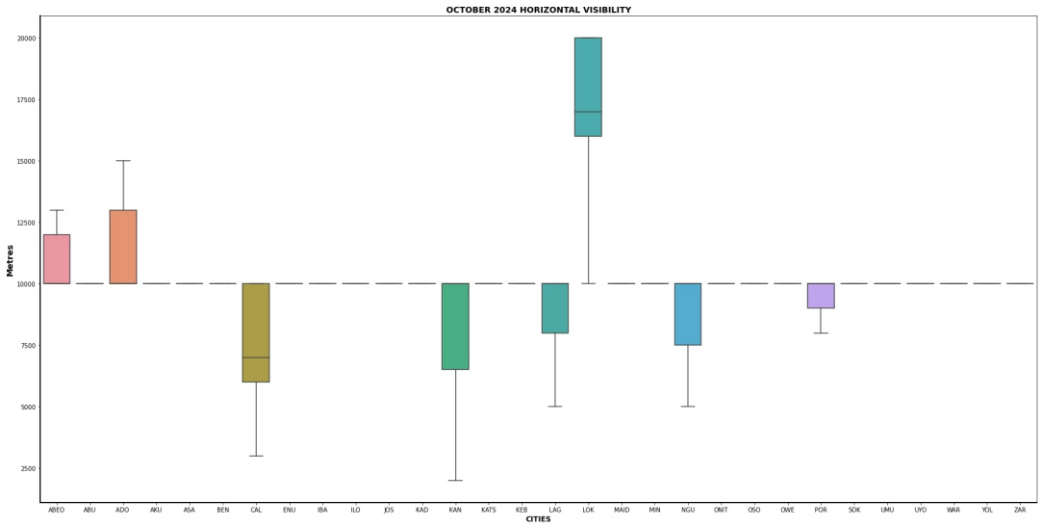


Figure 1.4: Mean Daily Horizontal Visibility in October 2024.

In October 2024, most cities in Nigeria reported daily horizontal visibility of 10Km while Abeokuta, Ado-Ekiti and Lokoja reported visibility above 10Km. The visibilities recorded during the period in Calabar, Kano, Lagos, Nguru and Port Harcourt were below 10km. The lowest horizontal visibility of 800m was observed over Nguru on the 25th, 26th, 27th and 29th October, 2024 while the highest value of 20Km was observed over Lokoja in Kogi State. From Table 4, it can be seen that no

city in Nigeria reported visibility values below 600m. Only Nguru therefore recorded visibilities between 601m to 1000m on 4 days of the month. The reduction in horizontal visibility over the Northern States was as a result of incursion of dust particles into the country from the source regions in Niger and Chad. However, the reduction in horizontal visibility to 2000m over Asaba in Delta State and Port Harcourt in Rivers was as a result of heavy precipitation from isolated thunderstorms that occurred during the morning hours of 3rd and 14th October, 2024

Table 4: Cities in Nigeria that Recorded Horizontal Visibility between 100 and 2000m in October, 2024.

VISIBILITY (m)	LOCATIONS	DATE	TOTAL NUMBER OF DAYS
100-200m	-	-	-
201-400m	-	-	-
401-600m	-	-	-
601-1000m	Nguru	25th,26th,27th,29th	4
1001-2000m	Asaba, Kano, Katsina, Port-Harcourt.	3rd,14th,25th,26th,27th,30th	6

The good horizontal visibility observed over most of the cities is attributed to convective activities and minimal presence of dust particles in the atmosphere in October 2024 across the country.

1.6: Nitrogen Dioxide (NO2) Concentration across Nigeria in October, 2024

The mean concentration of nitrogen dioxide (NO_2) pollution across Nigeria in October 2024 is shown in Figure 1.5. There were notable variations in NO_2 pollution levels across the country, with urban and industrialized cities of Kano, Lagos, Ogun and the FCT showing NO_2 concentrations levels exceeding 8 µg/m³. This could be attributed to industrial and vehicular emissions. Moderate level of NO_2 concentrations between 4.0 and 8.0 µg/m³ (below WHO standard limit) was observed over most parts of the country. The Eastern part of the country, extending to During the period under review, Niger, Kwara, Ekiti, Kogi, Benue, Enugu, Anambra, Cross River, Akwa-Ibom, Ebonyi, Abia, Plateau, Gombe, Nasarawa, Adamawa and Taraba states

recorded cleaner air with stable and lower NO_2 concentrations between 1.0 and 4.0 µg/m³, indicating reduced pollution by No_2.

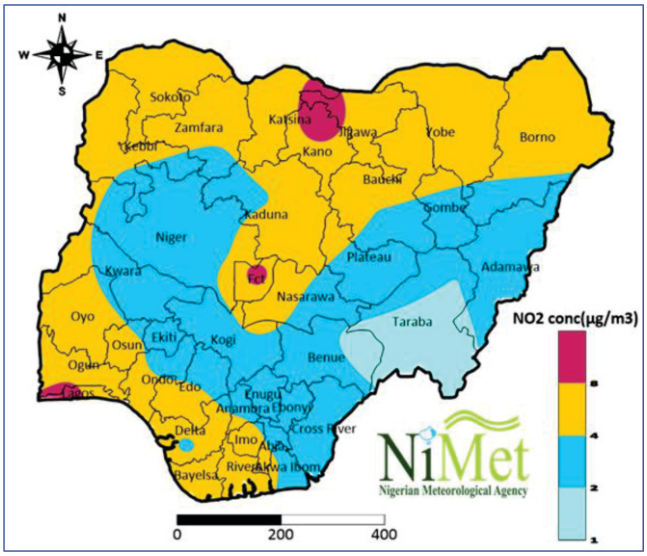


Figure 1.5: Mean Concentration of Nitrogen Dioxide (NO_2) across Nigeria in October 2024

1.7: Carbon Monoxide Concentration Over Nigerian Cities in October 2024

Carbon monoxide (CO) is an odourless, colourless and toxic gas that results from incomplete combustion of carbon-based compounds such as fossil fuels. It can kill rapidly even before it can be detected. At lower levels of exposure, CO causes mild effects that are often mistaken for the flu. These symptoms include headache, dizziness, disorientation, nausea and fatigue. Figure 1.6 shows that the observed monthly mean concentration of CO generally ranged between 200 and 620 ppbv (0.19 and 0.61 mg/m3) across the country. CO concentrations ranging from 300 to 400 ppbv (0.29 to 0.38 mg/m3) were observed in some parts of Sokoto, Zamfara, Plateau, Kebbi, Yobe, Gombe, Bayelsa, Ogun and Nasarawa, Benue, Enugu, Osun, Kwara, Taraba, Rivers, Ondo, Kogi, Lagos states. The highest concentrations of 600ppbv and above were observed over parts of Katsina and Jigawa states, while Edo, Delta, Bayelsa, Yobe, Akwa Ibom, Borno and Adamawa states recorded the lowest CO concentrations ranging from 250 to 300 ppbv (0.23 to 0.29 mg/m3). Southern Kaduna, Anambra, Ekiti, Bauchi, Jigawa, Sokoto and parts of Plateau states recorded CO concentrations between 400 and 500 ppbv (0.37 and 0.45 mg/m3). Parts of Katsina, Jigawa and Kano states recorded values ranging from 500 to 600 ppbv (0.47 to 0.58 mg/m3). The range of values 200 to 620ppbv (0.19 to 0.61

mg/m3) recorded across the country in October 2024 was generally below the WHO recommended guidelines of 4 mg/m3 in 24 hours and therefore posed no health risks to Nigerians during the month under review.

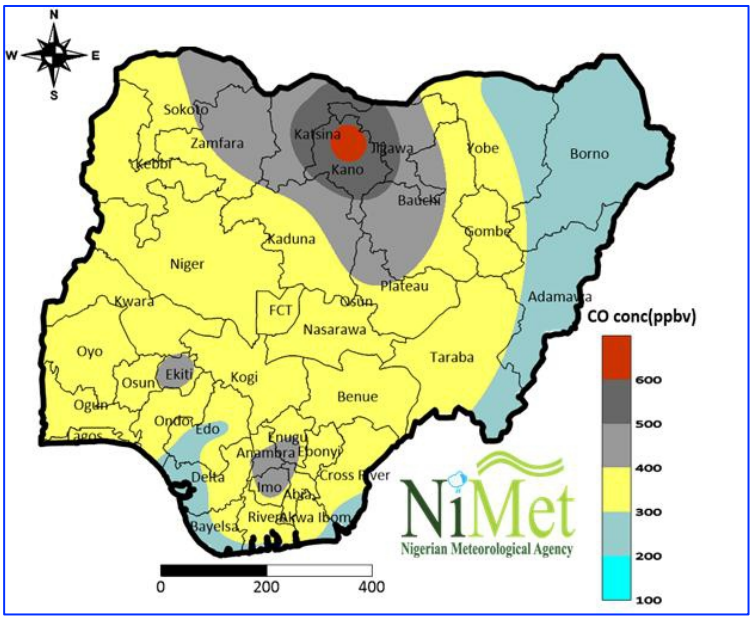


Figure 1.6: Mean Carbon Monoxide Concentration Over Nigerian Cities in October 2024

1.8: Mean Sulfur Dioxide (SO_2) Concentration across Nigeria in October 2024

Sulfur Dioxide, SO2, is a colorless gas that has a strong, pungent smell. It is derived from the burning of fossil fuels (coal and petroleum oil) and the smelting of mineral ores (aluminum, copper, zinc, lead and iron) that contain sulfur. Sulfur dioxide (SO2) concentrations in the atmosphere can range from milligrams per square meter (mg/m2) or micrograms per cubic meter (µg/m3) to parts per billion (ppb).

The mean atmospheric concentration of sulfur dioxide SO2 in October 2024 generally ranged from 1.3 to 127.0 (µg/m3) across the country. The lowest concentration of 1.3 to 19.5 (µg/m3) was observed in cities such as Ado-Ekiti, Sokoto, Kaduna, Katsina, Kano, Maiduguri, Jos, Abuja, Makurdi, Enugu Ibadan and parts of Benin. Cities with SO2 concentration between 20.1 and 37.1 (µg/m3) were Abakaliki, Asaba, Calabar, Ikeja, Owerri and Uyo in October 2024. Warri had the highest concentration of SO2, 127.0µg/m3. This can be attributed to the petroleum (Crude) mining/refining and Gas flaring activities around this city. Vehicular emission, urbanizations and other industrial activities are likely responsible for the observed higher concentration of SO2 in Port Harcourt (75.8µg/m3), Yenegoa (64.0µg/m3) and

Lokoja (47.5µg/m3) compared to other cities. The observed monthly mean SO2 concentrations for most of the cities across the country were generally lower than the WHO 2021 recommended standard of 40 µg/m^3 in 24 hours (Table 1)[3]

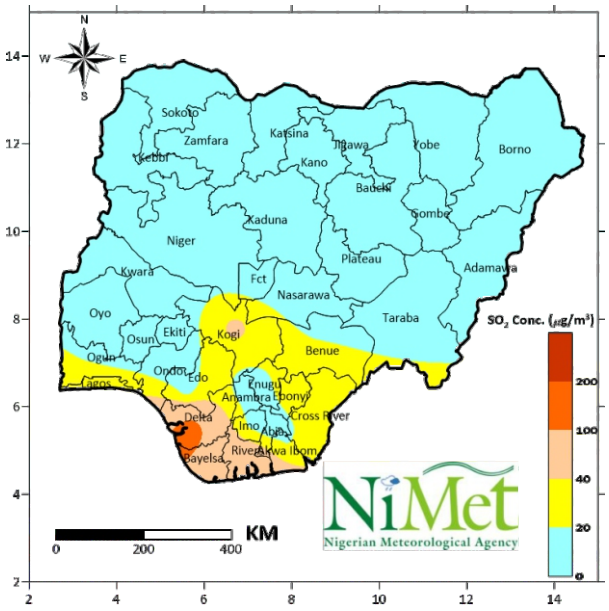


Figure 1.7: Mean Monthly Sulfur Dioxide (SO_2) Concentration across Nigeria in October 2024 **2024**

1.9 Air Quality Index across Nigeria in October, 2024

Figure 1.8 shows the mean Air quality index (AQI) across the country for October 2024. The FCT, Nasarawa, Taraba, Kwara, Kogi, Benue, Ebonyi, Plateau, Ekiti, Borno, Rivers, Delta, Akwa Ibom, and Cross River observed good air quality with AQI of 1-50 that was safe for outdoor activities across these States. The observed low AQI in these places indicates reduced emission from pollution sources. Moderate air quality (AQI 51-100) was observed over most of the northern states possibly due to the presence of dust, industrial emissions, and vehicular emissions. The levels of pollution did not pose significant threat to health of persons living in the region. However, parts of Katsina and Kano experienced air quality with AQI of 101-150 considered unhealthy for sensitive groups in October.

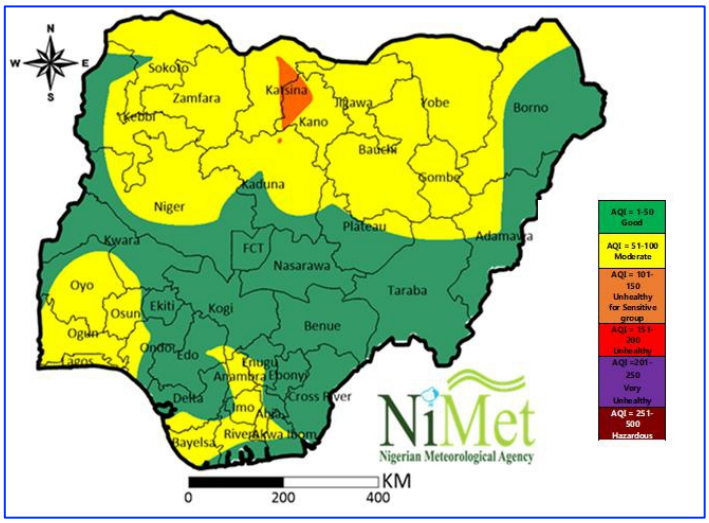


Figure 1.8 Mean AQI across Nigeria in October, 2024

[3] World Health Organization. Air Quality Guidelines - Update 2021)

CHAPTER TWO
NOVEMBER 2024 REVIEW

2.1 Position of the Inter-Tropical Discontinuity (ITD) and Rainfall across Nigeria in November 2024

The ITD moved slightly northwards from latitude 7°N in the first dekad to 7.1°N in the second dekad and then retreated to latitude 6.3°N during the 3rd dekad of the month. The mean position of the ITD was about 6.8°N. This ITD position was slightly more southerly than the climatological mean position of 9.6°N (Figure 2.1). The observed position in November was more southerly compared to the previous month's position of 14.1ON, as a result of rainfall cessation in the northern part of the country, and subsequent influx of Saharan dust into the northern and central states. These conditions were responsible for the reduced horizontal visibility and extreme weather (strong winds and violent thunderstorms) associated with cessation usually experienced during this period of the year. The coastal states of the country still recorded total precipitation amounts which ranged from 10 to 240mm during the month.

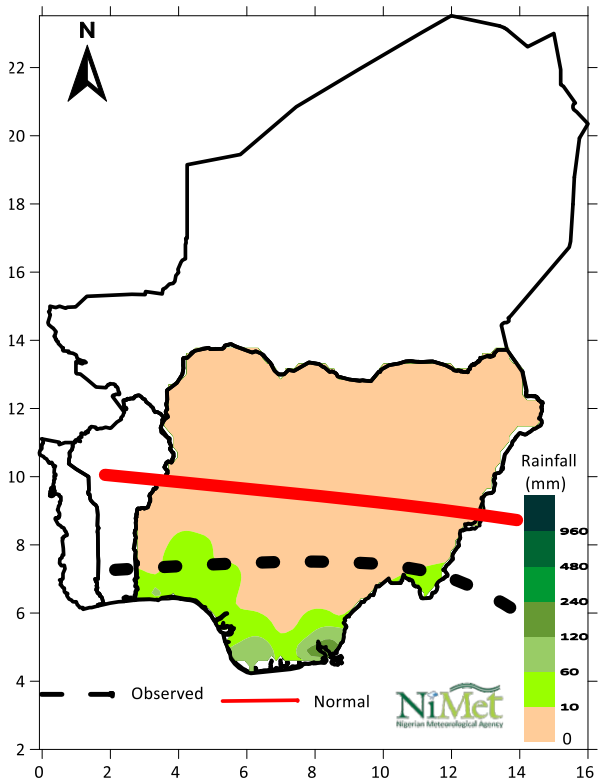


Figure. 2.1: Mean Position of ITD and Rainfall amounts across Nigeria in November 2024.

2.2 Mean Sea Level Pressure (Azores and St. Helena Highs) in November 2024

During the month, the pressure of Azores core fluctuated between 1014 and 1033 hPa, with an average centre value of 1018 hPa. The daily center values of St. Helena High ranged from 1016 to 1039 hPa, with an average of 1022 hPa in the month (Figure 2.2).

The 1015 hPa isobar had an average monthly position of 15.1°N approximately over Nigeria. Areas with pressure below 1012 hPa, which promote convection and monsoon weather systems, were mainly concentrated in the Southern states of the country.

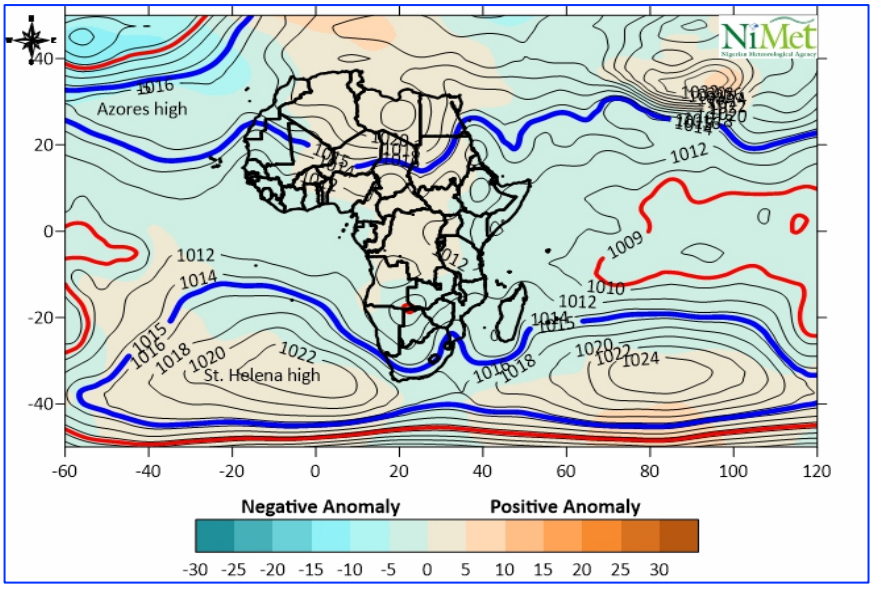


Figure 2.2 Mean Sea Level Pressure in November 2024

2.3 Winds

2.3.1 Winds at 925 hPa Level (900m above the ground level)

Dry and dust-laden northeasterly winds dominated the entire country with speeds of 5 to 30kts. These winds were associated with cyclonic vortices on 13th and 23rd days of the month around the northcentral, northeastern and southwestern parts of the country. Occasionally, maritime winds with speeds of 0 to 15kts associated with cyclonic vortices were observed over the southwest and northcentral states on some days of the month. Air quality deteriorated, due to the influx of dust into the country. The influx of dust also resulted in reduced horizontal visibility to as low as 400m over Jos and 600m over Nguru and Katsina, respectively during the month.

2.3.2 Winds at 850 hPa Level (1500m above the ground level)

Moisture laden winds with speeds up to 10kts were observed over the coastal region on some days of the month. A cyclonic vortex over the southwest and an anticyclone over northcentral Nigeria was also observed. The rest of the country was dominated by continental trade winds with speeds of 5 to 35kts. Cyclonic vortices were observed on the 26th and 27th in the southern parts of the country. The predominant continental winds were responsible for the dry, hazy harmattan weather observed over most parts of the country especially in the North during the month.

2.4: Particulate Matter (PM 2.5) Concentration

The analysis (Figure 2.3) shows that in November 2024, the mean concentration of PM2.5 in the atmosphere over most parts of the country was between 35 µg/m3 and 45 µg/m3. However, parts of Borno, Adamawa, Taraba, Ogun, Lagos, Ondo, Delta, Rivers, Akwa Ibom and Cross River states recorded mean PM2.5 concentration between 25 µg/m3 and 35 µg/m3 during the period. The lowest mean PM2.5 concentrations of 15 µg/m3 to 25 µg/m3 was observed over parts of Bayelsa, Rivers and Akwa Ibom states, while the highest mean PM2.5 concentration of 45 µg/m3 and above was recorded over the north including parts of Katsina, Kano, Jigawa, Bauchi, Kaduna, Niger, Osun, Kwara, Enugu, Anambra and Kogi states.

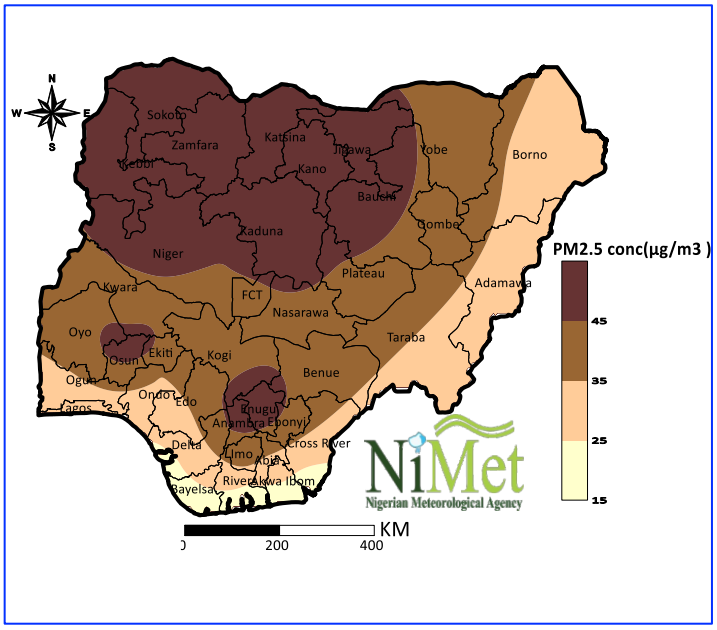


Figure 2.3: Mean Concentration of Particulate Matter ($PM_{2.5}$) Over Nigeria in November, 2024.

2.5: Horizontal Visibility in November, 2024

Low horizontal visibility was observed over Kano, Katsina, and Yobe which indicated an increase in pollutants (mostly particulate matter) concentration in the atmosphere. Figure 2.4 reveals that, the daily horizontal visibility in November ranged between 600m and 20000m (20km). The lowest horizontal visibility value of 600m was observed over parts of Katsina and Yobe on the 6th and 7th of November, while the highest visibility of 20Km was observed over part of Kogi on the 15th, 16th and 17th days of the month (Table 5).

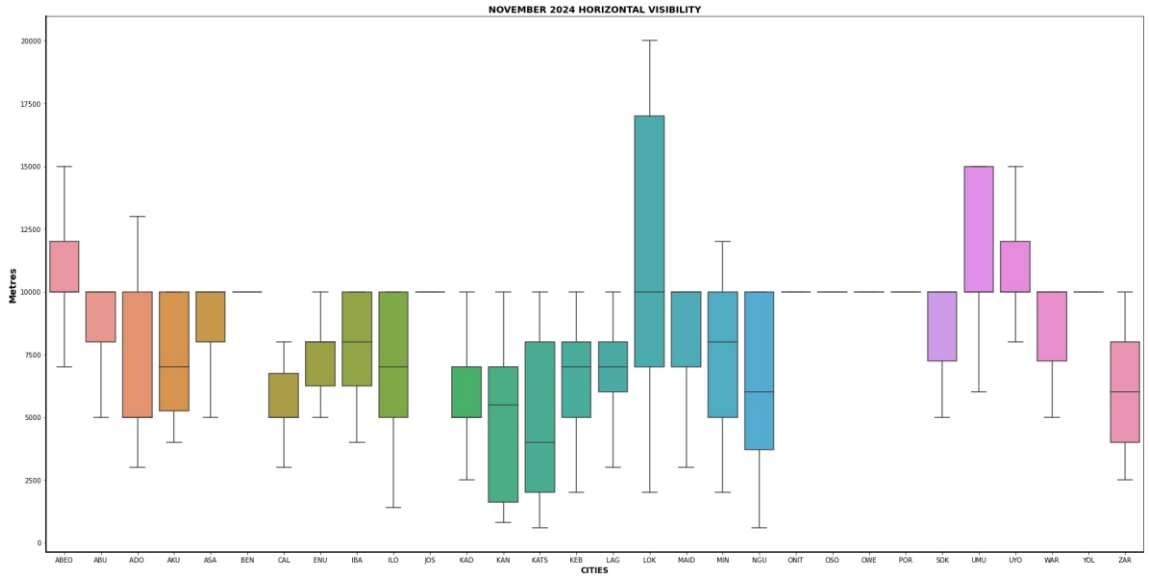


Figure 2.4: Mean Daily Horizontal Visibility in November 2024.

Most of the states recorded visibility of 10km and above, except Kano, Katsina and Yobe States that recorded visibility of 600m, 800m and 900m respectively (Table 5). The significant reduction in horizontal visibility to 1000m and 2000m in parts of Ilorin, Kaduna, Kebbi, Kogi, Niger and Rivers was mainly as a result of dust particles raised and transported from the source region into the country. This resulted in dust haze weather conditions generally reported across Nigeria in the month.

Table 5: Cities in Nigeria that Recorded Horizontal Visibility between 100 and 2000m in November, 2024.

VISIBILITY (m)	LOCATIONS	DATE	TOTAL NUMBER OF DAYS
100-200	-	-	-
201-400	-	-	-
401-600	Katsina, Nguru	6th,7th	2
601-1000	Kano, Katsina, Nguru, Sokoto.	3rd,6th,7th,8th,17th,19th 28th	7
1001-2000	Ilorin, Kaduna, Kano, Katsina, Kebbi,	2nd,3rd,7th,8th,17th,18th,19th,20th, 21st,25th,28th 29th	12
	Lokoja, Minna, Port Harcourt, Sokoto.		

2.6: Concentration of Nitrogen Dioxide (NO2) over Nigeria in November 2024

In November 2024, a significant increase in NO_2 concentration up to 8 µg/m³ and above was observed across Osun, Oyo, Ekiti, Ogun, Lagos States and the FCT (Figure 2.5).

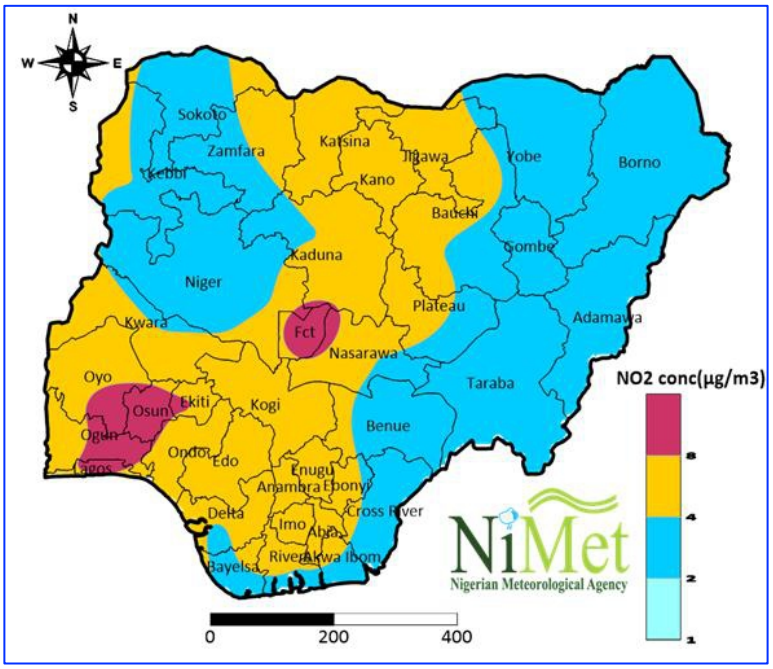


Figure 2.5: Mean Concentration of Nitrogen Dioxide (NO_2) over Nigeria in November 2024

Seasonal changes associated with strong wind patterns or decreased emissions may have contributed to improved NO_2 concentration levels over the Northern States of Kano and Katsina from previous month. Lower NO_2 concentrations between 4.0 and 8.0 µg/m^3 were also recorded over most of the western half of the country. Based on the observed NO_2 levels, it can be said that clean air prevailed in most parts of Borno, Yobe, Adamawa, Gombe, Benue, Cross River, Bayelsa, Rivers, Akwa Ibom, Plateau, and Taraba states where the lowest NO_2 concentration levels between 2.0 and 4.0 µg/m^3 was recorded. Generally a notable increase in NO_2 concentration patterns across Nigeria was observed in November 2024 compared to October. However, the observed levels were lower than the standard recommended limits

2.7: Concentration of Carbon Monoxide Over Nigerian Cities in November 2024

The observed monthly mean concentration of CO generally ranged between 100 and 600 ppbv (0.9 to 0.58 mg/m3) across the country (See Figure 2.6). The lowest concentration of 100 to 200 ppbv (0.9 to 0.23 mg/m3) was observed in parts of Yobe and Jigawa States, while the highest mean concentration of 500 to 600ppbv (0.45 to 0.58 mg/m3) was over parts of Enugu, Anambra, Osun, Kano, Katsina Nasarawa and Benue States. CO mean concentration between 300 and 400 ppbv (0.33 to 0.39 mg/m3) were recorded over Kaduna, Niger, Osun, and parts of Lagos, Delta, Rivers, Cross River, Taraba, Nasarawa, Katsina, Jigawa, Bauchi and Taraba states

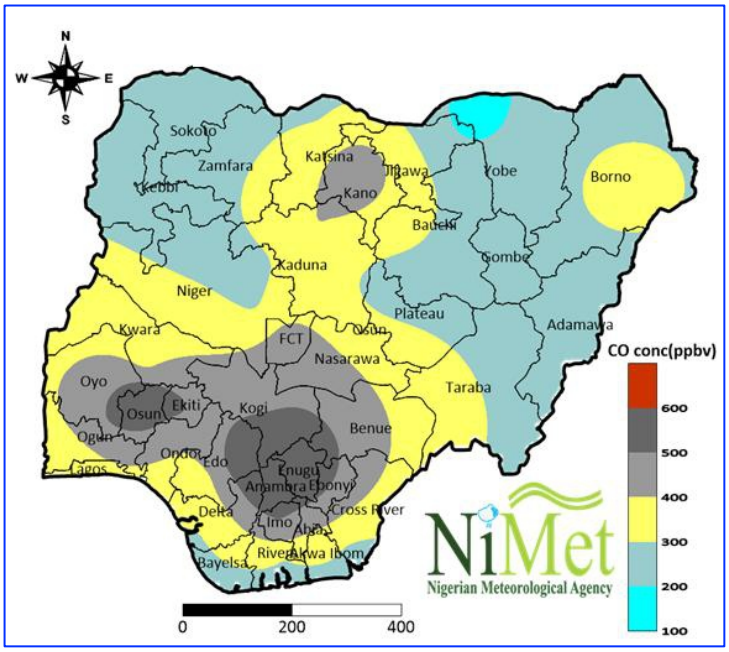


Figure 2.6: Mean Carbon Monoxide Concentration Over Nigerian Cities in November 2024

The observed monthly mean concentrations of CO across Nigeria were generally lower than the WHO 2021 recommended standard of 4 mg/m3 in 24 hours (Table 1)

2.8: Concentration of Sulfur Dioxide (SO_2) Across Nigeria in November 2024

The observed monthly mean concentration of SO2 generally ranged from 2.1 to 406.9 (µg/m3) across the country as shown in Figure 2.7. The lowest concentrations of 2.1 to 20.0 (µg/m3) were observed in cities such as Abuja, Akure, Sokoto, Minna, Ibadan, Oshogbo, Nguru, Kebbi, Kano, Kaduna, Jos, Ilorin, Zaria, Maiduguri, Gusau, Ibadan and Katsina.

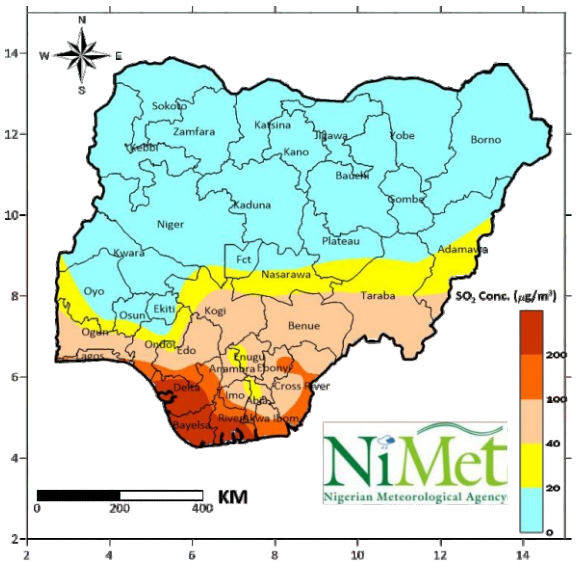


Figure 2.7: Mean Concentration of Sulfur Dioxide (SO_2) in November 2024

Part of Adamawa, Taraba, Enugu, Nasarawa, Ondo and Oyo states had SO2 concentrations ranging from 20.0 to 40.0 (µg/m3). Southern Taraba state, Enugu, Benue, Kogi, Ebonyi, Anambra, Imo, Abia, Delta, and other coastal states all recorded concentrations between 40µg/m^3 and 406. The highest SO2 concentrations of 218.5µg/m3, 247.9 µg/m3 and 406.9µg/m3 were observed over Yenegoa, Port Harcourt, and Warri respectively. The observed monthly mean concentration across most states in the country was generally lower than the World Health Organization (WHO) recommended standard except for most of the southern states where the concentrations were above 40µg/m^3 observed to be higher than the WHO standard limit of 40µg/m^3 in 24 hours.

2.9: Air Quality Index across Nigeria in November, 2024

The analysis of Air Quality Index showed that in November 2024, the quality of air deteriorated across the country compared to October. This could be attributed to the intensification of drier and hazy weather across the country due to the incursion of dry and dusty north-easterly winds from dust source regions in Niger and Chad. The northern states of Sokoto, Katsina, Zamfara, Kebbi, Jigawa, Bauchi, Kaduna, Kano, Niger, and Kwara, as well as the FCT observed Air Quality Index ranging from 101 to 150, considered unhealthy for people allergic to air pollutants (Figure 2.5)

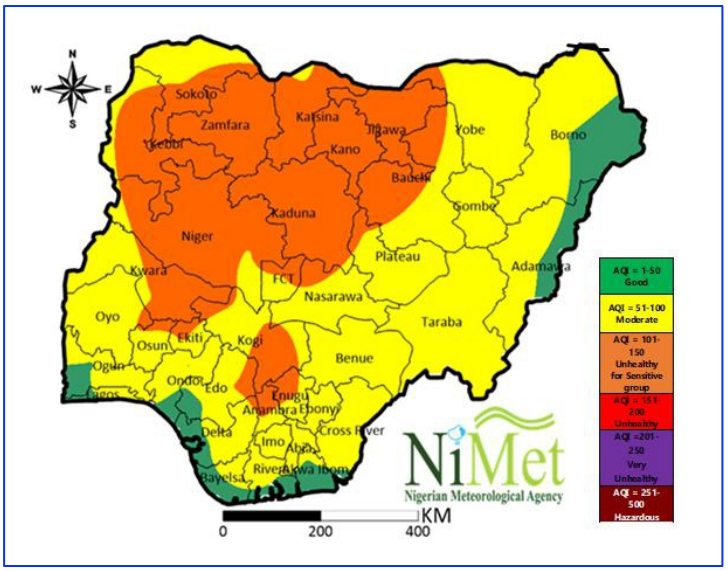


Figure 2.8: Mean AQI across Nigeria in November, 2024

During the period under review, Oyo, Osun, Ekiti, Benue, Ogun, Lagos, Ondo, Edo, Delta, Imo, Abia, Rivers, Benue, Taraba, Gombe, Yobe, Nasarawa, Plateau, Taraba, Ebonyi, Cross River and Anambra states observed moderate air quality index between 51 and 100 which posed no significant threat to the health of persons living in these states. In some parts of Lagos, Bayelsa, Akwa Ibom, Borno, and Adamawa states, the air quality was good, with Air Quality Index between 1 and 50 in November 2024. Parts of Kwara, Ekiti, Kogi, Enugu states and the FCT also experienced air quality that was considered unhealthy for sensitive persons.

CHAPTER THREE
December 2024 Review

3.1 Position of the Intertropical Discontinuity (ITD) and Rainfall Across Nigeria in December 2024.

Saharan dust is majorly distributed over the country seasonally by the action of northeasterly trade winds. The movement of these winds is obvious over the country during the dry season, and aerosols especially PM2.5, being environmental pollutants, are dispersed over the entire country at this time of the year. Also, the position, structure, and oscillation of the ITD play an important role in determining the characteristics of ocean-atmosphere and land-atmosphere interactions on a local scale. The ITD moved southwards from latitude 6.0°N in the 1st dekad to 5.5°N in the 2nd dekad, and thereafter moved slightly northward to latitude 5.6°N during the 3rd dekad of the month. It maintained a monthly mean position of 5.7°N. Comparatively, the mean position of 5.7°N was more southerly than that of November 2024 (6.8°N) and a great departure from the climatological mean position of latitude 11.5°N shown in Figure 3.1. These changes triggered dry, dusty and harsh atmospheric conditions across the country except the coastal regions which still experienced some rainfall.

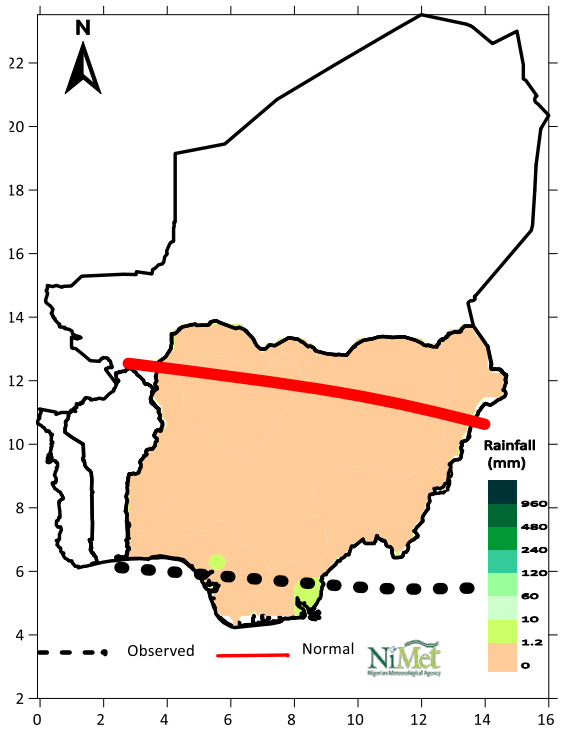


Figure 3.1: Mean ITD Position and Rainfall Amounts across Nigeria in December 2024.

3.2 Mean Sea Level Pressure (Azores and St. Helena Highs), December 2024

In December 2024, the daily center value of Azores High fluctuated between 1018 and 1034 hPa with a monthly mean of 1028 hPa. Meanwhile, the St. Helena High pressure fluctuated between 1016 and 1030 hPa, with a mean value of 1020 hPa during the period (See Figure 3.2).

The 1015 hPa isobar maintained a mean position of about 20 degrees North in the northern hemisphere and 14 degrees North over Nigeria. Only few coastal states with pressure below 1012 hPa recorded rainfall in the southern parts of the country.

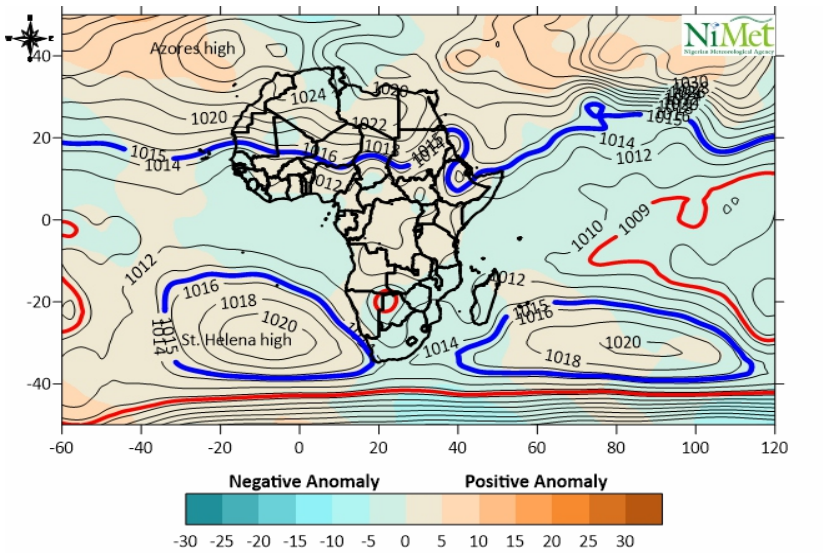


Figure 3.2: Mean Sea Level Pressure in December 2024

3.3 Winds over Nigeria in December 2024

3.3.1 Winds at 925 hPa Level (900m above the ground level)

At this height, dry and dusty northeasterly winds dominated the entire country with speeds of 5 to 35kts in the first half (1st to 16th) of December 2024. Southwesterly winds with speeds between 0 and 10knots were observed occasionally over the coastal states on some days. These were accompanied by anticyclonic vortex in the Northcentral parts of the country. The entire country was overlain by Northeasterly trade winds carrying dust from the Sahara, thereby establishing the harmattan season with its high concentration of particulate matter (mostly PM2.5). The lowest horizontal visibility were recorded over Nguru (200m), Kebbi (400m) and Maiduguri (500m). Air Quality transited from `unhealthy` level to `very unhealthy`, with hazardous instances recorded on certain days of the month mostly in the Northeastern and Northwestern parts of the country as reflected in the reduction in horizontal visibility observed over these regions.

3.3.2 Winds at 850 hPa Level (1500m above the ground level)

In December 2024, the Northeasterly winds with speeds varying from 5 to 35kts were predominant at the 850hPa atmospheric level over the country. Anticyclonic vortices were observed on the 7th and 25th of the month in the Northcentral part of the country. These conditions enhanced the dispersion of dust and particulate matter (PM2.5) into the upper atmosphere and suppressed rainfall.

3.4 Particulate Matter ($PM_{2.5}$) Concentration in December, 2024.

As depicted in Figure 3.3, there was high concentration of $PM_{2.5}$ in the atmosphere across the country in December 2024. Mean concentration was observed to be 45 µg/m3 and higher across the country. However the Southern states of Bayelsa, Rivers, Akwa Ibom and Cross River recorded mean $PM_{2.5}$ concentration of 35 µg/m3 to 45 µg/m3. This was the highest concentration of $PM_{2.5}$ when compared to October and November 2024.

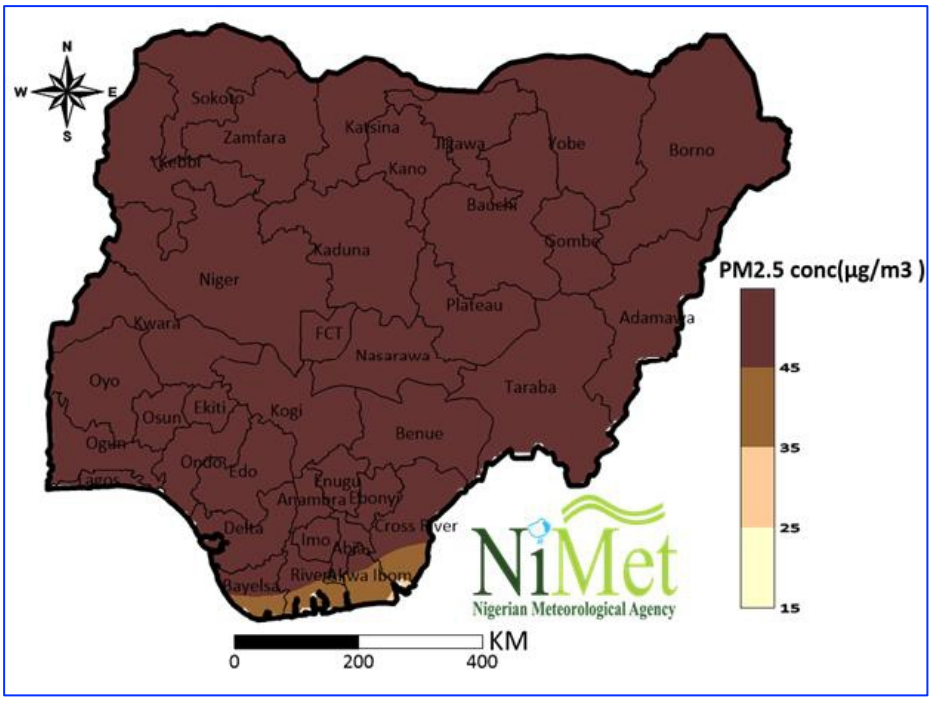


Figure 3.3: Mean Concentration of Particulate Matter ($PM_{2.5}$) in the Atmosphere over Nigeria December, 2024

3.5 Horizontal Visibility in December 2024

Figure 3.4 depicts a distinctive variation in daily horizontal visibility ranged between 200m and 12000m (12km) across Nigerian cities in December 2024. As expected, December recorded more number of days with reduced horizontal visibility values between 200m to 2000m over most of the cities in northern Nigeria when compared with October and November. This can be attributed to the already established dry season over the North, coupled with wind properties and the amount of dust particles raised and transported from the source region (Sahara desert) into the country. Horizontal visibility between 200m and 1000m due to thick dust haze were observed over Adamawa, Borno, Kaduna, and Kano, Katsina, Kebbi and Yobe states.

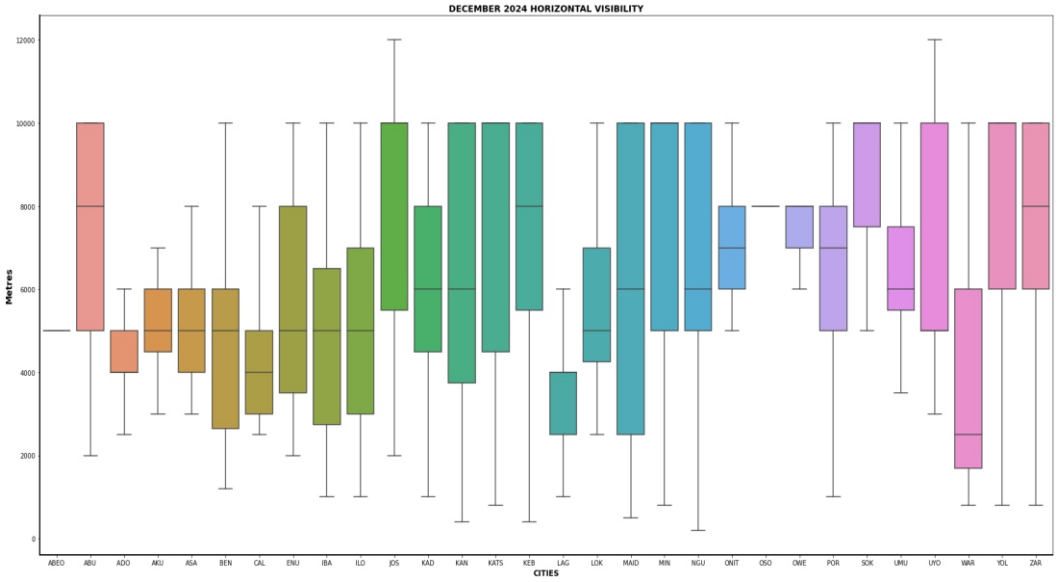


Figure 3.4: Mean Daily Horizontal Visibility Over Nigerian Cities in December 2024.

Some cities in the central and southern Nigeria including Abuja, Ilorin, Jos, Minna, Ado-Ekiti, Akure, Benin, Enugu, Ibadan, Lagos, Port-Harcourt and Warri also observed visibilities between 200m to 2000m on some days of the month. Table 6 shows the date(s) and total number of days for cities that observed horizontal visibility between 100m to 2000m in December 2024.

TABLE 6: Cities in Nigeria where with Horizontal Visibility between 100 and 2000 Were Recorded in December, 2024.

VISIBILITY(m)	LOCATIONS	DATE	TOTAL NUMBER OF DAYS
100-200	Nguru	15th	1
201-400	Kano, Kebbi, Nguru	15th,20th	2
401-600	Maiduguri, Nguru.	20th,21st,28th	3
601-1000	Ibadan, Ilorin, Kaduna, Kano, Katsina, Kebbi, Lagos, Maiduguri, Minna, Nguru, Port-Harcourt, Sokoto, Warri, Yola, Zaria.	15th,16th,17th,18th,20th,21st,22nd,23rd,28th,29th 31st	11
1001-2000	Abuja, Ado-Ekiti, Akure, Benin, Enugu, Ibadan, Ilorin, Jos, Kaduna, Kano, Katsina, Kebbi, Lagos, Maiduguri, Nguru, Minna, Port-Harcourt, Sokoto, Umuahia, Warri, Zaria.	4th,8th,9th,14th,15th,16th,17th,18th,21st,22nd,23rd,24th,25th,29th,30th,31st	16

3.6: Concentration of Nitrogen Dioxide ($NO_{2)}$ over Nigeria in December 2024

The distribution of NO_2 concentrations in the atmosphere over Nigeria in December 2024 is shown in Figure 3.5. The analysis reveals that the NO_2 concentrations exceeding 8.0 µg/m³ that were recorded in Ogun, Osun and Lagos states in November 2024 had persisted into December and extended to Ondo, Ekiti, Edo, Kwara, Kogi, Anambra and Enugu states. There was significant increase in the level of NO_2 concentration in the southwestern and the central states, including the FCT.

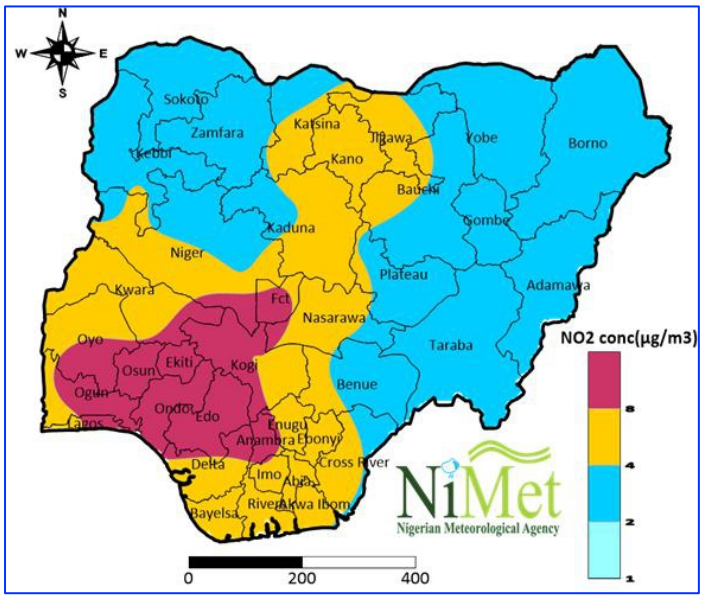


Figure 3.5: Mean Concentration of Nitrogen Dioxide (NO_2) over Nigeria in December 2024

Moderate NO_2 concentrations between 4.0 and 8.0 µg/m³ were recorded over Kaduna, Kano, Bauchi, Nasarawa, Katsina, and Niger states; extending to the south-south region as well as parts of Kwara, Oyo and Ogun states. The lowest NO_2 concentration between 2.0 and 4.0 µg/m³ were observed over parts of Borno, Gombe, Bauchi, Plateau, Sokoto, Kebbi, Zamfara, Yobe, Taraba, Adamawa, Cross River and Benue states. The FCT and some parts of Lagos, Ogun, Osun, Ekiti, Ondo, Edo, and Kwara, Kogi, Anambra and Enugu states also experienced high concentrations of NO_2 from a likely mixture of urban and anthropogenic activities.

3.7 Carbon Monoxide Concentration Over Nigeria in December 2024

The observed monthly mean concentration of CO in December 2024 generally ranged from 100 to 650 ppbv (0.9 to 0.60 mg/m3) across the country (Figure 3.6). The lowest concentrations of 100 to 200 ppbv (0.9 to 0.23 mg/m3) was observed in some parts of Borno State, while the highest range of 600 to 650ppbv (0.50 to 0.55 mg/m3) was over parts of Edo, Osun and Enugu States.

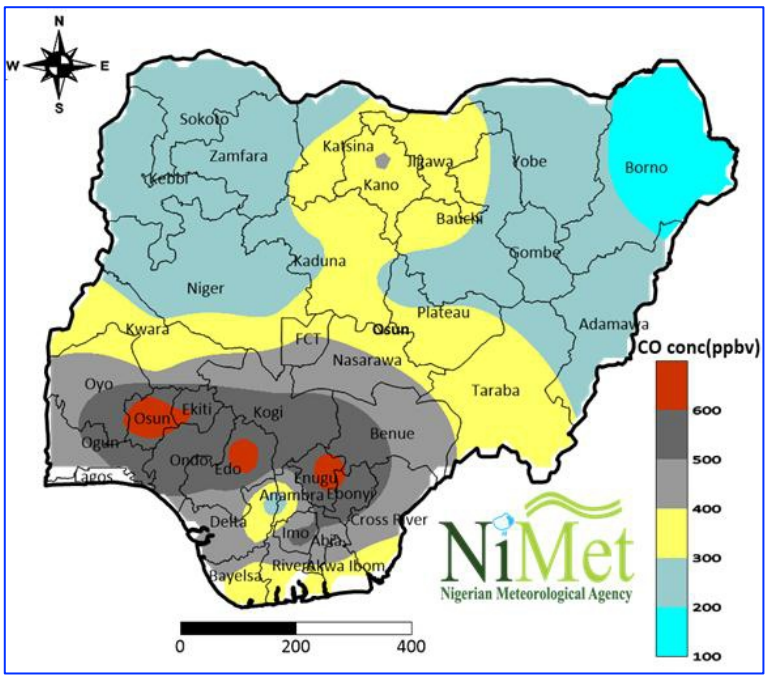


Figure 3.6: Mean Carbon Monoxide Concentration Over Nigerian Cities in December 2024

CO concentration of 200 to 300 ppbv was recorded over parts of Anambra, Adamawa,Yobe,Gombe,Niger, Kaduna, Zamfra, Kebbi and Sokoto States, while concentrations between 300 and 400 ppbv (0.33 to 0.39 mg/m3) was recorded over Osun, Plateau, Adamawa, Taraba, Ibom,Bayelsa,River, Anambra, Bauchi, Jigawa, Kano ,Kastina, parts of Sokoto and Kaduna States. The observed monthly mean CO concentration across Nigeria was lower than the WHO 2021 recommended standard of 4 mg/m3 in 24 hours.

3.8 Concentration of Sulfur Dioxide (SO_2) Across Nigeria in December 2024

The mean SO_2 concentration across Nigeria in December 2024 ranged from 6.6 to 824.9 (µg/m3). The north and central regions of the country observed SO_2 concentrations from 6.6 to 40 (µg/m3). Adamawa, Taraba, Benue, Kogi, Nasarawa, Enugu, Anambra, Imo, Ogun and part of Oyo states recorded concentrations between 40 and 200 (µg/m3), See figure 3.7. The coastal cities Asaba, Calabar, Ikeja, Port Harcourt, Warri and Yenegoa recorded the highest concentrations between 203.8 and 824.9 (µg/m3). The observed concentrations of SO2 in December were generally below the WHO recommended Standard threshold of 40 µg/m³ in 24-hours over the North and north-central states but higher than the standard threshold over the southern states.

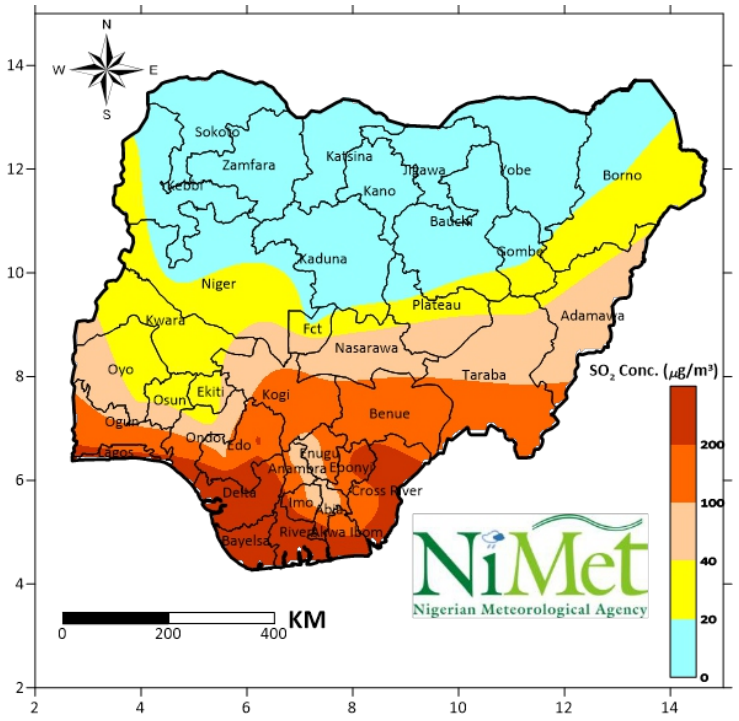


Figure 3.7 Sulfur Dioxide (SO_2) Concentration Across Nigeria in December 2024

3.9 Air Quality Index across Nigeria in December 2024

There was significant increase in air quality index across Nigeria in December 2024. Unhealthy air quality was recorded over Sokoto, Zamfara, Kebbi, Kano, Kaduna, Niger, Oyo, Ekiti, Kwara, Katsina, Kogi, Jigawa, Enugu, and the FCT Abuja.

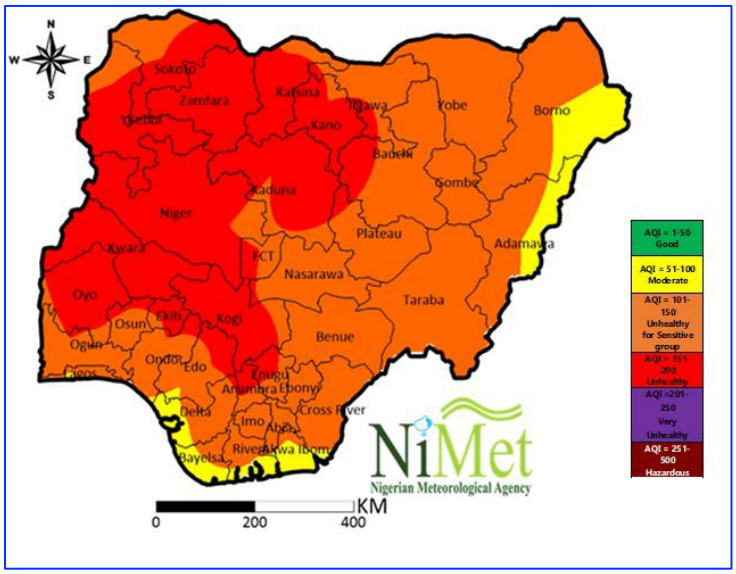


Figure 3.8 Mean AQI across Nigeria in December, 2024

Nasarawa, Osun, Ogun, Borno, Lagos, Ondo, Delta, Imo, Edo, Abia, Anambra, Ebonyi, Benue, Taraba, Bauchi, Yobe, Plateau and Rivers states, as well as the FCT all observed air quality that was unhealthy for sensitive group (children, elderly, and people with respiratory conditions) with AQI of 101-150. Parts of Akwa Ibom, Bayelsa, Rivers, Cross-River, Adamawa and Borno states experienced moderate air quality index (51-100) that were safe for outdoor activities.

CHAPTER FOUR

Quarterly Trends: October, November, December (OND)

4.1 Observed ITD Positions in October - December 2024

During the fourth quarter of 2024 (October, November and December), the ITD steadily retreated from a position of latitude 16.3°N in the 1st dekad of October to latitude 5.8°N by the 3rd dekad of December (Figure 4.1). It maintained mean monthly positions of 14.3°N, 6.8°N and 5.7°N in October, November and December, respectively with the peak attained in October and the lowest position reached in December. The rapid drop from latitude 16.3°N to 5.8°N during the fourth quarter is consistent with the well-known pattern of faster southward migration of the ITD than the northward movement. The ITD was observed to be northwards of the climatological mean position only during the 1st and 2nd dekads of October after which it maintained mean positions southward of the climatological mean position from the 3rd dekad of October to December. The unusually southwards-than-normal position in November and December resulted in below normal rainfall over the coastal states and continued incursion of dust into the country thereby reducing horizontal visibility and negatively impacting air quality during the period.

Northeasterly winds with speeds ranging from 5 to 35 kts at both 925hPa and 850hPa supported the dust/ PM 2.5 dispersion and propagation during the period.

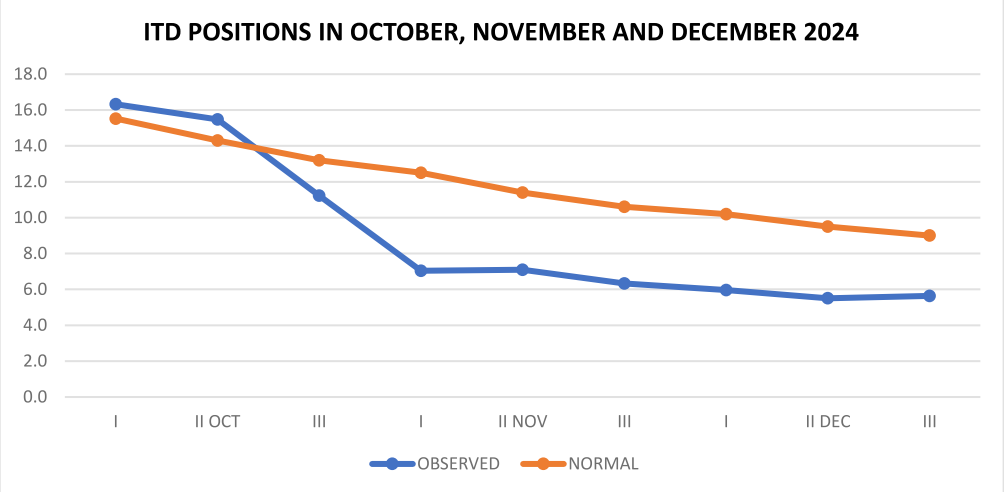


Figure. 4.1: Fourth Quarter 2024 ITD Positions

4.2: Daily Mean Concentration of Particulate Matter ($PM_{2.5}$) over cities in Northern Nigeria from October to December 2024

During the fourth quarter, consistent increase in daily mean concentration of $PM_{2.5}$ was observed over the North (Figure 4.2). This increase is not unusual and can be attributed to dust influx into the country from established dust source regions. This process generally increases the concentration of dust particles in the atmosphere over the entire country. The northern states experienced daily mean PM2.5 concentrantion between 16 µg/m3 and 202 µg/m3 with the lowest concentration recorded in October while the highest over the entire region was recorded in December.

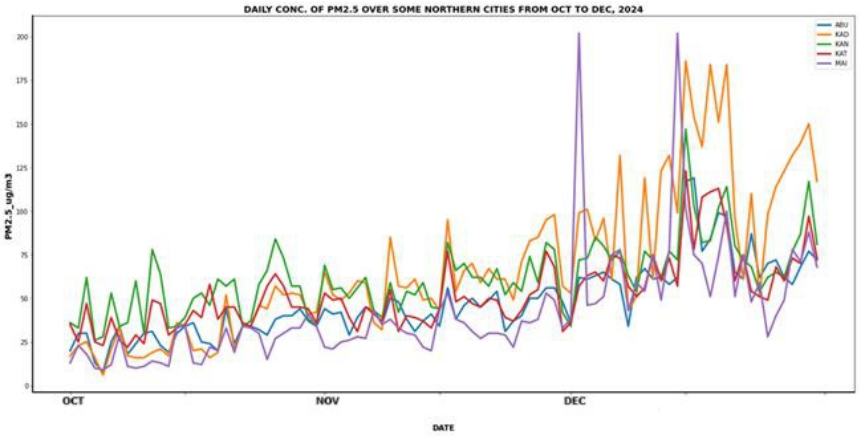


Figure 4.2: **Daily mean concentration of particulate matter (PM2.5) over cities in Northern Nigeria from October to December 2024**

The lowest daily $PM_{2.5}$ mean concentration of 16 µg/m3 was observed over Kaduna on the 5th of October, 2024 while the highest concentration of 202 µg/m3 was recorded over Maiduguri on the 2nd of December, 2024. The daily mean values recorded over most northern cities were above WHO threshold of 15 µg/m3 in 24 hours, and as such people in these areas were exposed to high health risks associated with high $PM_{2.5}$ concentration.

4.3: Daily Mean Concentration of Particulate Matter ($PM_{2.5}$) Over Cities in Southern Nigeria from October to December 2024

Similar to the trend observed in the North, concentration of $PM_{2.5}$ steadily increased over the southern states from October to December and reached the peak levels in December (Figure 4.3). The minimum daily $PM_{2.5}$ concentration of 4 µg/m3 was observed over Akure on the 5th of October, 2024 and the maximum daily concentration of 126 µg/m3 was recorded over Enugu on the 23rd of December, 2024.

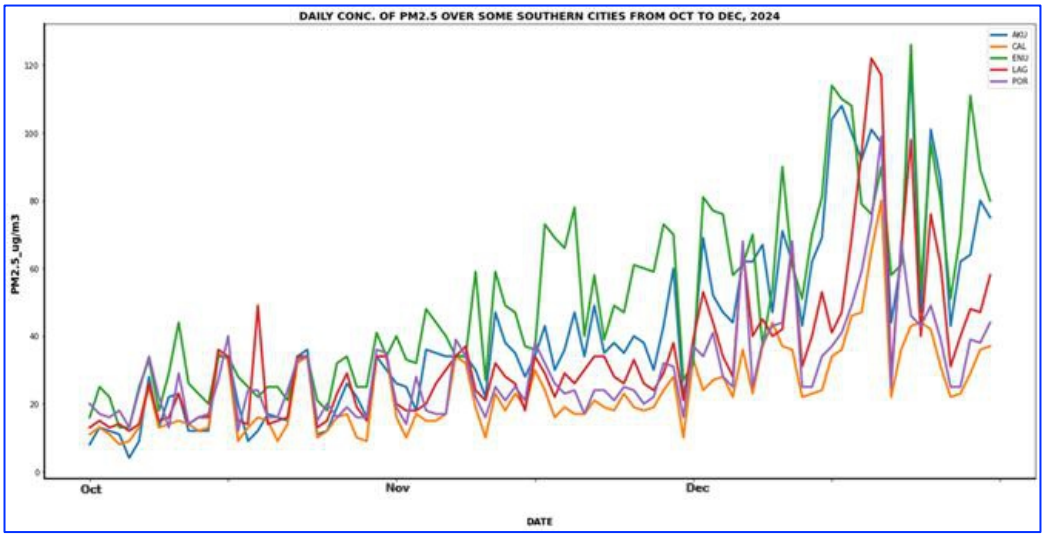


Figure 4.3: Daily Mean Concentration of Particulate Matter (PM2.5) Over Cities in Southern Nigeria in the Last Quarter of 2024

The high concentration of PM2.5 during the quarter, especially in December was as a result of the high influx of Saharan dust into the atmosphere over the region.

4.4:Monthly Mean $PM_{2.5}$ Concentration over Nigeria from October to December 2024

The analysis of the average PM2.5 concentration over the country for the last quarter of 2024 is shown in Figure 4.4. It can be observed that all the cities recorded the highest average PM2.5 concentration in December and the lowest in October. PM2.5 concentration in November were higher than levels recorded in October but lower than December observed levels.

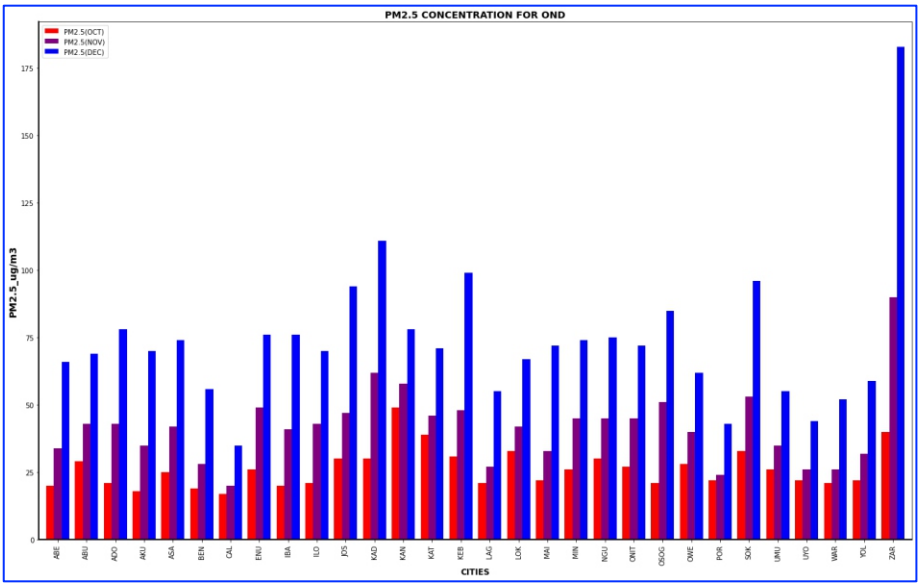
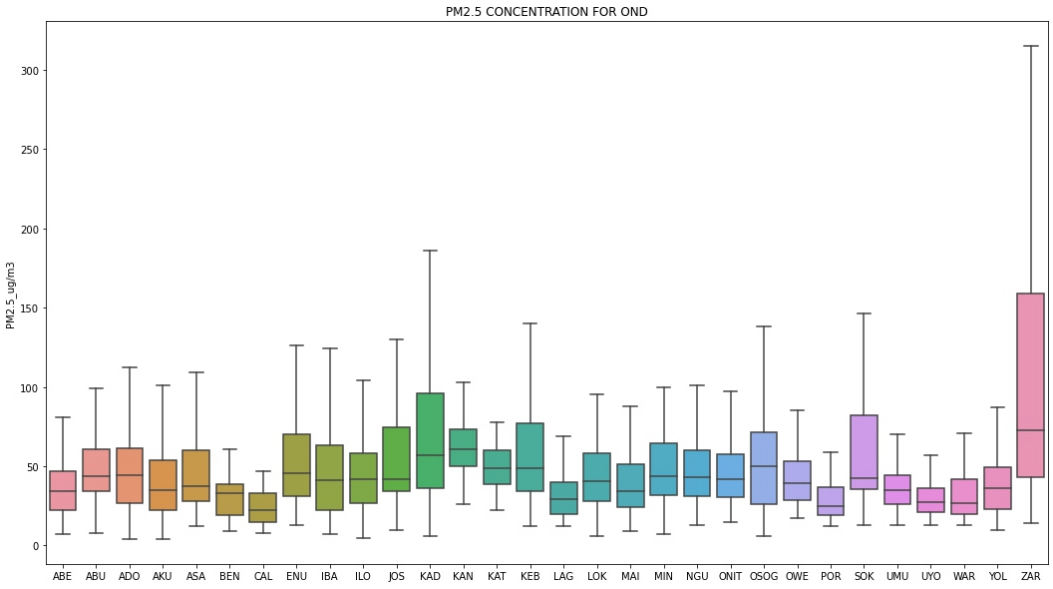


Figure 4.4: Mean $PM_{2.5}$ concentration over Nigeria for last quarter of 2024

The maximum average $PM_{2.5}$ concentration of 104 µg/m3 was observed in Zaria while the minimum average concentration of 35 µg/m3 was recorded in Calabar. The three months average corresponding to the seasonal average (Oct-Nov-Dec) concentration of PM2.5 across the country during the fourth quarter of the year were observed to be higher than the WMO threshold of 15µg/m3 in 24 hours. The highest seasonal mean PM2.5 concentration of 315µg/m3 was recorded in Zaria, while Ado Ekiti and Akure observed the lowest seasonal mean concentration of 4µg/m3 (See Figure 4.5)



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Mean Daily Particulate Matter ($PM_{2.5}$) Concentration across the Country from October to December 2024

The Maximum, Minimum and Mean Concentration of Particulate Matter PM2.5 (µg/m3) Over Nigerian Cities from October to December 2024 is shown on Table 7.

Table 7: Maximum, Minimum and Mean Concentration of Particulate Matter $PM_{2.5}$ ($\mu g/m^3$) for last Quarter of 2024

	OCTOBER			NOVEMBER			DECEMBER		
CITY	Maximum	Minimum	Mean	Maximum	Minimum	Mean	Maximum	Minimum	Mean
ABEOKUTA	39	7	20	61	19	34	124	31	67
ABUJA	44	8	29	56	29	43	119	34	70
ADO EKITI	46	4	21	65	21	43	133	32	78
AKURE	36	4	18	60	18	35	120	36	71
ASABA	47	12	25	79	23	43	124	36	74
BENIN	36	9	19	51	17	28	117	31	57
CALABAR	35	8	17	34	10	20	80	22	36
ENUGU	44	13	26	78	27	50	126	32	76
IBADAN	38	7	20	70	22	41	124	43	77
ILORIN	41	5	21	60	24	43	120	38	71
JOS	42	10	30	77	29	47	151	36	94
KADUNA	57	6	30	98	32	63	186	43	111
KANO	84	26	49	82	39	58	147	34	79
KATSINA	64	22	39	77	31	47	123	36	72
KEBBI	69	12	32	106	30	49	165	42	99
LAGOS	49	12	21	38	18	27	122	28	56
LOKOJA	37	6	22	55	26	42	105	38	67
MAIDUGURI	41	9	22	53	20	33	202	28	74
MINNA	44	7	26	67	22	45	135	40	75
NGURU	50	13	30	86	24	46	145	43	76
ONITSHA	49	15	27	80	26	45	118	38	73
OSOGBO	36	6	21	81	21	51	147	38	85
OWERRI	45	17	28	66	24	40	114	37	63
PORT HARCOURT	40	12	22	39	14	24	99	25	44
SOKOTO	54	13	33	94	17	49	171	37	96
UMUAHIA	39	13	26	58	21	35	94	33	55
UYO	39	13	22	38	14	26	95	27	45
WARRI	44	13	22	44	19	26	140	27	54
YOLA	40	10	22	48	22	33	104	43	60
ZARIA	76	14	41	165	39	90	315	55	183

4.5 Mean AQI across Nigeria from October to December 2024

Moderate AQI of 51 to 100 dominated most of the country during the period (Figure 4.6). However, AQI ranging from 101 to 150 (which is considered unhealthy for sensitive persons) was recorded in Sokoto, Zamfara, Kebbi, Niger, Kwara, Kaduna, Katsina, Kano, Jigawa, Bauchi, parts Kogi and Enugu states. The prolonged exposure of persons living in these places to elevated AQI for three months is a significant health hazard to the public.

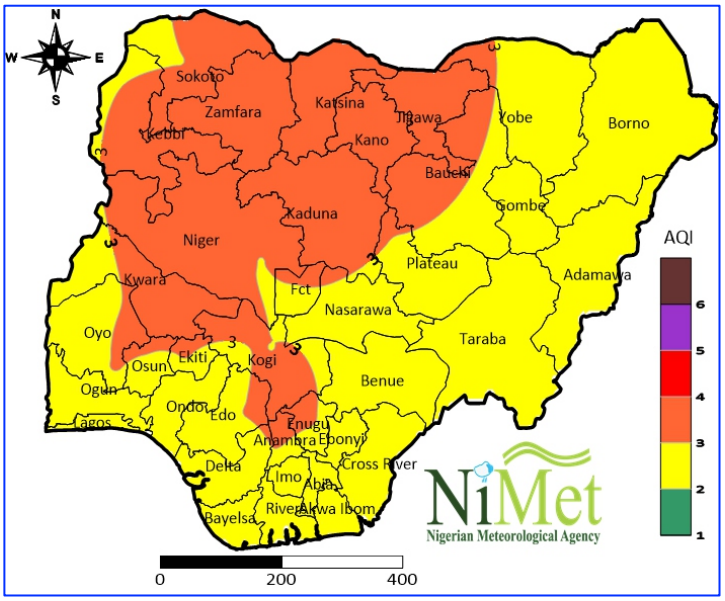

Figure 4.6 Mean AQI across Nigeria in the Last Quarter of 2024

4.6: Spatial Distribution of Mean Nitrogen Dioxide ($NO_{2)}$ Concentration over Nigeria from October to December 2024

NO_2 emission across Nigeria during the last quarter of the year showed significant increase in mean concentration across states of Lagos, Ogun, Osun, and the FCT. These states, usually characterized by high population densities, industrialization, and heavy vehicular movements contributed to elevated NO_2 emissions sources exceeding 8.0 $\mu g/m^3$.

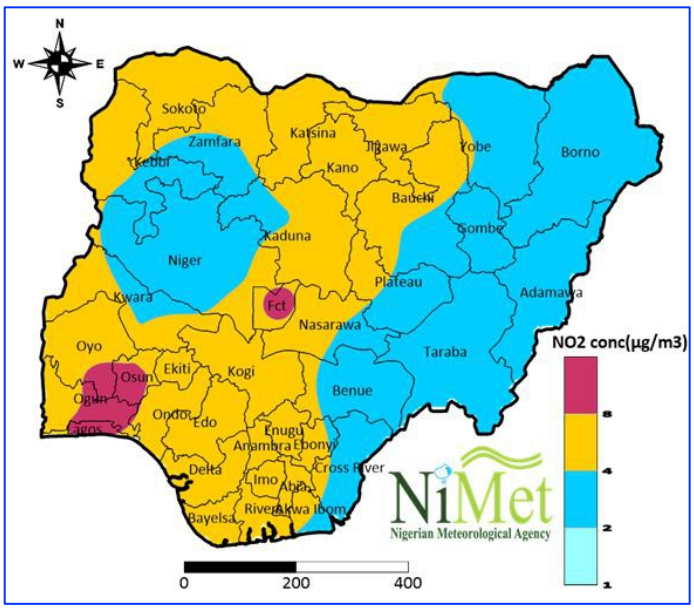

Figure 4.7: Mean Concentration of Nitrogen Dioxide (NO_2) over Nigeria in the Last Quarter of 2024

The lowest NO_2 concentrations between 1.0 and 4.0 µg/m³ were recorded in the Northeastern states of Borno, Yobe, Gombe, Adamawa, Taraba states, as well as parts of Niger, Benue and Plateau states extending to parts of Cross River, and Akwa Ibom. Moderate NO_2 concentration between 4.0 and 8.0 µg/m³ were observed over the rest of the country.

4.7: Regional Daily Concentration of Nitrogen Dioxide (NO2) over Cities in Southern Nigeria from October to December 2024

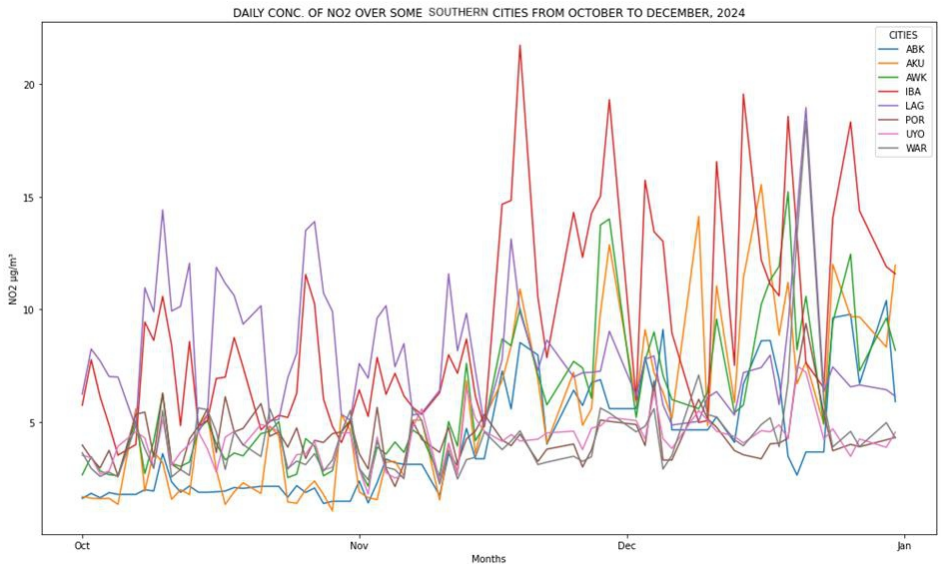

Figure 4.8: Daily Concentration of NO_2 over Southern Cities from October to December, 2024

The data showed increasing NO_2 concentrations from mid-November to December 2024. This could be attributed to seasonal effect, increased industrial activity, and harmattan-related atmospheric changes. Ibadan, Lagos and Awka recorded increases in daily mean NO_2 concentration from 3.62 to 23.33 µg/m³. The highest NO_2 concentration of 23.33 µg/m³ was observed over Benin on 20th December, 2024. While October to mid-November have recorded lower daily mean NO_2 concentration between 0.81 to 5.33 µg/m³. Also the lowest single day mean NO_2 of 0.81 µg/m³ was observed over Yenegoa on 4th November, 2024. Relatively lower NO2 concentration remained over Abeokuta, Uyo, Yenegoa and Calabar compared to other cities, suggesting lower vehicular emissions, fewer industrial activities, or favorable weather conditions for dispersion of atmospheric pollutants.

4.8: Regional Daily Concentration of Nitrogen dioxide (NO2) over Cities in Northern Nigeria from October to December 2024

Notable spikes in NO_2 spikes concentration was observed in October 2024, especially in Abuja and Kano where NO_2 levels exceeded 15.0 µg/m³ daily average. However, by December a temporary drop in NO_2 concentration was observed across all cities. This was likely due to weather patterns indicating seasonal variability associated with cessation of dry season conditions that trap pollutants closer to the ground

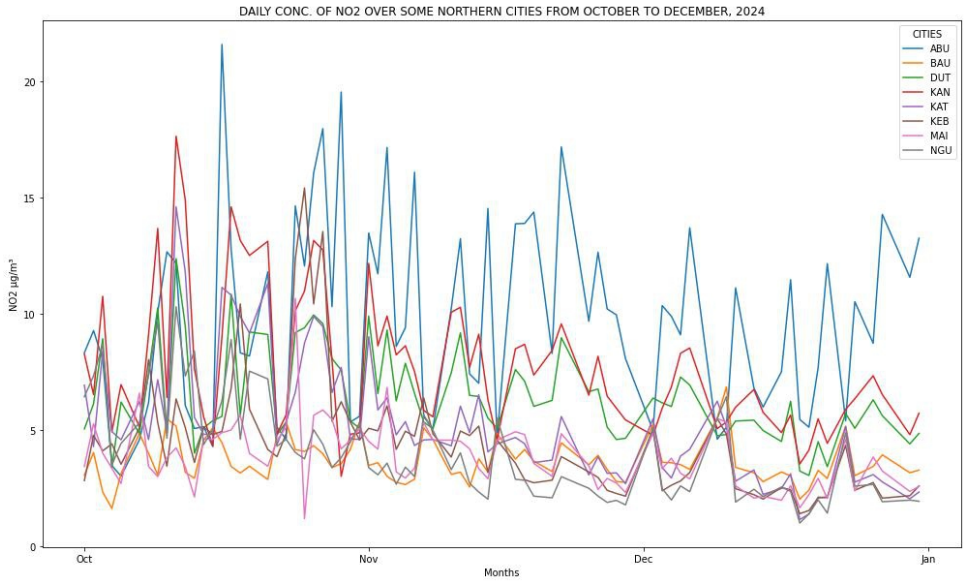

Figure 4.9: Daily Concentration of NO_2 over Northern Cities from October to December, 2024

The highest single day mean NO_2 concentration of 21.60 µg/m³ was recorded over Abuja on 10th October, 2024. The maximum NO_2 concentration ranged between 4.88 and 21.60 µg/m³, while the minimum ranged from 0.60 to 4.68 µg/m³. The lowest single daily mean NO_2 concentration of 0.60 µg/m³ was observed over Jalingo on 25th October, 2024. Relatively low concentration of NO_2 persisted over Bauchi, Nguru, Maiduguri and Dutse indicating less active pollution sources or more effective dispersion processes. The maximum, minimum and mean concentrations of Nitrogen Dioxide (NO2) from October to December 2024 are shown in Table 8.

4.8: Regional Daily Concentration of Nitrogen dioxide (NO2) over Cities in Northern Nigeria from October to December 2024

	OCTOBER			NOVEMBER			DECEMBER		
CITY	Maximum	Minimum	Mean	Maximum	Minimum	Mean	Maximum	Minimum	Mean
ABEOKUTA	8.44	4.01	5.73	12.26	4.02	7.42	16.10	4.60	8.88
ABUJA	21.60	3.02	9.40	17.19	4.68	10.94	14.29	4.61	8.86
ADO EKITI	6.25	2.09	3.70	18.27	3.03	8.33	17.70	4.63	11.72
AKURE	5.61	1.09	2.68	12.87	1.56	5.25	15.53	4.85	9.06
ASABA	6.04	2.26	3.56	13.61	2.01	5.96	16.06	4.91	9.32
BENIN	8.86	4.00	5.69	12.76	3.03	6.89	23.33	5.33	10.34
CALABAR	5.35	1.81	3.10	5.08	1.72	3.13	6.98	2.99	4.15
ENUGU	5.37	2.00	3.38	11.55	2.14	5.96	13.38	4.05	8.40
IBADAN	11.55	3.55	6.59	21.71	4.80	9.84	19.54	5.00	11.86
ILORIN	5.10	1.82	3.22	6.99	2.50	4.62	7.16	1.85	4.22
JOS	6.99	2.55	4.72	4.91	2.15	3.36	6.69	2.22	3.70
KADUNA	6.13	1.72	3.73	5.02	2.71	3.85	5.66	1.98	3.57
KANO	17.65	3.01	9.05	12.18	4.58	7.90	8.54	3.55	5.83
KATSINA	14.61	4.29	7.38	9.02	2.69	4.71	6.25	1.16	3.19
KEBBI	15.42	2.83	6.24	6.39	2.16	4.03	5.50	1.41	2.80
LAGOS	14.41	4.56	8.80	13.12	4.88	8.07	18.95	4.88	7.54
LOKOJA	5.35	1.56	3.44	10.84	1.80	6.03	11.52	3.99	8.05
MAIDUGURI	10.67	1.20	4.48	6.84	2.32	3.92	5.50	1.66	3.10
MINNA	5.68	1.20	2.80	5.10	1.63	2.84	5.40	1.40	3.15
NGURU	10.31	3.40	5.88	5.65	1.79	3.04	6.44	1.00	2.71
ONITSHA	6.27	2.55	3.76	14.01	2.17	6.11	15.21	4.95	8.50
OSOGBO	6.96	2.79	4.27	19.21	3.04	9.21	15.35	4.77	10.57
OWERRI	7.66	3.24	4.53	10.56	3.15	5.77	12.45	4.85	7.61
PORT HARCOURT	6.30	2.62	4.36	5.67	2.16	4.02	9.38	3.33	4.72
SOKOTO	15.26	3.48	6.56	6.11	2.04	3.79	6.12	1.34	3.01
UMUAHIA	5.84	2.89	3.92	9.84	2.77	5.12	9.23	4.85	6.40

UYO	5.14	2.72	3.86	6.55	1.82	4.07	7.51	3.49	4.81
WARRI	5.64	2.58	3.80	5.64	2.27	3.70	18.34	2.93	5.79
YOLA	5.64	1.00	2.98	5.10	1.78	2.93	4.88	1.96	3.25
ZARIA	9.18	2.89	5.36	7.63	1.75	5.43	22.32	2.91	5.38

4.9: Spatial Distribution of Mean Carbon Monoxide (CO) Concentration over Nigeria from October to December 2024

The observed quarterly mean concentration of CO generally ranged from 200 to above 580 ppbv across the country during the quarter. The lowest concentration of 200 to 300 ppbv was observed in some parts of Sokoto, Kebbi and Akwa Ibom states, while the highest range between 500 ppbv and above was observed over parts of Osun, Ekiti, Enugu, Katsina, Kano, Kaduna and Jigawa states.

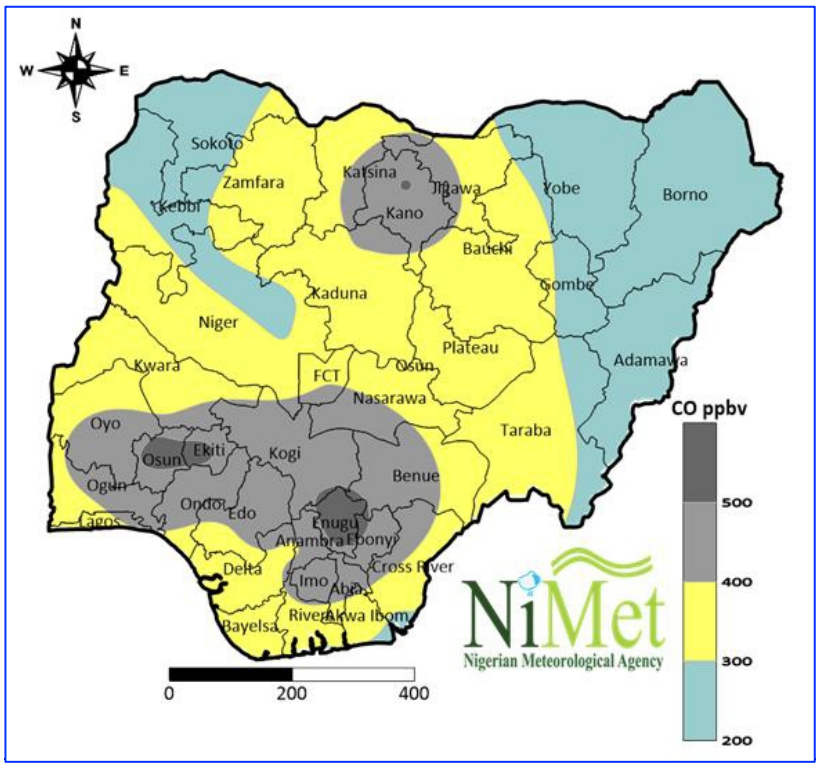

Figure 4.10: Mean Carbon Monoxide Concentration over Nigeria in the Fourth Quarter of 2024

Other States recorded CO concentration between 300 and 400 ppbv, while Kogi, Benue, Oyo, Ondo, Ogun, Edo, Imo, Anambra, Ebonyi, Kastina, Jigawa and Kano states recorded concentrations between 400 and 500 ppbv. The observed last quarter mean concentration over most States of Nigeria was lower than the WHO 2021 recommended standard of 4.0 µg/m3 in 24 hours.

4.10: Regional Daily Concentration of Carbon Monoxide (CO) over Cities in Southern Nigeria in the Fourth Quarter of 2024

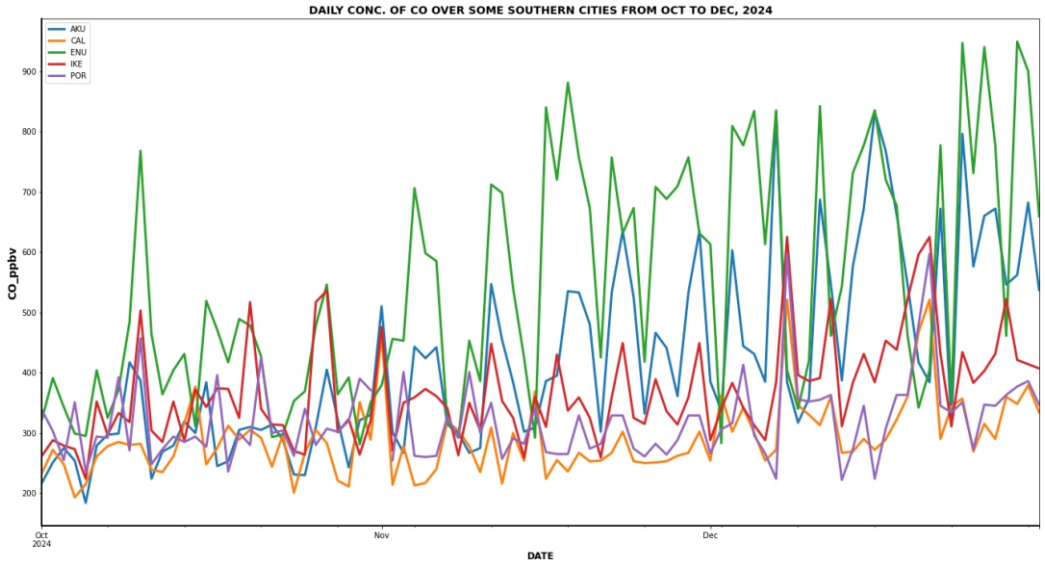

Figure 4.11: Daily Concentration of CO Over Southern Cities in the Last Quarter of 2024

Enugu experienced the highest CO concentration in the region compared to other Southern cities during the period under review. (Figure 4.11). The highest concentration of 860 ppbv (0.75 mg/m3) was observed on the 25th of December while Akure experienced the lowest level of CO concentration at 150ppbv (0.15 mg/m3) during the period.

4.11: Regional Daily Concentration of Carbon Monoxide (CO) over Cities in Northern Nigeria in the Fourth Quarter of 2024

During the period under review, Lokoja experienced the lowest CO concentration of 165 ppbv (=0.19 mg/m3) on the 10th of November, while the highest concentration (1060 mg/m3) of CO concentration was recorded over Jos on the 26th of November 2024. Generally, the concentration of CO across the country ranged from 200 to 1120 ppbv (0.15 to 0.158 mg/m3).

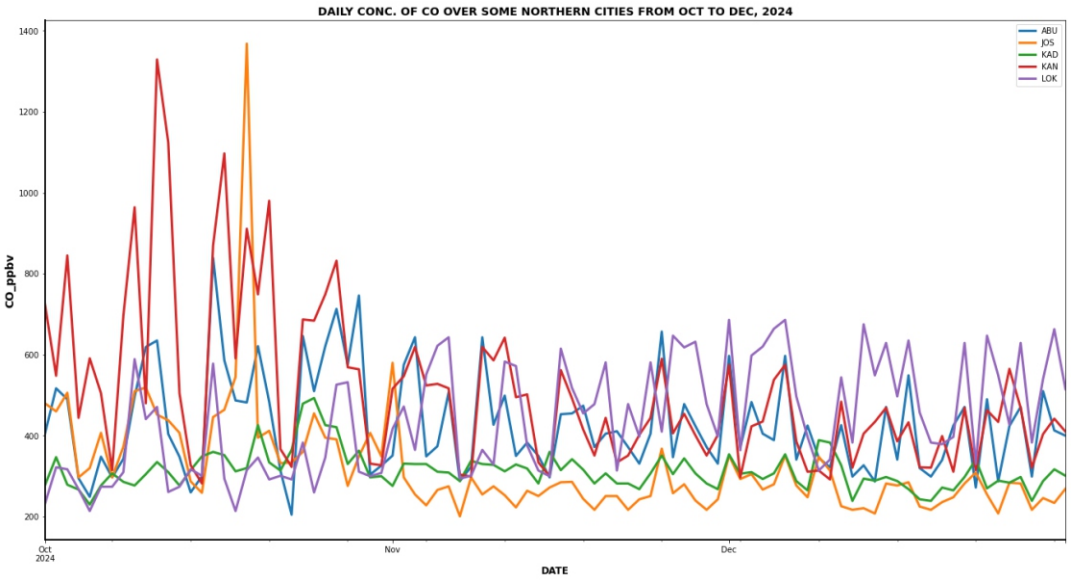

Figure 4.12: Daily Concentration of CO over Northern Cities in the Fourth Quarter of 2024

The observed CO concentrations in the quarter under review were below WHO threshold of 4 mg/m3 in 24 hours which implies that there was no health risk due to carbon monoxide.

4.12: Mean Concentration of SO2 over Nigeria from October to December 2024

As depicted in Figure 4.13, Rivers, Bayelsa, Delta and Akwa Ibom states recorded the highest SO2 concentration above 200 µg/m3 of during the last quarter of 2024. Among these four states, Warri in Delta recorded the highest concentration of 668.4 µg/m3 while the lowest concentrations of 1.9 to 40 (µg/m3) were reported over most of the North and Nasarawa in the north-central, as well as south-western states of Ekiti, Oyo, and Osun. Other states of the country: Benue, Kogi, Cross River, Ebonyi, Edo and Ogun, recorded SO2 concentration in the range of 40 to 100 (µg/m3). The Overall mean SO2 concentration recorded was below the WHO recommended standard in the North and few south-western states.

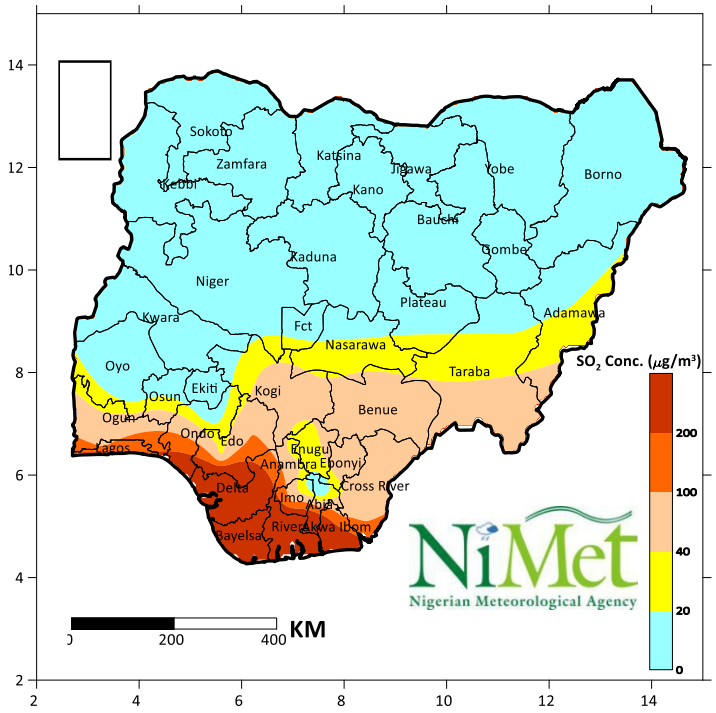

Figure 4.13 Mean Concentration of SO_2 over Nigeria in the Fourth Quarter of 2024

4.13: Regional Daily Concentration of Sulfur Dioxide (SO2) over Cities in Northern Nigeria in the Fourth Quarter of 2024

In the North, SO2 concentration progressively increased from October to December, however, a single day peak concentration of 507.8µg/m3 was observed over Lokoja in October while Jos recorded the lowest SO2 concentration of 0.2µg/m3 also in October (Figure 4.14). The observed concentration of SO2 during the fourth quarter was generally below the standard limit in October and November but above the recommended limit in December for all the selected northern cities except Lokoja. The observed concentrations were also higher over Lokoja than Maiduguri, Kano, Jos and Abuja.

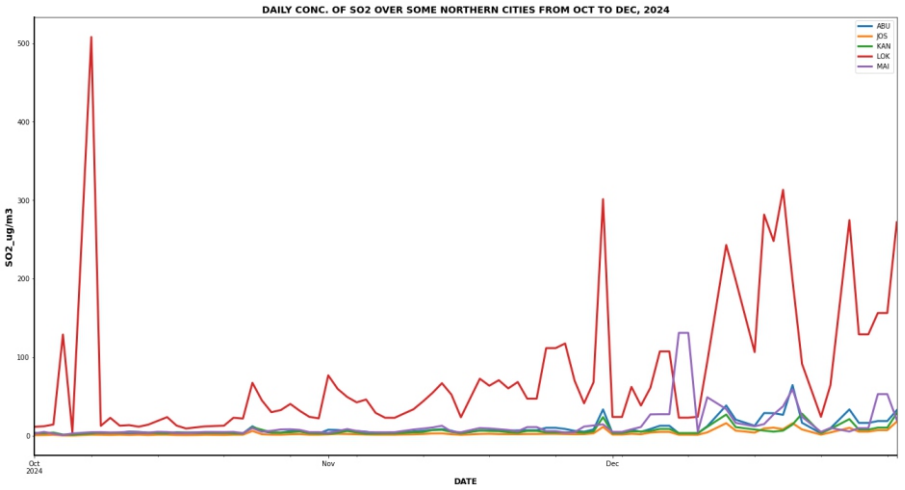

Figure 4.14: Observed Daily Mean Concentration of Sulfur Dioxide Over Cities in Northern Nigeria in the Last Quarter of 2024

4.14 Daily Concentration of Sulfur Dioxide (SO2) over Cities in Southern Nigeria in the Fourth Quarter of 2024

As shown in Figure 4.15, among the cities in the southern part of the country, Warri had the highest concentration of 7192.5µg/m^3 observed on the 30th of November during the fourth quarter of 2024. Abeokuta and Ikeja recorded overall lowest concentrations from October to December. Similar to the pattern observed in the North, the South also recorded a progressive increase in SO2 concentration from October to December and attained its peak in December. Most cities in the south recorded concentrations above the standard limit of 40µg/m^3 in 24 hours. The maximum, minimum and mean concentrations of observed Sulfur Dioxide over cities across Nigeria from October to December 2024 are shown in Table 9.

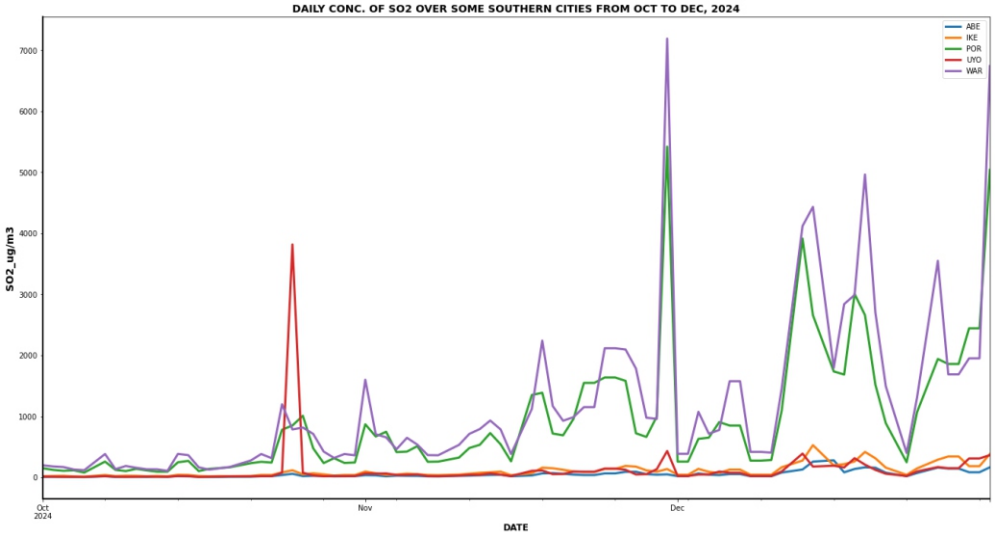

Figure 4.15 Daily Concentration of SO2 over Southern Cities in the Fourth quarter of 2024

Table 9: Maximum, Minimum and Mean Concentration of Sulfur Dioxide So_2 (µg/m3) in the Last Quarter Of 2024

	OCTOBER			NOVEMBER			DECEMBER		
CITY	Maximum	Minimum	Mean	Maximum	Minimum	Mean	Maximum	Minimum	Mean
ABEOKUTA	59.0	5.7	15.9	92.4	15.3	41.5	279.9	18.0	101.1
ABUJA	12.0	0.5	3.1	33.5	3.0	7.2	64.5	3.0	17.2
ADO EKITI	10.3	0.5	3.0	32.2	3.2	9.1	45.4	3.4	19.3
AKURE	11.5	0.7	3.4	35.5	4.1	10.7	57.6	4.4	23.0
ASABA	110.1	9.9	29.4	563.5	29.8	107.8	606.4	34.0	207.9
BENIN	56.2	4.4	14.1	220.8	16.0	50.0	304.5	17.7	99.3
CALABAR	128.6	8.1	32.0	588.4	35.6	126.0	678.9	35.6	233.9
DUTSE	11.9	1.1	4.1	24.1	2.6	5.6	35.9	3.5	11.8
ENUGU	31.7	2.5	7.1	104.7	7.2	25.8	132.0	8.1	48.7
IBADAN	28.6	2.1	7.0	46.6	8.1	19.6	116.4	7.9	43.9
ILORIN	18.5	0.9	4.6	29.6	5.2	11.6	67.8	5.2	27.6
JOS	6.1	0.2	1.3	11.2	1.2	2.3	18.0	1.2	6.2
KADUNA	10.1	0.4	2.9	26.4	2.5	4.8	34.2	2.3	11.9
KANO	10.8	1.4	4.0	23.7	2.7	5.3	28.6	3.3	10.5
KATSINA	7.7	1.5	3.0	7.1	1.9	3.8	14.4	2.9	6.7
KEBBI	21.7	1.4	6.4	13.3	5.5	8.9	54.5	6.5	19.0
LAGOS	116.8	12.1	33.8	187.9	36.1	89.7	528.3	41.4	197.7
LOKOJA	507.8	4.4	47.5	301.3	22.8	65.1	313.2	23.0	129.8
MAIDUGURI	9.7	0.9	4.7	14.5	3.7	7.6	131.0	4.9	28.9
MINNA	22.9	1.0	6.5	67.5	5.5	13.8	85.6	6.5	32.5
NGURU	13.4	1.2	4.9	27.7	2.5	6.6	40.4	4.0	11.1
ONITSHA	46.3	4.4	12.5	251.3	12.3	47.2	256.2	14.1	83.4
OSOGBO	20.8	1.0	4.7	29.8	5.1	12.4	66.3	5.3	27.4
OWERRI	69.0	7.8	20.1	474.8	20.5	78.3	455.0	19.6	155.8
PORTHARCOURT	1010.0	78.8	252.5	5421.7	255.4	966.3	5040.8	247.9	1551.0
SOKOTO	15.9	1.8	5.2	10.2	3.6	6.7	192.2	5.0	19.1
UMUAHIA	29.5	3.0	8.5	175.1	8.5	32.3	158.2	8.6	57.2
UYO	3818.0	6.7	142.0	432.9	20.7	79.9	389.8	23.2	140.7
WARRI	1198.8	107.5	317.6	7192.5	362.5	1222.6	6741.3	386.3	2034.9
YOLA	36.3	1.5	9.8	55.9	9.4	21.6	167.3	9.4	57.9
ZARIA	519.4	0.6	19.5	22.2	2.4	4.3	30.2	2.4	10.2

5.0 Summary And Conclusion

During the fourth quarter of 2024 (October, November and December), the ITD steadily retreated from latitude 16.3°N in the 1st dekad of October to latitude 5.8°N by the 3rd dekad of December. It maintained mean monthly positions of 14.3°N, 6.8°N and 5.7°N in October, November and December, respectively with the peak attained in October. The mean position of the ITD during the quarter was 8.9°N. The observed position especially in November and December was responsible for the drier and hazy conditions over the Northern part of the country, below normal rainfall over the coastal areas and poor horizontal visibilities reported in different parts of the

country.

The Azores high pressure centers were 1020hPa, 1018hPa and 1028hpa in October, November and December respectively averaging 1022hPa in the 4th quarter, while the St. Helena centers were 1022hPa, 1022hPa, and 1020hPa with an average of 1022hPa also during the 4th quarter of 2024.

Winds at 925hPa and 850hPa were predominantly continental northeasterly flows with speeds which varied from 5 to 35Kts during the three months period. The 1015hpa Isobar in the northern hemisphere maintained a mean position of approximately 19°N during the period under review.

The concentration of PM2.5 in the atmosphere over Nigeria increased consistently from October to December with monthly mean concentrations which varied from 15 to 45 µg/m^3 and above during the period. The highest mean monthly PM2.5 concentration of 45µg/m^3 and above was recorded in December. The observed concentration during the 4th quarter far exceeded the WHO recommended threshold of 15 µg/m^3 in 24 hours.

Mean monthly NO2 concentration fluctuated between 2.0 and 8 µg/m^3 and above during the period with the highest concentrations of 8 µg/m^3 and above observed over the southwest and lowest over the northeast in December. The observed levels were however, below WHO threshold of 25 µg/m^3 in 24 hours.

CO concentration during the 4th quarter of 2024 ranged from 100 to 620ppbv (0.19-0.62 mg/m^3) with the highest concentrations observed over Edo, Osun and Enugu in December.

SO2 monthly mean concentration ranged from 1.3 to 329.3 (µg/m3) in October to 6.6 to 2172.0 (µg/m3) in December 2024. Asaba, Calabar, Port Harcourt and Warri were the cities with recorded highest monthly mean concentrations of 100µg/m3 and above in December.

The Air quality Index during the 4th quarter of 2024 progressively deteriorated from a moderate status (AQI 51-100) in October to unhealthy status for all categories of persons in December. November and December 2024 were therefore characterized by very poor air quality which was unhealthy for most people across the country.

Acronyms

AQGs	Air Quality Guidelines
CAMS	Copernicus Atmospheric Monitoring System
CO	Carbon monoxide
hPa	Hectopascal
ITD	Inter-Tropical Discontinuity
Kt	Knot
MSLP	Mean Sea Level Pressure
mg/m3	Milligram per cubic meter
NO_2	Nitrogen dioxide
O3	Ozone
PM	Particulate Matter
ppbv	Part per billion by volume
PPM	Part per million
SO_2	Sulfur dioxide
WHO	World Health Organization
µg/m3	Microgram per cubic meter
µm	Micrometer

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