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AIR QUALITY
BULLETIN

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3rd Quarter 2024

Air Quality Bulletin

July -September 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 has continued to pose significant threat to the global population, and thus a great concern to all. It is alarming to know that about 99% of the global population inhale air that exceeds the World Health Organization (WHO) guideline limits, with the low-income countries suffering the highest exposure. This is because most of the low-income countries either lack the resources or technology to enforce policies and put in place structures that will help reduce or prevent the emission of pollutants and greenhouse gases by human into the atmosphere. As a result, the people become exposed to risk of respiratory, cardiovascular, pulmonary diseases and cancer. According to WHO, strong evidence also links air pollution to some health challenges such as low birth weight, cognitive impairment and mental health impacts.

There is also a strong relationship between air pollution, weather, health and climate change as some meteorological conditions impact air pollution directly and indirectly through entrainment, transport, and deposition of air pollutants. Weather phenomena such as wind speed, wind direction, rainfall. humidity and atmospheric pressure determine the air quality of a place and help in monitoring and prediction of air pollutants.
NiMet Air Quality Quarterly Bulletin is produced to provide relevant information on quality of air across the country in relation to World Health Organization recommended air quality standards. The information in this Bulletin will help to improve health and regulate practices that may deteriorate the quality of air. In Nigeria, the major pollutant of air quality is particulate matter.

Particulate Matter (PM)

Particulate matter (PM) refers to the microscopic solid or liquid droplets with a diameter of less than 10 micrometers. 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 enter the bloodstream. Exposure to these fine particles can cause short-term health problems such as eye, nose, throat and lung irritation, coughing, sneezing, runny nose and shortness of breath. These have been associated with a range of healthproblems, including cardiovascular diseases (ischemic heart disease and stroke), chronic obstructive pulmonary disease, acute lower respiratory infections and lung cancer There is growing evidence of other adverse health effects of these microscopic particles. PM of diameter 10µm (PM_{10}) or 2.5µm ($PM_{2.5}$) 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.

[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 quality of air over any given place is assessed and measured using the Air Quality Index (AQI). The index is based on the level of pollutant concentrations in the air and its associated health risks. The AQI has values which range 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 various categories and respective health impacts are presented in Table 2. Generally, air quality index within the months under review fell within the range of 50 to 100, indicating a relatively good to moderate air quality across the country during the period.

Air Quality Index	Class	Advisory
1-50	Good	The quality of the air is good, it presents no threat to human 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.

Table 2: Air Quality Index Chart (Nigerian Meteorological Agency)

CHAPTER ONE
July 2024 Review

1.1 The Inter-Tropical Discontinuity (ITD) and Rainfall Over Nigeria

The ITD is the zone where the moist winds from the Atlantic Ocean meet with the dry trade winds from the Sahara Desert. The position of the ITD oscillates northward and southward throughout the year. Its latitudinal position relative to any place at any time determines the type of weather that will prevail over that place.

The position of the ITD in July 2024 is shown in Figure 1.1. It moved northwards from Latitude 19.4°N in the 1st decade to Latitude 20.2°N in the 2nd decade, and reached 20.8°N in the 3rd decade of the month under review. The mean position of the ITD in July was approximately 20.1°N (black dash line) and was observed to be slightly above the climatological mean position of 18.2°N (red bold line). The position was favorable for rainfall over the entire country. During the month under review, the observed rainfall amounts across the country ranged from 41.4mm in Obudu, Cross Rivers State to 765.7mm in Lafia, Nasarawa State.

The observed rainfall contributed significantly in reducing the concentration of pollutants in the atmosphere over Nigeria. This resulted in improved horizontal visibility and incidences of air pollution, hence, a moderate air quality was observed in the month.

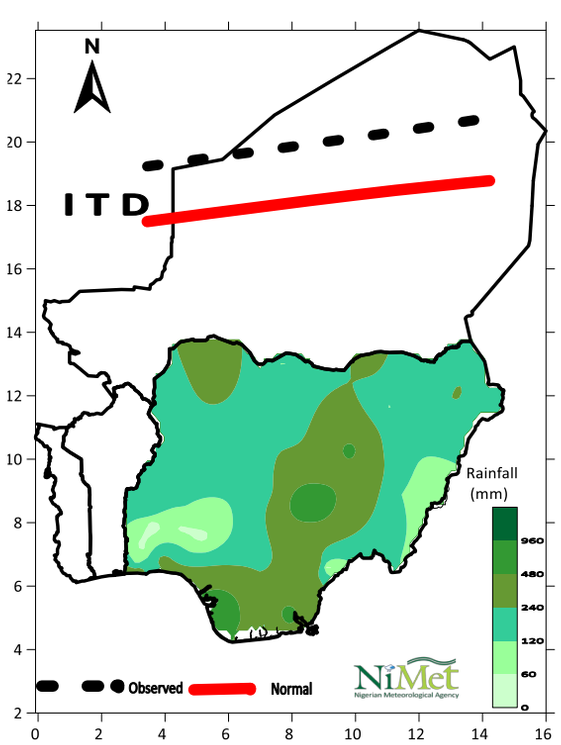

Figure 1.1: Mean Position of the ITD and rainfall amounts across Nigeria in July 2024

1.2 Mean Sea Level Pressure (Azores and St. Helena Highs) in July 2024

The two high-pressure areas which modulate weather over Africa are the Azores and St. Helena high pressure systems located around 30oN and 30oS, respectively.

Daily center values of the Azores mean sea level pressure varied from 1017 to 1031 hPa with a mean value of 1024hPa observed in the month, while values over the St. Helena high pressure system varied between 1023 and 1034 hPa with a mean center value of 1027hPa (Figure 1.2). The monthly mean position of the 1015hPa isobar (blue line) was approximately 2.6oS. Pressures below 1012hPa which are favorable for rainfall prevailed over the Northern parts of the country.

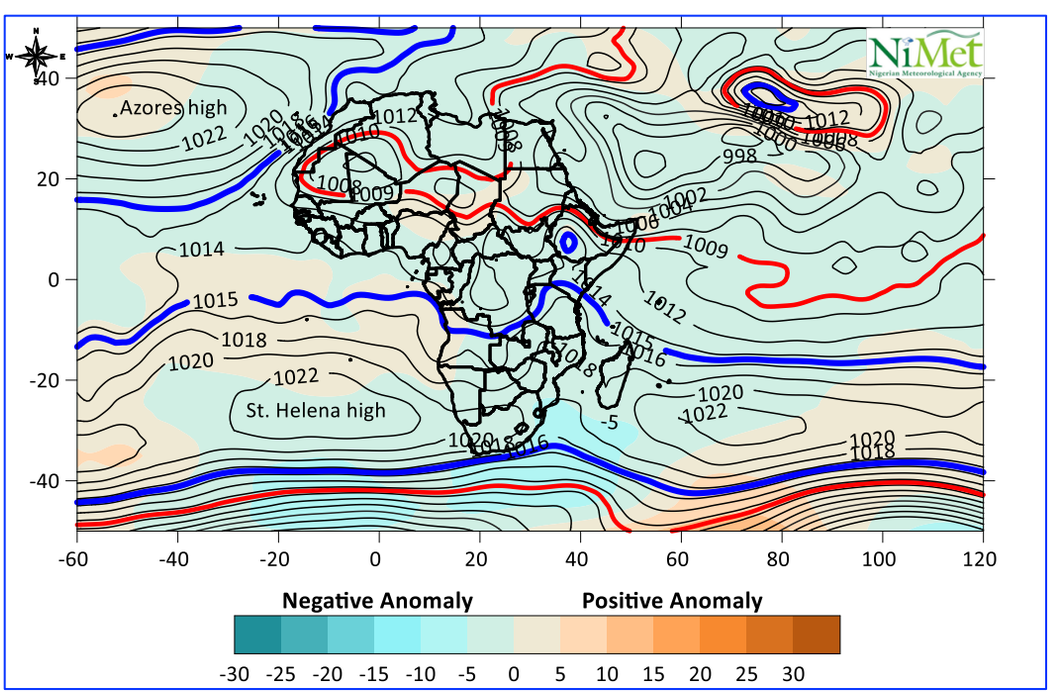

Figure 1.2 Mean Sea Level Pressure in July 2024

1.3 Winds

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

In July 2024, moist winds prevailed across the country. The mean wind direction at 925hPa was southwesterly, with speeds which varied from 5 to 30 kts (about 2.6 to 15 m/s) and mean speed of 17.5 kts (9 m/s). The winds were favorable for low level precipitation across the country. Horizontal visibility across the country was above 10km during in the month.

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

At 850hPa level about 1500m above the ground level, the average wind direction was southwesterly across the country. Occasionally, the winds changed to northeasterly direction over the North in the 1st decade of the month. Daily values of wind speeds ranged from 5 to 35 kts but mostly 5 to 20 kts. The winds were also favorable for rainfall over the country in the month.

1.4 Particulate Matter (PM2.5) Concentration Across Nigeria in July, 2024

The observed monthly mean concentration of PM2.5 in the month generally ranged from 9.0 to 21.0µg/m3 (Figure 1.4). Concentrations of 9.0 to 13.0µg/m3 were observed over parts of Ekiti, Kwara, Kogi, Oyo, Osun, Ondo, Edo, Ogun, Taraba, southern Adamawa, Kaduna and western parts of Niger states, while higher concentrations of 21.0µg/m3 and above were recorded over parts of Kano, Jigawa, Katsina, Yobe, and Northern parts of Bauchi states. Most parts of the country recorded PM2.5 concentrations ranging from 13.0 to 17.0µg/m3, while Northern Sokoto, Northern Zamfara, Southern Kano, Bauchi, Northern Gombe, southern Yobe, Northern Borno and Imo states recorded concentrations between 17.0 and 21.0µg/m3. The highest mean concentration of PM2.5 was observed over Kano with 26.0µg/m3 in 24 hours.

Mean monthly concentrations over most of the cities were above the recommended World Health Organization (WHO) 2021 updated Air Quality Guidelines (AQGs) limit of 15 µg/m in 24 hours for PM2.5. This indicates unhealthy, air quality for the people with high risk for the prevalence of respiratory health symptoms.

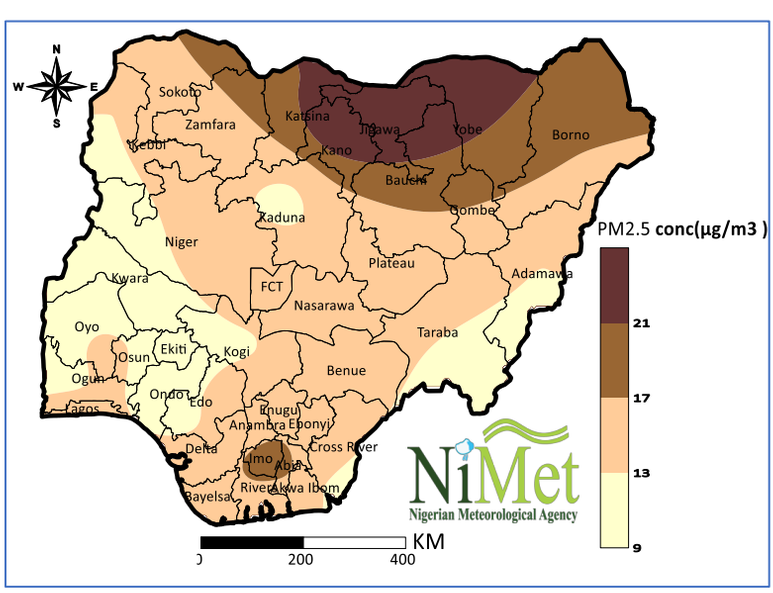

Figure 1.4: Mean PM2.5 Concentration Over Nigerian Cities in July 2024

1.5 Nitrogen dioxide (NO2) Concentration Across Nigeria in July, 2024

The mean concentration of NO2 over Kano, Lagos, Ogun, Jigawa and parts of Oyo, Katsina, Yobe, and Sokoto states, as well as the FCT in July 2024, ranged between 4.0 and 8.0 µg/m³ (Figure 1.5), indicating a moderate level of NO_2 concentration for the month. The sources were mainly from activities of urbanization, traffic, farming, and industries.

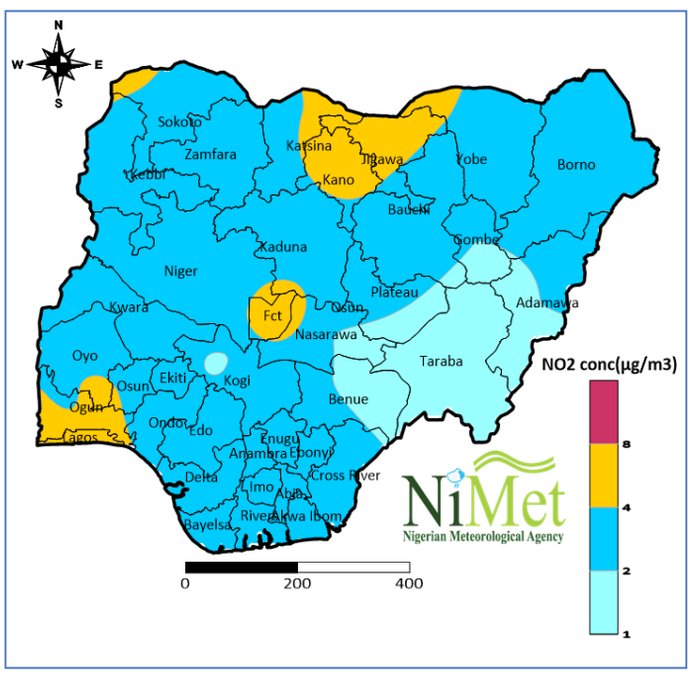

Figure 1.5: Mean Monthly Nitrogen Dioxide (NO_2) Concentration Across Nigeria in July 2024

In July 2024, most parts of the country, recorded mean concentrations of NO_2 between 2.0 and 4.0 µg/m³, while the central states of Taraba, and parts of Adamawa, Benue, Plateau, Nasarawa, Kogi, Gombe, and Bauchi states recorded mean NO_2 concentrations between 1.0 and 2.0 µg/m³. These were lower than WHO standard guidelines limit of 25 µg/m³ /hour and 10 µg/m³ /year, indicating relatively healthy levels during the month.

1.6 Carbon Monoxide (CO) Concentration Across Nigeria in July, 2024

The observed monthly mean concentration of CO generally ranged from 220 to above 400 ppbv across the country (See Figure 1.6). The lowest concentration range of 220 to 270 ppbv was observed in some parts of Kebbi, Kwara, Niger, Oyo, Ogun, Ondo, Adamawa, Borno, and Lagos states, while the highest above 420 ppbv was observed over parts of Kano and Jigawa States. Most of the States recorded CO concentrations of 270 to 320 ppbv.

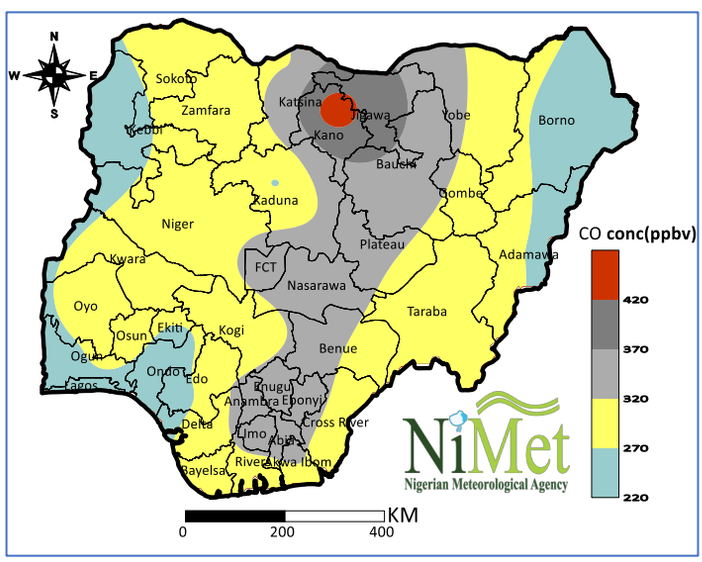

Figure 1.6: Carbon Monoxide (CO) Concentration in July 2024

while some states such as Nasarawa, Imo, Anambra, Enugu, Ebonyi, parts of Benue, Plateau, Bauchi, Yobe, Gombe and Katsina States, as well as the FCT recorded concentrations between 320 and 370 ppbv. The observed monthly mean concentration of 270 to 320ppbv (about 0.3-0.37 µg/m3) over most states was lower than the WHO 2021 Standard Guideline limit of 4.0 µg/m3 in 24 hours. The observed levels of CO across the country in July 2024 were therefore within acceptable levels and did not constitute significant risk to human health.

CHAPTER TWO
August 2024 Review

2.1 The Inter-Tropical Discontinuity (ITD) and Rainfall Across Nigeria

The Inter-Tropical Discontinuity (ITD) oscillated meridionally between Latitudes 20.4 and 20.8 degrees North in August 2024. It moved from latitude 20.4°N during the 1st dekad to 20.0°N in the 2nd dekad of the month. Thereafter, it surged northwards to reach a mean position of latitude 20.8ON during the 3rd dekad. The observed mean position in August 2024 was 20.4°N, and was more northerly than the normal mean position of 19.1°N (Figure 2.1). The ITD mean position in the month was favorable for rainfall across the country. During the month under review, the observed rainfall amounts across the country ranged from 14.8mm in Usi-Ekiti, Ekiti State to 575.7mm in Kebbi, Kebbi State.

However, the total monthly rainfall over the southwestern states was lower than other parts of the country because of the effect of the Little Dry Season (LDS) usually referred to as "August break". A decrease in rainfall frequency and amount was therefore observed over the Southwestern states during the month contrary to the increased rainfall recorded in the northern and other southern states in August.

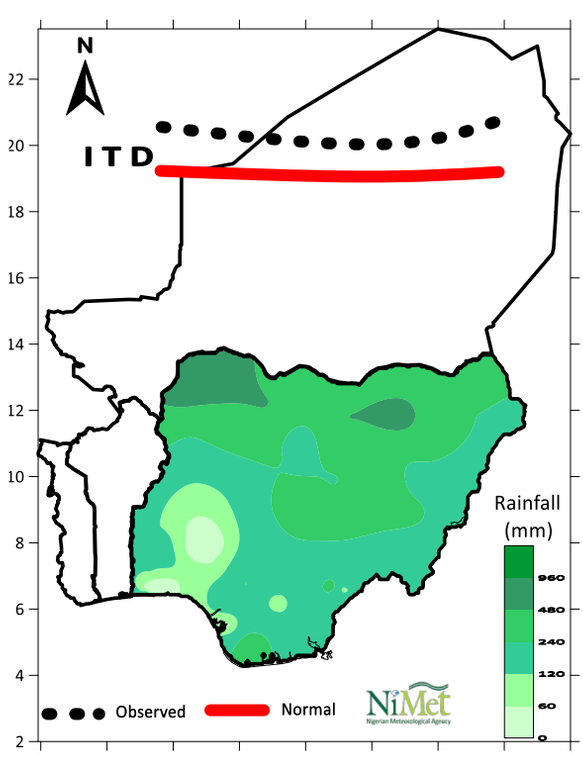

Figure 2.1: Mean ITD Position and Rainfall Amounts Across Nigeria in August 2024

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

Daily center values of the Azores mean sea level pressure varied from 1019 to 1037 hPa while the St. Helena high pressure system recorded daily values which varied between 1023 and 1035 hPa. Both Azores and St. Helena pressure systems maintained mean center values of 1022hPa in the month (Figure 2.1). The average monthly mean position of the 1015hPa isobar was about 4.7oS and closer to the Gulf of Guinea than in the previous month. The proximity of this pressure Isoline to the coast of Nigeria kept pressure high over the southwest coast with a resulting subsidence of moist air. Thus, a decrease in rainfall amount and frequency over the Southwestern States of Ogun, Lagos, Ondo, Osun, Ekiti and higher in rainfall amount over the northern than the southern (Figure 2.1).

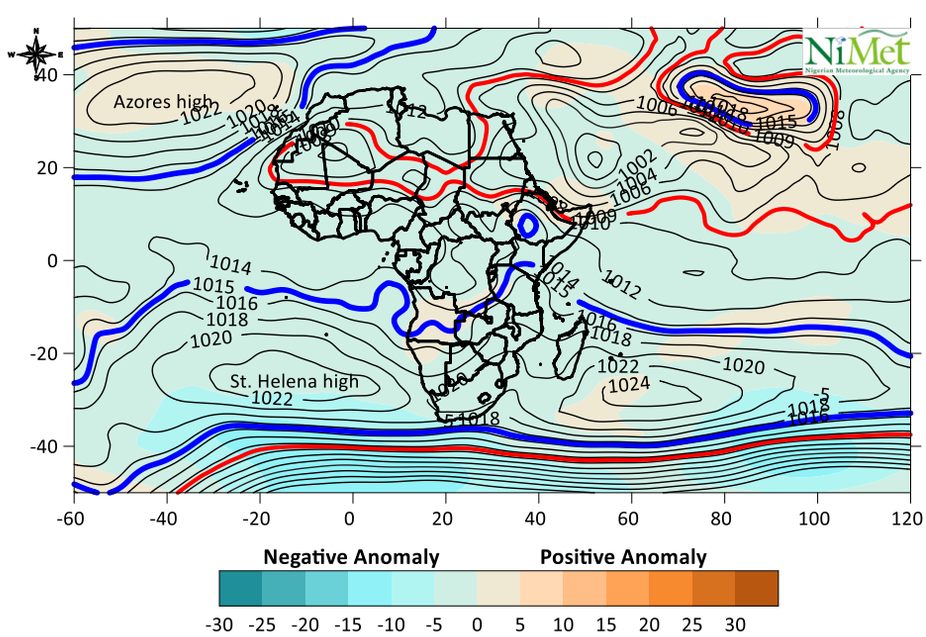

Figure 2.2: Mean Sea Level Pressure in August 2024

2.3 Winds

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

Southwesterly winds from the Atlantic Ocean, rich in moisture were dominant at this level over the country. The daily wind speeds ranged from 5 to 30 kts. Monthly average speed of the winds recorded were 17.5 kts (9m/s). These winds favored precipitation across most parts of the country, enhanced horizontal visibility and reduced particulate matter (PM2.5) concentration in the atmosphere during the month. Moderate air quality was therefore observed across the country in August 2024.

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

In August 2024, southwesterly moist winds were dominant over the country. Daily wind speeds observed, ranged from 5 kts to 20 kts, with a monthly average speed of 12.5 kts. These conditions were also favorable for rainfall over the country.

2.4 Particulate Matter (PM2.5) Concentration Across Nigeria in August, 2024

Monthly mean concentration of particulate matter of 2.5µm or less (PM2.5) recorded in the month ranged generally from 10.0 over Akure to 23.1 µg/m3 over Kano. Most states in the country recorded PM2.5 monthly mean concentrations ranging from 12.0 to 15.0µg/m3. The northern states of Kebbi, Zamfara, Nasarawa, Yobe, and some parts of Kaduna, Bauchi, and the FCT recorded mean PM2.5 concentrations ranging from 15.0 to 18.0µg/m3. P.M.2.5 concentrations in the same range were recorded over Enugu, Ebonyi, Anambra, Rivers, Akwa Ibom and Bayelsa states in the south. The highest monthly mean PM2.5 concentration slightly above 18.0µg/m3 was observed over parts of Katsina, Kano, Jigawa, Imo, northern Bauchi, northern Yobe and Sokoto states. The lowest mean PM2.5 concentrations of 9.0 to 12.0µg/m3 were recorded over of parts of Oyo, Ogun, Ondo, Edo, Kogi, Kwara, Adamawa, Taraba and Ekiti states (Figure 2.3). 24 hour mean P.M.2.5 concentration over Kano reached 44.2 µg/m3 while Katsina, Minna, Kebbi, Gusau , Jos, Awka, Enugu, Owerri, and Asaba recorded daily mean conentrations of 18 to 28 µg/m3 on 18th August. This was the highest concentration recorded in the month.

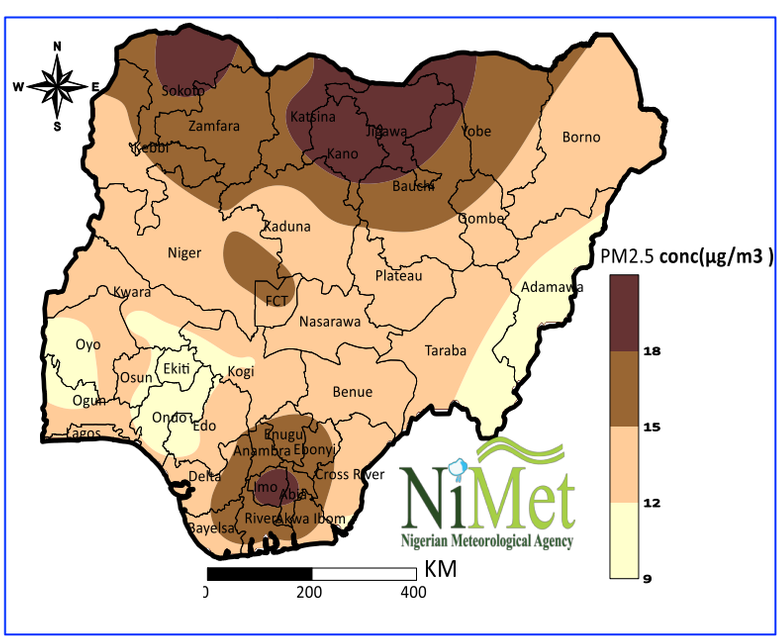

Figure 2.3: Mean PM2.5 Concentration Over Nigerian Cities in August 2024

The incresed P.M.2.5 concentration could be attributed to locally generated PM2.5 sources from dust, vehicular emission and industrial sources. The observed 24-hour mean values of 18 -28 µg/m3 over some locations in the month and 44 µg/m3 over Kano state on 18th August are far higher than the World Health Organization Air Quality Standard Guideline limit of 15 µg/m3, implying the the people living in those locations in Nigeria were exposed to unhealthy air quality and the associated health risk in August despite increased rains in the most parts of the country.

2.5 Concentration of Nitrogen dioxide (NO2) Across Nigeria in August, 2024

NO_2 levels remained relatively low all over Nigeria, with isolated increases observed in Bauchi and parts of Jigawa, Yobe, Sokoto, and Kebbi, FCT Abuja, Lagos, and Ogun where mean spatial concentration similar to the previous month was recorded. Most states across the country observed mean NO_2 concentrations between 2.0 and 4.0 µg/m (Figure 2.4). The slight decrease in spatial mean concentration over Adamawa state could be attributed to the rainfall-induced cleansing of the atmosphere during the August rains, and lower emissions due to less industrial activities in Taraba, Gombe, Kogi, and Borno states where mean concentrations between 1.0 and 2.0 µg/m^3 were recorded during the month.

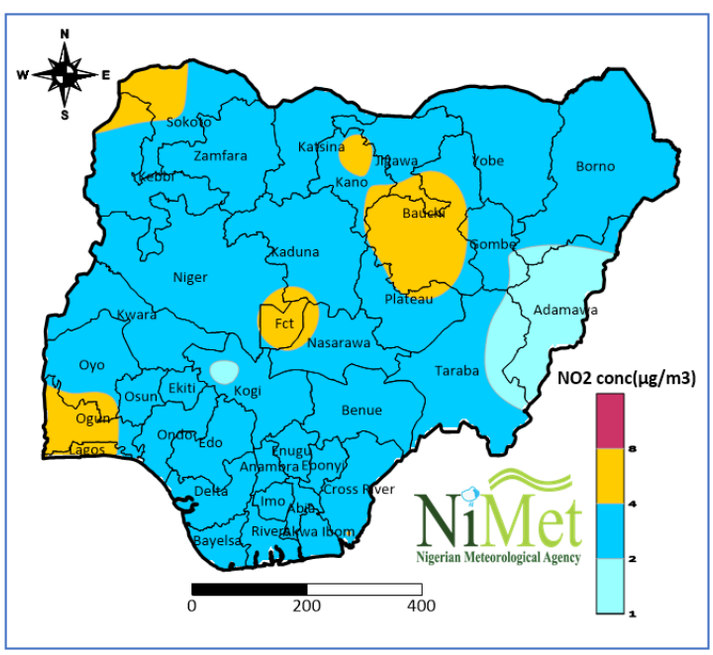

Figure 2.4: Nitrogen Dioxide (NO_2) Mean Concentration in August 2024

2.6 Carbon monoxide (CO) Concentration Across Nigeria in August, 2024

The observed monthly mean concentration of CO generally ranged from 200 to 390 ppbv (0.19 to 0.45 mg/m3) across the country in August 2024. A greater portion of the country recorded carbon monoxide concentrations that ranged between 250 and 300 ppbv. The lowest concentrations of 200 to 250 ppbv (0.23 to 0.29 mg/m3) were observed in parts of Oyo, Ogun, Kwara, Ekiti, Ondo, Edo, Delta, Bayelsa and Akwa Ibom States, while the highest range of 300 to 390ppbv (0.34 to 0.45 mg/m3) was recorded over parts of Katsina, Jigawa, Bauchi, Nasarawa and Kano States. Others are Enugu, Anambra, Ebonyi states, and the FCT (Figure 2.4)

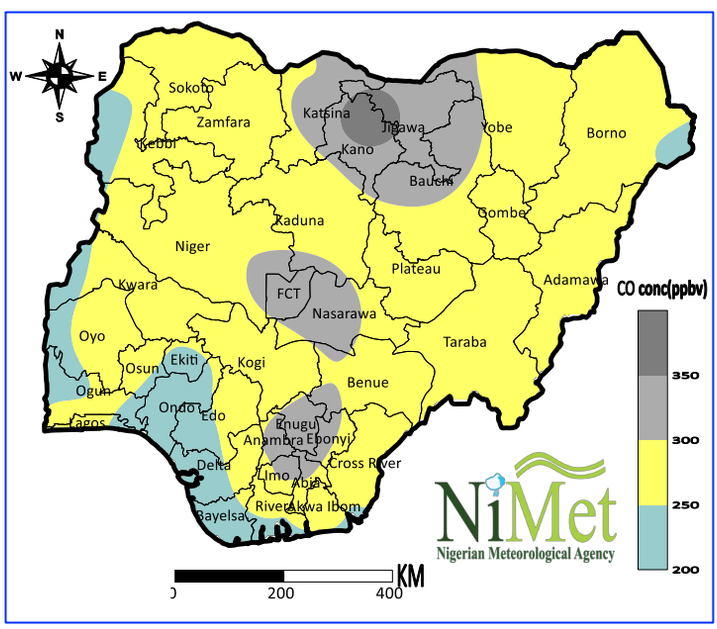

Figure 2.4: Carbon Monoxide (CO) Concentration Across Nigeria in August 2024

The monthly and daily mean CO concentration observed during the month across Nigeria was lower than the WHO 2021 recommended standard of 4 mg/m3 in 24 hours. These levels of CO concentration therefore posed no threat to the health of persons in the country in August 2024

CHAPTER THREE
September 2024 Review

3.1 Inter-Tropical Discontinuity (ITD) and Rainfall Across Nigeria

The Inter-Tropical Discontinuity (ITD) which is the zone where the dry North-East trade winds meet the moist South-West trade winds, continued its northward movement from latitude 20.8°N in the 3rd dekad of August to latitude 21.9°N in the 1st dekad of September. Thereafter, it retreated southwards to latitude 20.5°N in the 2nd dekad and reached a position of latitude 18.4°N during the 3rd dekad of September 2024. The ITD therefore fluctuated between latitudes 18.4 and 21.9 during the month and maintained a monthly mean position of latitude 20.3°N. The observed mean position in the month was more northerly than the climatological mean position of 17.4°N. This ITD position was favourable to enhanced rainfall in the southern parts of the country during the month. The southward pull of the ITD during the 2nd and 3rd dekads of the month marked the beginning of rainfall cessation in the northern states of the country. A sharp decline in rainfall amount was recorded during the month, especially over the Northeast (Figure 3.0). Moderate air quality therefore prevailed in the month.

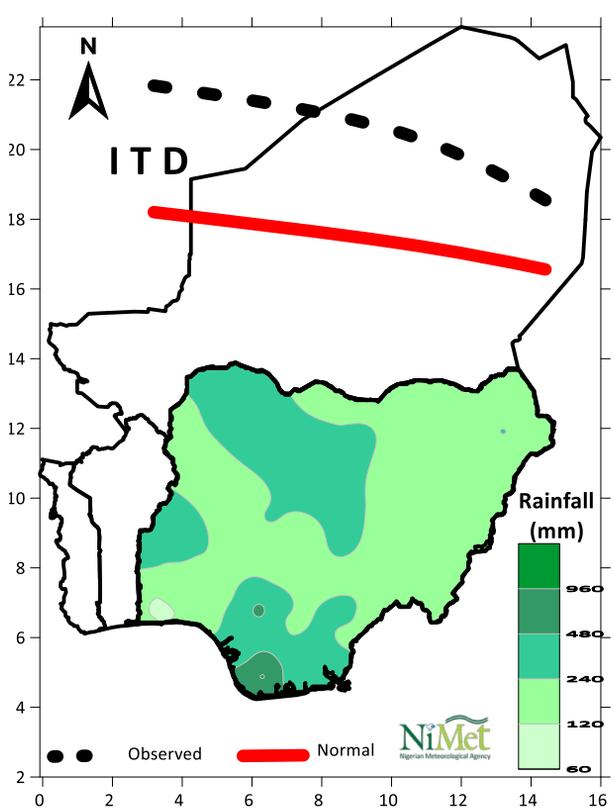

Figure 3.1: Mean ITD Position and Rainfall Amounts Across Nigeria in September 2024

3.2 Mean Sea Level Pressure (Azores and St. Helena Highs) in September 2024

During the month, the daily center values of the Azores mean sea level pressure varied from 1017 to 1031 hPa, with a mean center value of 1022hPa. This is the same value as the previous month. St. Helena high pressure varied between 1025 and 1043 hPa with a mean center value of 1026hPa (Figure 3.0). The average monthly mean position of the 1015hPa isobar was about 13.2oS. These conditions were favorable for rainfall in the country especially in the southern parts of the country.

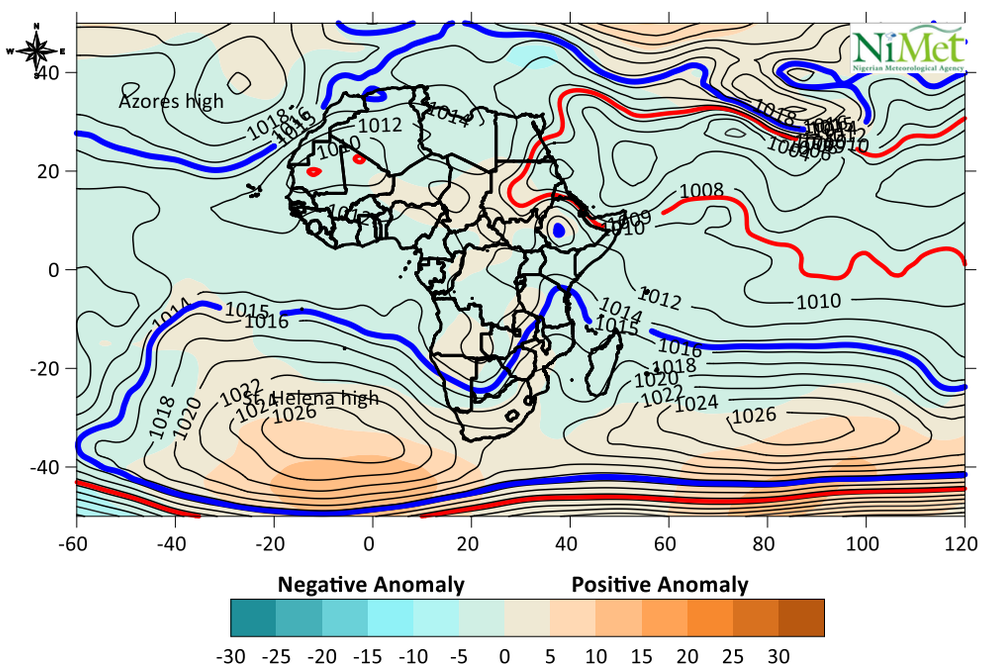

Figure 3.2: Mean Sea Level Pressure in September 2024

3.3 Winds

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

At this height in the atmosphere, moist southwesterly winds prevailed over the southern parts of the country while dry northeasterly winds prevailed over the North. Wind speeds observed in the month ranged from 5 to 25 kts with a mean of about 13 kts (6.5m/s). The winds enhanced precipitation and suppressed the concentration of PM2.5 from the dust sources across the country, especially over the South.

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

Winds at about 1500m above the ground were mostly of tropical maritime air mass from the Atlantic Ocean. Wind direction was southwesterly across the country but flows over the North were sometimes Northeasterly as the rainfall cessation gradually started by 3rd dekad of the month. Wind speeds ranged from 5 to 30 kts on daily basis. The mean wind speed for the month was about 17.5 kts. The winds at this level generally enhanced the rainfall in the month.

3.4 Particulate Matter ($PM_{2.5}$) Concentration Over Nigeria in September, 2024

The mean concentration of $PM_{2.5}$ in September 2024 (Figure 3.3) was observed to be highest over Kano (35.3.0µg/m^3) and Jigawa (28.5µg/m^3) as was the case in the previous months. Most parts of the country recorded mean $PM_{2.5}$ concentrations ranging from 11.0 to 17.0µg/m^3, while parts of Sokoto, Zamfara, northern Kaduna, Nasarawa, Plateau, Gombe, Bauchi, Yobe, Benue, Enugu, Anambra, Ebonyi, Imo, Abia, Rivers and Akwa Ibom states, as well as the FCT recorded mean $PM_{2.5}$ concentrations of 17.0 to 23.0µg/m^3. Katsina, Kano, northern Bauchi and Jigawa states recorded mean $PM_{2.5}$ concentrations of 23.0 to 29.0µg/m3. Kano and environs recorded the highest concentration above 29.0µg/m^3. During the month under review, daily mean concentration of $PM_{2.5}$ reached 42.5µg/m^3 over Kano, 35.5µg/m^3 over Dutse, and 23.5µg/m^3 over Nguru. Both observed daily and monthly mean values in most states are above WHO 2021 recommended guidelines limit of 15 µg/m^3 in 24 hours. This suggests that most people in those places were exposed to unhealthy air quality in the month with the associated increased health hazard.

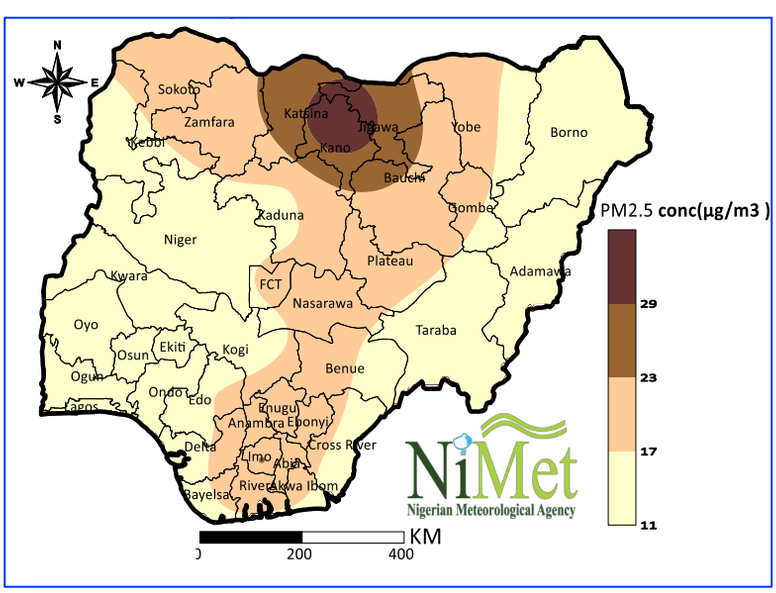

Figure 3.3: Mean $PM_{2.5}$ Concentration Over Nigerian Cities in September 2024

3.5 Nitrogen dioxide (NO_2) Concentration Over Nigeria in September, 2024

The monthly mean concentration of NO_2 in September 2024 ranged from 4.0 to 8.0 µg/m³ over Sokoto, Jigawa, Katsina, Kano, Yobe, Abuja, Nasarawa, Delta, Rivers, Imo, Lagos, Ogun, and parts of Akwa Ibom, Abia, Edo, Ondo, Osun, Oyo, Niger, Kaduna, Borno, Kebbi, Zamfara, Plateau, and Bayelsa states (Figure 3.4).

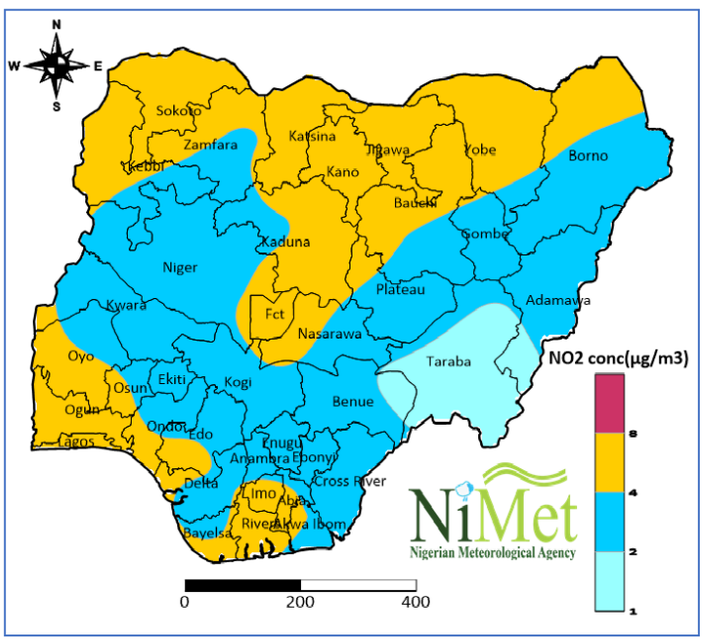

Figure 3.4: Mean Concentration of NO_2 Over Nigeria in September 2024

These states are primarily urbanized or industrial regions with increased activities of transportation and resultant emissions from vehicles, industries and energy generation. which may These account for the high concentration of the pollutant in the atmosphere over these places. Taraba, and part of Adamawa and Benue recorded mean NO_2 concentrations between 1.0 and 2.0 µg/m³ while all other states recorded mean NO_2 concentrations between 2.0 and 4.0 µg/m³ during the period under review

3.6 Carbon monoxide (CO) Concentration Over Nigeria in September, 2024

The monthly mean concentration of CO ranged from 200 to 500 ppbv (0.23 to 0.57mg/m^3) over the country. The lowest concentrations of 200 to 300 ppbv (0.23to 0.34 mg/m^3) was observed in some parts of Kwara, Ekiti, Oyo, Ogun, Osun, Ondo, Lagos, Akwa Ibom, Adamawa and Borno, while the highest range of 400ppbv (0.46 mg/m3) and above was observed over parts of Katsina, Kano, Kaduna, Bauchi and Jigawa States. Concentrations of 300 to 400 ppbv were recorded over the rest of the country (Figure 3.5).

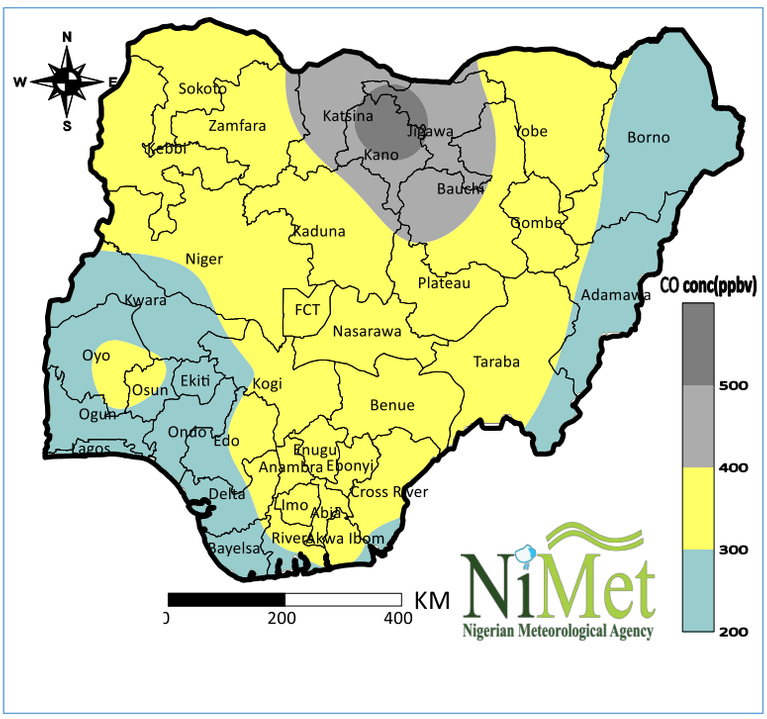

Figure 3.5: Carbon Monoxide (CO) Concentration Over Nigeria in September 2024

In September 2024 the observed monthly mean CO concentration across Nigeria was lower than the WHO recommended 24-hour standard limit of 4 mg/m^3.

CHAPTER FOUR
Quarterly Trends: July-August-September (JAS)

4.1 Observed ITD Positions in July - September 2024

The mean position of the ITD during the third quarter (July, August and September 2024) reached its extreme positions in September. The position of the ITD therefore oscillated between these two extremes (latitudes 18.4°N and 21.9°N) during the quarter. Monthly mean positions were 20.1°N in July, 20.4°N in August and 20.3°N in September. A quarterly mean position of latitude 20.26^{0}N was observed (Figure 4.1). Southwesterly winds with speeds of 5 to 35kts at 925hpa and 850hpa levels dominated the southward zone of the ITD within where the country is located. These wind flows supported atmospheric processes that enhanced rainfall, horizontal visibility and quality of air during the quarter.

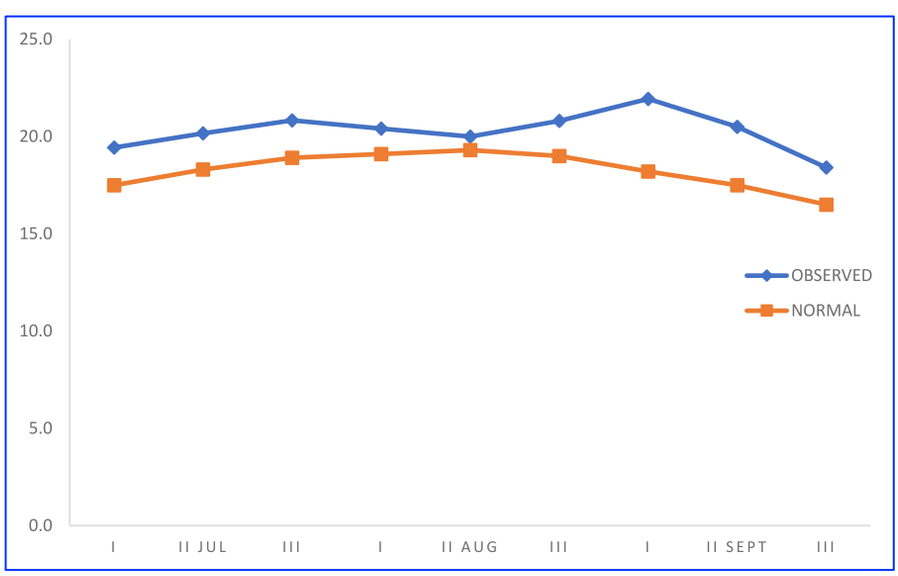

Figure 4.1: Mean ITD position Across Nigeria during the 3rd Quarter of 2024

4.2 Mean Daily Particulate Matter ($PM_{2.5}$) Concentration over Nigeria from July to September 2024

Figure 4.2 shows the lowest and highest daily average $PM_{2.5}$ concentration observed over Nigerian cities during the 3rd quarter of 2024. The highest daily value of 66 µg/m^{3} and seasonal mean of 28 µg/m^{3} was observed over Kano while the lowest daily average of 3 µg/m^{3} was observed over Jos.

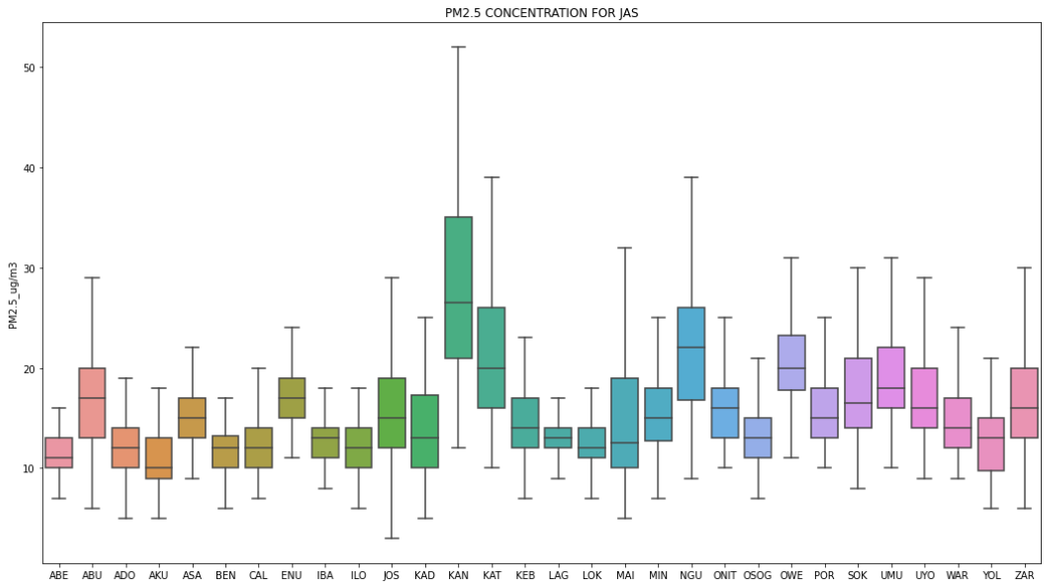

Figure 4.2: Mean Daily Particulate Matter ($PM_{2.5}$) Concentration over Nigerian Cities in the Third Quarter of 2024

Most of the cities in the country experienced a seasonal average $PM_{2.5}$ concentrations that were higher than the WHO threshold of 15 µg/m^3 in 24 hours. This suggests that Nigerians were exposed to health risks associated with high concentrations of $PM_{2.5}$ in the atmosphere during the 3rd quarter of 2024.

4.3 Monthly Mean Particulate Matter ($PM_{2.5}$) Concentration over the country from July to September 2024

From Figure 4.2, it can be deduced that in September 2024 all the cities in the country recorded peak values of PM2.5 concentration with the exception of Maiduguri and Nguru where the highest average PM2.5 concentration was recorded in July Kano recorded the highest average concentration of 38 µg/m^3 in September.

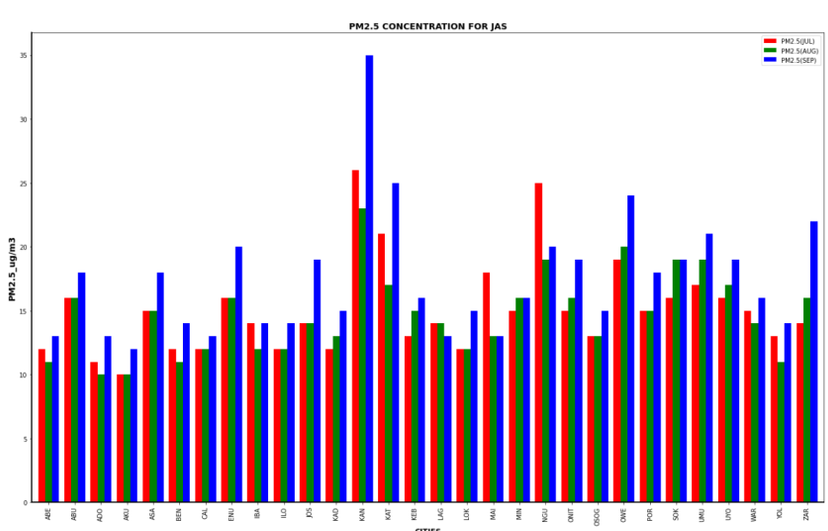

Figure 4.3: $PM_{2.5}$ concentration over cities in Nigeria from July to September, 2024

The lowest average concentration was however recorded over Akure and Ado Ekiti with both cities experiencing average concentration of 10 µg/m^3. The observed daily values of most cities were above WHO threshold of 15 µg/m^3 in 24 hours which suggest that people in these areas were exposed to high health risks of PM2.5 concentration.

4.4 Spatial Analysis of Mean Particulate Matter $PM_{2.5}$ Concentration in the Third Quarter of 2024

The spatial distribution of mean concentration of particulate matter $PM_{2.5}$ across Nigeria for July to September 2024 is shown in Figure 4.4. The lowest mean $PM_{2.5}$ concentration range of 10 µg/m^3 to 15 µg/m^3 was recorded in parts of Niger, Kwara, Kogi, Taraba, Adamawa, western Kaduna and the south western region parts of Nigeria. Sokoto, Zamfara, Bauchi, Gombe, Yobe, Nasarawa, Benue, Enugu, Anambra, Ebonyi, Delta, Bayelsa, Rivers, Abia, Akwa Ibom and part of Borno and Kaduna states, as well as the FCT Abuja, recorded mean $PM_{2.5}$ concentrations in the range of 15 to 20 µg/m^3. Few places in states such as Katsina, southern Kano, southern Jigawa and northern Bauchi recorded mean $PM_{2.5}$ concentration ranging from 20 µg/m^3 to 25 µg/m^3. The highest $PM_{2.5}$concentrations of 25 µg/m^3 and above were reported over Kano and environs. Generally, $PM_{2.5}$ concentrations over most cities in the country during the period of July through September 2024 was above WHO air quality guidelines limit of 15 µg/m^3 per 24-hour period. The maximum, minimum and mean $PM_{2.5}$ concentrations recorded in July, August and September are summarized in Table 3.

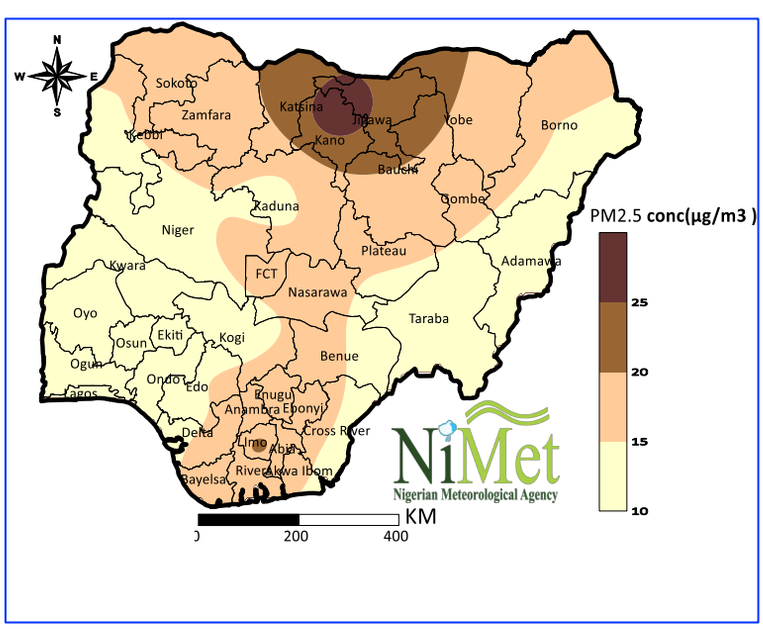

Figure 4.4: Mean $PM_{2.5}$ Concentration Across Nigeria from July to September 2024

TABLE 3: MAXIMUM, MINIMUM AND MEAN CONCENTRATION OF PARTICULATE MATTER $PM_{2.5}$ ($\mu g/m^3$) FROM JULY TO SEPTEMBER 2024

	JULY			AUGUST			SEPTEMBER		
STATION	**Maximum**	**Minimum**	**Mean**	**Maximum**	**Minimum**	**Mean**	**Maximum**	**Minimum**	**Mean**
ABEOKUTA	18	8	12	15	7	11	25	9	13
ABUJA	29	7	16	27	6	16	31	8	18
ADO EKITI	15	5	11	14	5	10	25	7	13
AKURE	16	6	10	18	5	10	30	6	13
ASABA	21	11	15	26	9	15	28	10	18
BENIN	17	9	12	22	6	11	33	8	14
CALABAR	20	9	12	17	8	12	28	7	13
ENUGU	22	11	16	24	11	16	32	13	20
IBADAN	28	9	15	17	8	12	31	8	14
ILORIN	21	7	12	18	6	12	41	7	14
JOS	22	6	14	29	3	14	30	9	19
KADUNA	22	6	12	25	5	14	29	5	15
KANO	52	12	26	44	13	24	66	19	36
KATSINA	39	12	21	26	10	17	38	14	25
KEBBI	21	8	13	23	7	15	31	8	17
LAGOS	31	9	14	26	10	14	27	11	13
LOKOJA	18	6	12	20	5	12	30	8	15
MAIDUGURI	32	7	18	29	6	13	29	5	13
MINNA	26	8	15	24	7	16	27	9	16
NGURU	40	10	25	33	10	19	31	9	20
ONITSHA	26	10	15	25	11	16	34	10	19
OSOGBO	17	7	13	24	7	13	26	10	15
OWERRI	29	11	19	29	12	20	37	14	24
PORT HARCOURT	31	11	16	28	10	16	31	10	18
SOKOTO	33	9	16	30	9	19	33	8	19
UMUAHIA	29	11	18	34	10	19	31	13	21
UYO	24	11	16	34	9	17	30	11	19
WARRI	29	12	16	28	9	15	26	10	16
YOLA	26	6	13	19	6	11	28	6	14
ZARIA	26	7	14	32	6	16	34	9	22

4.5 Regional concentration of Particulate Matter ($PM_{2.5}$) over cities in Northern Nigeria in the Third Quarter of 2024

Concentration of $PM_{2.5}$ during the 3rd quarter of 2024 ranged from 5.0µg/m^3 to 66.0µg/m^3 over the northern states of Nigeria (Figure 4.5). Kano recorded the highest $PM_{2.5}$ concentration in September 2024. This could be attributed to the sharp decrease in rainfall over the North as a result of the southward pull of the ITD in the 3rd dekad of September. These conditions activated the Zone A (Dust Haze region) of the ITD, and in the presence of strong surface and lower atmospheric level winds, caused dust to be raised and transported to the region, thereby causing high concentration of $PM_{2.5}$ over most Northern cities. Kaduna experienced the lowest (5.0µg/m^3) $PM_{2.5}$ concentration on the 23rd August, 31st August and September 7th, 2024.

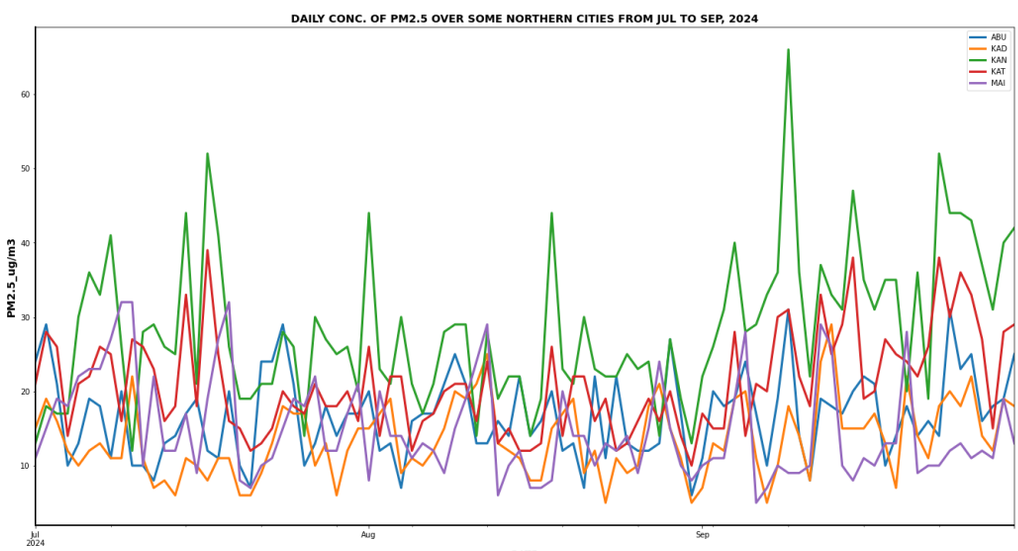

Figure 4.5: Daily concentration of Particulate Matter ($PM_{2.5}$) over cities in Northern Nigeria from July to September, 2024

The observed daily values were above WHO threshold of 15 µg/m^3 in 24 hours over most Northern cities. Such high level of $PM_{2.5}$ concentration in the atmosphere was unhealthy for people in the region.

4.6 Regional Concentration of Particulate Matter ($PM_{2.5}$) over cities in Southern Nigeria in the Third Quarter of 2024

Most parts of southern Nigeria recorded $PM_{2.5}$ concentration between 5.0µg/m^3 and 32.0µg/m^3 during the months of July to September, 2024 (Figure 4.6). The highest concentration of 32.0µg/m^3 was recorded over Enugu on the 8th of September, 2024, while Akure experienced the lowest $PM_{2.5}$ concentration of 5.0µg/m^3 on the 31st of August, 2024. Generally, the mean concentration of $PM_{2.5}$ levels in most of the southern cities were lower in July and August than September possibly as a result the observed changes in pattern of rainfall during the period.

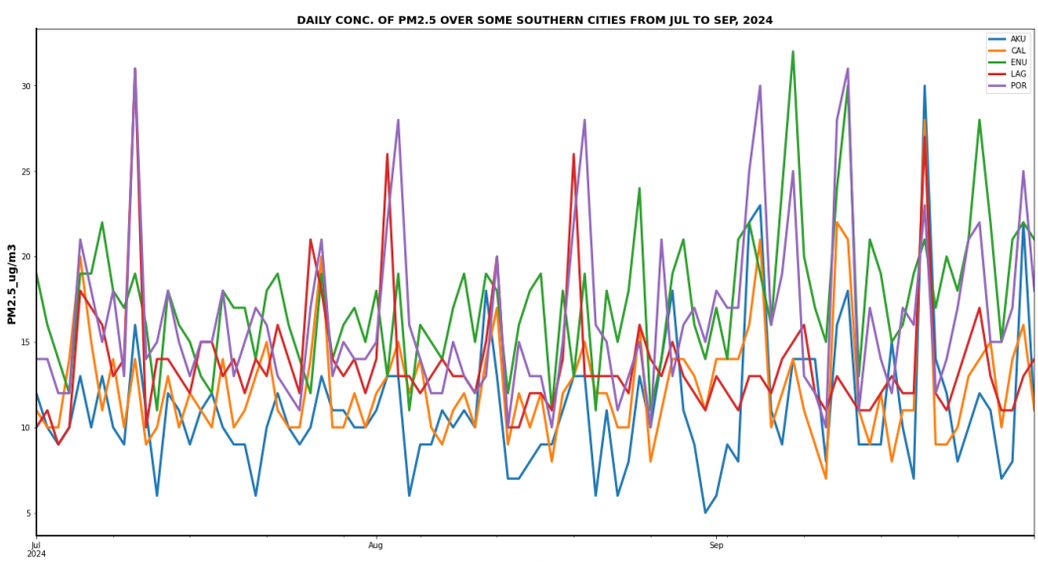

Figure 4.6: Daily concentration of Particulate Matter ($PM_{2.5}$) over cities in southern Nigeria in the Third Quarter of 2024

The observed daily concentrations of $PM_{2.5}$ were above 15 µg/m^3 in 24 hours over most southern cities, which is higher than WHO threshold of 15 µg/m^3. Consequently, most people in the South were exposed to some high health risks associated with high levels of $PM_{2.5}$ in the atmosphere.

4.7 Spatial Distribution of Mean Nitrogen Dioxide (NO_2) Concentration Over Nigeria in the Third Quarter of 2024

The mean concentration of nitrogen dioxide during the 3rd quarter of 2024 was observed to be highest over FCT-Abuja, Lagos, Kano, Jigawa, and Sokoto and parts of Katsina, Yobe, and Kaduna where values of 4.0 to 8.0 µg/m^3 were recorded (Figure 4.7). The NO_2 levels remained lowest over Taraba, Benue and Adamawa, with concentration levels that ranged between 1.0 and 2.0 µg/m^3. The analysis also showed that most parts of the country experienced moderate to good NO_2 concentration levels between 2.0 and 4.0 µg/m^3 suggesting cleaner air quality in terms of NO_2 levels. Overall mean value of 3.41 µg/m^3 NO_2 concentration recorded across the country from July to September 2024 was below the WHO recommended standard of 25 µg/m^3 in 24 hours.

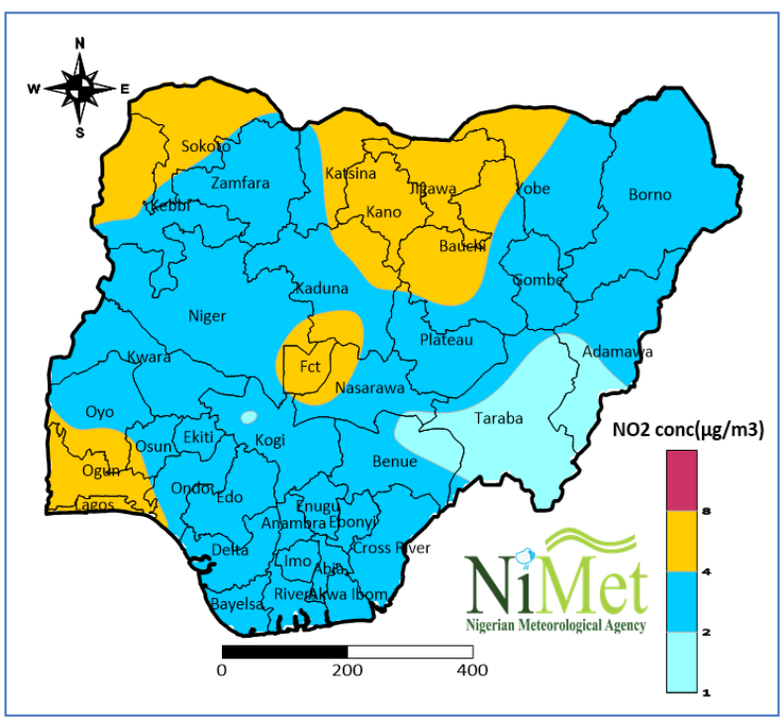

Figure 4.7: Nitrogen Dioxide (NO_2) Mean Concentration Over Nigeria in the Third Quarter of 2024

4.8 Regional Daily Mean Concentration of NO_2 Over Cities in Northern Nigeria in the Third Quarter of 2024

As shown in Figure 4.8 there was a rising trend in NO_2 concentration with intermittent peaks, particularly in Abuja, Kano, and Katsina during the 3rd quarter of 2024. Bauchi, Maiduguri, Jalingo and Kebbi cities maintained stable NO_2 concentration levels during the period, suggesting cleaner air and fewer pollution sources. Daily mean concentration generally ranged between 1.2 and 19.8 µg/m^3. Abuja recorded the highest single day mean NO_2 concentration of 19.8 µg/m^3. This occurred on 19th September, 2024, while the lowest single day mean value of 0.38 µg/m^3 was observed on 17th August, 2024 over Jalingo. Generally the observed NO_2 mean monthly levels in the atmosphere over Nigeria were highest in September and lower in August than July. The observed increases in the NO_2 from mid to late September could be linked to seasonal effects or increased emissions.

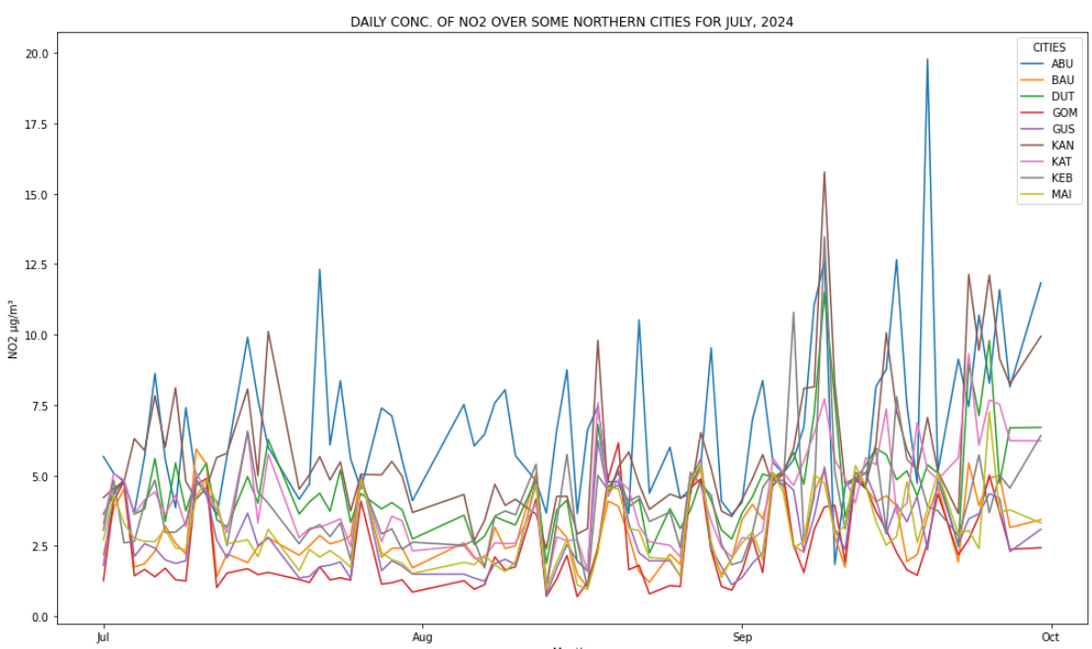

Figure 4.8: Daily Concentration of NO_2 over Cities in Northern Nigeria from July to September, 2024

Reduced rainfall in September over northern Nigeria signalled the beginning of dry season with reduced humidity, variable winds which could enhance transportation of emissions from both industrial and vehicular sources over the region. This could explain the significant NO_2 pollution spikes seen in September. The observed daily and monthly mean levels of NO_2 throughout the 3rd quarter of 2024 are however, lower than WHO standard limit of 25 µg/m^3 in 24 hours without serious threat to health of persons living in northern Nigeria.

4.9 Regional Daily Mean Concentration of NO_2 Over Cities in Southern Nigeria Over Nigeria in the Third Quarter of 2024

In southern Nigeria, the mean NO_2 levels in the atmosphere during the 3rd quarter of 2024 were generally below 6µg/m³. The overall daily mean concentration ranged between 0.45 and 10.86 µg/m³. However, spikes were observed over Ikeja in Lagos State and Benin in Edo State during the 1st week of July, and late August and September. Akure, Onitsha, and Calabar maintained lower levels of NO_2 concentration and cleaner air throughout JAS. Ikeja consistently maintained higher NO_2 concentration levels during the 3rd quarter of the year, with daily average peak values of 10.86 µg/m³ in July, 9.74 µg/m³ in August and 10.81 µg/m³ in September. This could be linked to its status as a commercial hub with high vehicular emissions and industrial presence. The lowest value of 0.45 µg/m³ was recorded over Akure on 13th August, 2024.

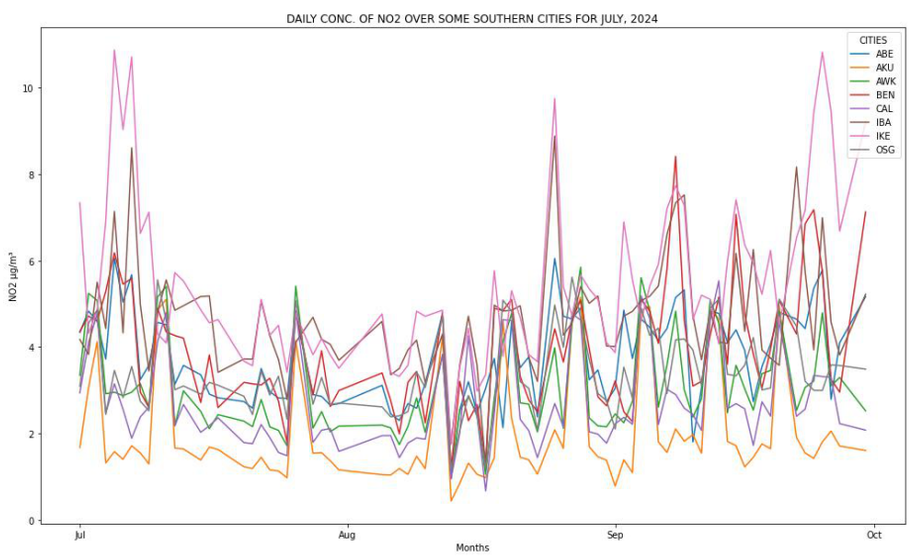

Figure 4.8: Daily Concentration of NO_2 over Cities in Southern Nigeria from July to September, 2024

The Southwest may have experienced higher NO_2 concentrations with urbanization and industrial emissions playing a dominant role, the observed high levels were also below WHO limits as was the case in the northern Nigeria. The maximum, minimum and mean concentrations of NO_2 recorded over cities in Nigeria during the period are tabulated in Table 6.

TABLE 6: MAXIMUM, MINIMUM AND MEAN CONCENTRATION OF NITROGEN DIOXIDE (NO_2) ($\mu g/m^3$) FOR JULY TO SEPTEMBER 2024

	JULY			AUGUST			SEPTEMBER		
STATION	Maximum	Minimum	Mean	Maximum	Minimum	Mean	Maximum	Minimum	Mean
ABEOKUTA	2.32	1.57	1.82	6.05	0.96	3.33	5.78	1.81	1.82
ABUJA	6.06	2.59	3.01	10.52	3.61	5.93	19.77	1.84	3.01
ADO EKITI	12.31	3.59	6.43	4.85	0.79	2.44	4.85	1.06	6.43
AKURE	5.10	1.26	2.25	5.15	0.45	1.85	4.95	0.79	2.25
ASABA	5.10	0.98	1.56	4.98	0.95	2.61	5.18	2.05	1.56
BENIN	5.93	1.41	2.66	5.10	1.18	3.33	8.40	2.28	2.66
CALABAR	6.18	1.79	3.15	4.77	0.68	2.44	5.53	1.73	3.15
ENUGU	6.28	2.75	4.10	5.66	0.81	2.67	5.43	2.09	4.10
IBADAN	5.05	1.34	2.07	8.87	1.22	4.23	8.16	3.58	2.07
ILORIN	10.86	3.42	4.14	5.11	0.76	2.46	4.93	1.66	4.14
JOS	5.40	0.55	1.04	5.13	0.95	2.58	7.58	1.71	1.04
KADUNA	4.91	1.61	2.70	4.88	1.04	2.29	6.09	1.47	2.70
KANO	5.39	1.21	1.92	9.80	2.40	4.38	15.76	3.65	1.92
KATSINA	10.11	3.69	5.28	7.58	1.16	3.15	9.32	2.74	5.28
KEBBI	6.54	2.32	3.40	5.75	0.91	3.50	13.47	1.95	3.40
LAGOS	8.60	2.79	4.05	5.85	1.05	4.51	10.81	3.87	4.05
LOKOJA	4.86	0.95	1.68	5.13	0.82	2.43	7.73	1.27	1.68
MAIDUGURI	5.35	1.47	2.13	5.40	0.96	2.52	7.26	2.00	2.13
MINNA	5.34	0.64	1.55	5.90	0.67	2.63	6.35	1.14	1.55
NGURU	5.09	1.26	2.13	6.33	1.36	3.54	11.92	2.82	2.13
ONITSHA	4.86	1.63	2.23	5.85	1.05	2.77	5.60	2.25	2.23
OSOGBO	6.92	2.63	4.10	5.62	1.17	1.17	5.11	2.11	4.10
OWERRI	5.55	2.34	3.08	5.58	1.00	1.00	6.17	3.04	3.08
PORT HARCOURT	5.60	1.91	2.93	5.07	0.86	0.86	6.50	2.97	2.93
SOKOTO	6.61	1.71	2.61	7.63	1.28	1.28	11.91	2.08	2.61
UMUAHIA	8.82	2.10	3.43	5.08	0.97	0.97	10.93	2.51	3.43
UYO	5.10	1.94	2.73	4.85	0.88	0.88	6.15	2.33	2.73
WARRI	5.63	1.97	2.71	5.40	0.56	0.56	5.68	1.89	2.71
YOLA	5.40	1.45	2.12	4.61	0.62	0.62	5.35	1.25	2.12
ZARIA	6.21	0.95	1.54	5.09	1.26	1.26	8.68	1.94	1.54

4.10 Spatial Distribution of Mean Carbon monoxide (CO) Concentration Over Nigeria in the Third Quarter of 2024

The observed monthly mean concentration of CO generally ranged from 220 to above 500 ppbv across the country during the period under review. The lowest range of 220 to 280 ppbv was observed in some parts of Delta, Bayelsa, Kaduna, Rivers, Ondo, Edo, Akwa Ibom and in Ekiti, Ogun, Lagos, Oyo, Kwara, Adamawa, Borno states, while the highest concentration above 500 ppbv was observed over parts of Katsina, Kano and Jigawa States.

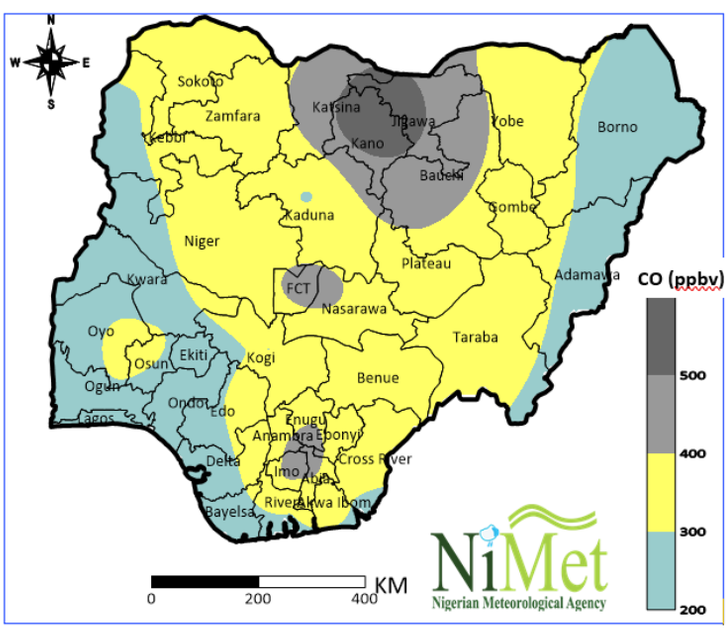

Figure 4.10: Mean Carbon Monoxide (CO) Concentration Over Nigeria in the Third Quarter of 2024

Most states in the country recorded CO concentration of 280 to 340 ppbv with the exception of parts of Anambra, Imo, Enugu, Ebonyi states and the FCT, that recorded concentrations between 340 and 400 ppbv. The observed monthly mean concentration of 280ppbv (0.32 µg/m3) over the country was lower than the WHO 2021 recommended standard of 4.0 µg/m3 in 24 hours.

4.11 Regional Daily Concentration of Carbon monoxide (CO) over Cities in Northern Nigeria in the Third Quarter of 2024

Generally, the concentration of CO over cities in northern Nigeria ranged from 165 to 950 ppbv (0.19 to 1.09 mg/m^3) during JAS season of 2024. As shown in Figure 4.11, during the quarter under review, the lowest CO concentration of 165 ppbv = 0.19 mg/m^3 was recorded over Lokoja on the 14th of August, while the highest concentration (950 ppbv = 1.03mg/m^3) was observed over Kano on the 16th of September 2024. Kano also maintained higher levels than other cities in the region during most days of the 3rd quarter 2024.

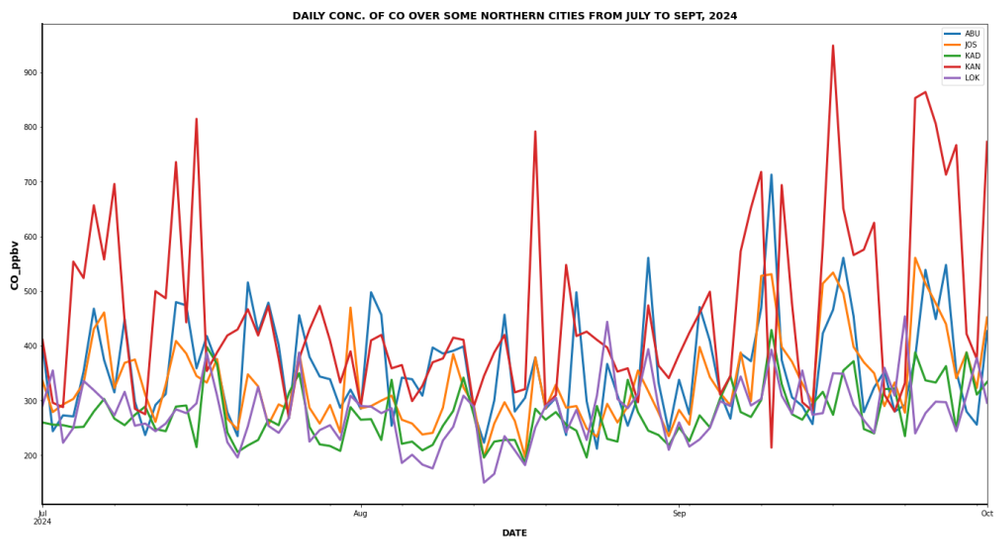

Figure 4.11: Daily Concentration of Carbon monoxide (CO) over Cities in Northern Nigeria in the Third Quarter of 2024

The observed values in the month under review were below WHO threshold of 4 mg/m^3 in 24 hours which implies that there was no serious health risk due to carbon monoxide.

4.12 Regional Daily Concentration of Carbon monoxide (CO) over Cities in Southern Nigeria in the Third Quarter of 2024

In the region, Ikeja recorded the highest CO concentration of 700 ppbv (0.80 mg/m^3) on the 15th of August, while the lowest CO concentration of 130ppbv (0.15 mg/m^3) was observed in Akure, also in August (see Figure 4.12).

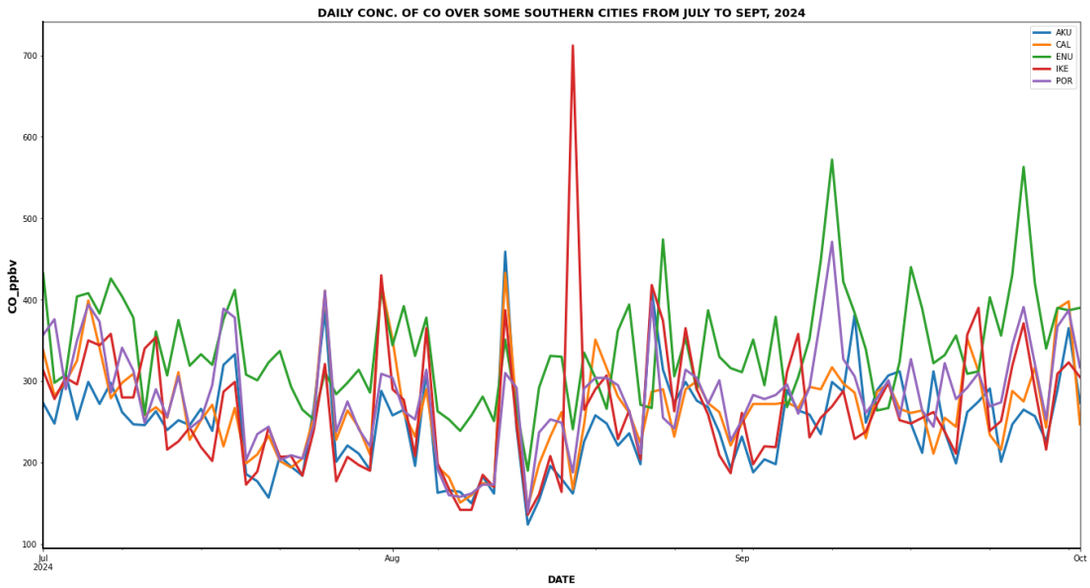

Figure 4.12: Daily Concentration of Carbon monoxide (CO) over Cities in Southern Nigeria in the Third Quarter of 2024

The monthly mean CO concentrations for July, August and September 2024 and daily mean values were less than 500ppbv (0.57 mg/m^3) which is also lower than WHO air quality limit of 4 mg/m^3 in 24 hours, thus the observed CO levels during the period posed no significant threat to human health. The maximum, minimum and mean concentration of CO for cities across Nigeria are summarized in Table 7.

TABLE 7: MAXIMUM, MINIMUM AND MEAN CONCENTRATION OF CARBON MONOXIDE (CO) (ppbv) FOR JULY TO SEPTEMBER 2024

	JULY			AUGUST			SEPTEMBER		
STATIONS	**Maximum**	**Minimum**	**Mean**	**Maximum**	**Minimum**	**Mean**	**Maximum**	**Minimum**	**Mean**
ABEOKUTA	475	227	351	356	236	296	443	229	336
ABUJA	338	242	290	332	227	280	360	231	296
ADO EKITI	364	237	301	400	232	316	355	268	312
AKURE	400	269	335	418	244	331	337	205	271
ASABA	355	236	296	347	205	276	305	198	252
BENIN	348	248	298	433	210	322	326	194	260
CALABAR	291	205	248	304	180	242	279	151	215

ENUGU	333	224	278	338	193	266	357	195	276
IBADAN	503	188	346	461	249	355	431	191	311
ILORIN	409	230	320	485	250	367	522	241	381
JOS	279	196	238	281	200	240	273	188	230
KADUNA	341	235	288	351	248	299	338	233	285
KANO	321	226	273	398	237	317	363	233	298
KATSINA	314	195	254	374	230	302	293	225	259
KEBBI	338	179	259	333	198	265	299	226	263
LAGOS	296	168	232	379	139	259	264	137	201
LOKOJA	325	225	275	346	197	272	294	195	244
MAIDUGURI	266	192	229	347	210	278	287	205	246
MINNA	381	247	314	367	261	314	385	260	323
NGURU	276	184	230	307	216	262	301	199	250
ONITSHA	321	248	285	322	192	257	251	197	224
OSOGBO	466	268	367	488	245	367	426	249	337
OWERRI	329	221	275	338	212	275	266	180	223
PORT HARCOURT	325	206	266	301	185	243	266	152	209
SOKOTO	333	179	256	341	204	272	315	225	270
UMUAHIA	329	225	277	347	203	275	259	186	222
UYO	322	214	268	324	185	254	255	158	206
WARRI	801	219	510	353	187	270	282	182	232
YOLA	285	196	240	315	195	255	270	181	226
ZARIA	332	156	244	350	241	295	346	269	307

4.13 Summary and Conclusion

The 3rd Quarter of 2024 season (JAS) witnessed significant increase in rainfall especially over northern Nigeria. The increase was as a result of the northward oscillation of the ITD which fluctuated between latitudes 18.4°N and 21.9°N, with mean positions of 20.1°N in July, 20.4°N in August and 20.3°N in September. It attained its northernmost position in September and maintained an average position about latitude 20.2°N during the 3rd quarter under review. The observed position of ITD was more northerly than the mean long-term position. Such position favored the influx of moisture laden winds and increase in rainfall over the country. Winds

at 925 and 850hPa levels were predominantly southwesterly direction with moderate speeds. The combined effect of rainfall, humid winds with moderate wind speeds reduced chances of dust uplift, transportation and deposition. Consequently, horizontal visibility was good and not impaired by dust particles in the atmosphere.

The observed average $PM_{2.5}$ concentration in the atmosphere during the period was above WHO standard limits, and therefore posed health risks to Nigerians living in both northern and southern states, even though the PM2.5 from dust sources reduced drastically due to weather conditions that prevailed during the period. The observed levels of NO_2 and CO during July to September season were however, lower than WHO standard limits which posed no significant threat to human health. Generally, an overall good to moderate air quality index with little health impacts prevailed during the quarter under review, except that $PM_{2.5}$ levels posed the greatest health risk to Nigerians during the period from July to September.

Acronyms

AQGs	**Air Quality Guidelines**
CAMS	**Copernicus Atmospheric Monitoring System**
CO	**Carbon monoxide**
CVDs	**Cardiovascular Diseases**
FCT	**Federal Capital Territory**
hPa	**Hectopascal**
ITD	**Inter-Tropical Discontinuity**
Kt	**Knot**
MSLP	**Mean Sea Level Pressure**
mg/m3	**Milligram per cubic meter**
NO2	**Nitrogen dioxide**
O3	**Ozone**
PM	**Particulate Matter**
ppbv	**Part per billion by volume**
PPM	**Part per million**
SO2	**Sulphur dioxide**
WHO	**World Health Organization**
µg/m3	**Microgram per cubic meter**
m	**Micrometer**

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