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Air Pollution and Human Health Implications in Urban Settlements of Abuja, Nigeria

BY

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Abstract

Urban air pollution is one of the major concern of this era, not only because of its impact on the environment but also its impact on public and individual health due to increasing morbidity and mortality. This study assessed the relationship between air pollution and health related diseases in the Federal Capital City (FCC) of Abuja, Nigeria. Eight (8) specific residential and commercial locations were considered during the study from December, 2017 to February, 2018. Field data on the spatial concentration of CO, CH_4, H_2S, O_2 and CO_2, in residential and commercial districts of the study area were collected, using sophisticated automatic air samplers. Eleven-year data on air pollution related diseases were also collected from hospitals within the FCC. The data were analysed to determine the nexus of the air pollutants and health related diseases. The results showed higher mean emission values of CO (<25ppm), H_2S (<2ppm) and CO_2 (<580ppm) at specific locations in the residential and commercial districts above the recommended FMEnv (NESREA), WHO and USEPA standards. The data on air pollution related diseases showed higher incidence of cancer, respiratory and cardiovascular diseases compared to asthma. The 46,919 air pollution related disease cases represents 2.38% of 2016 projected population of Abuja Municipal Area Council (AMAC). There are needs for proactive control measures such as Enforcement of air pollution laws and the implementation of policies that encourage greener city initiative and tree planting. These will help to curtail increase in air pollution and health challenges in the study area.

Key words: Air pollution, Urban environment, Pollutant dispersion, Pollutant emission, Respiratory disease, Cardiovascular disease.

1.0 Introduction

There has been continuous discussions on air pollution and its impact on human health and the environment. This has stimulated global, continental, regional, national, and local studies, articles, and publications on air pollution and its effects. The discussions are centred mainly on outdoor air pollution and its impacts; this has escalated to effects on climate change, agriculture, tourism, industries, among other sectors, in the recent past.

Air pollution is a major threat to human health. It has been linked to adverse health effects such as respiratory irritation and infections, heart disease, lung cancer, bronchitis, premature mortality and decreased life expectancy (Kampa and Castanas, 2008). Long-term effects of air pollution on the onset of diseases such as respiratory infections and inflammations, cardiovascular dysfunctions, and cancer is widely accepted (Yamamoto *et al*., 2014; Ghorani-Azam *et al*., 2016; Manucci and Franchini, 2017; Zhong *et al.*, 2019; Manisalidis *et al*., 2020) hence, air pollution is linked with millions of death globally each year (WHO, 2019). This has been of major concern to various organisations and institutions including World Health Organisation (WHO), European Union (EU), United States Environmental Protection Agency (USEPA), African Union (AU), Economic Communities for West African States (ECOWAS), Federal Ministry of Environment (FMEnv), Abuja Environmental Protection Board (AEPB), etc. The WHO (2018), reported that 91% of premature deaths occurred in low-and middle-income countries, with greater number in South-East and Western Pacific regions, noting that 4.2 million premature deaths were recorded in cities and rural areas worldwide in 2016, as a result of outdoor air pollution.

Ambient outdoor air pollution is one of the environmental challenges of cities; socio-economic, biodiversity and humans (Okobia, 2015; Okobia and Husaini, 2020). It is especially a burdensome factor, because it means harm to people's health as well as deterioration of living conditions (Mesjasz-Lech, 2016). Air pollution was the fifth leading risk factor for death in 2015, exceeded by high blood pressure, smoking, etc. (Fagan, 2017). The United States Environmental Protection Agency (USEPA) in 2018 emphatically expressed concern on air pollutants and the rising cases of asthma, a serious, life-threatening chronic respiratory disease that affects the quality of life for millions of American adults and children. The direct exposure of humans to outdoor pollutants has been linked to respiratory diseases observed in various studies globally, including China (Ding *et al.*, 2017; Zhe *et al.*, 2018).

Air quality in cities of Sub-Saharan African (SSA) countries has deteriorated (Hugo, 2016). When the human body is exposed to air pollutants, respiration may be affected and in more severe cases, may lead to asphyxiation, kidney damage, or coma (Thind, 2013). Lancet Neurology in February 2018, reported that there is a possibility of increased risk in neurological disorders based on environmental risk factors, particularly air pollution. This was the major discuss at the 2nd International Meeting on Environmental Health, held in Strasbourg, France, in 2017 (Lancet Neurology, 2018). Children in Sub Saharan Africa exposed to high concentration of air pollutants will more often develop respiratory ailments, which prevent them from developing and learning well (Schwela, 2012).

Increased urbanization is associated with urban air pollution problems, which in turn results to acidification of the atmosphere, soil, and water resources (Coker and Kizito 2018). The causes of urban air pollution in SSA includes burning of fuel wood, mining, use of fossil fuel in automobiles and power generating plants in commercial and residential buildings, among other anthropogenic activities (Abdullahi *et al*., 2012; Okobia, 2012; 2018; Okobia *et al.*, 2017; Makwe and Okobia, 2020). These has raised a lot of concerns and have generated doubts to research data and results from developing countries based on spot pollution research results. To erase these doubts, this research involved an in-depth analysis of the spatial concentration of air pollutants in Abuja on a local scale, integrating health records to scientific field data. The reason for speculative data is hereby eroded with this study, leaving no doubts to the authenticity of data from developing countries.

2.0 The Study Area

Abuja Municipal Area Council (AMAC) is the urban centre of the Federal Capital Territory (FCT) of Nigeria. It is located between latitude 8°40'N and 9°20'N of the equator and longitude 6°40'E and 7°40'E of the Greenwich meridian. The Federal Capital City (FCC) is situated within AMAC and it is the largest most developed of the six area councils. The major infrastructures and developmental projects are concentrated within AMAC. It has bulk of the built-up areas, designed into phases and districts. The main districts are Asokoro, Maitama, Garki, Wuse, Kado, Jabi, Utako, Gwarinpa I, Gwarinpa II, Central Area and other newly developed districts including Gaduwa, Mabushi, Gudu, Lokogoma, Nbora, Kaura, Kagini, Karsana, Karmo, Guzape, Katampe, Kafe, Karmo, Jahi, Galadimawa, Durumi, Dape, etc has shown recent developmental growth in the FCC. The FCT has a land mass of approximately 8000sq km, of which AMAC occupies about 250sq km with a population of 778,567 people (National Population Commission, 2006). This population was projected to 1,967,500 in 2016 (National Bureau of Statistics, 2017; National Population Commission, 2017).

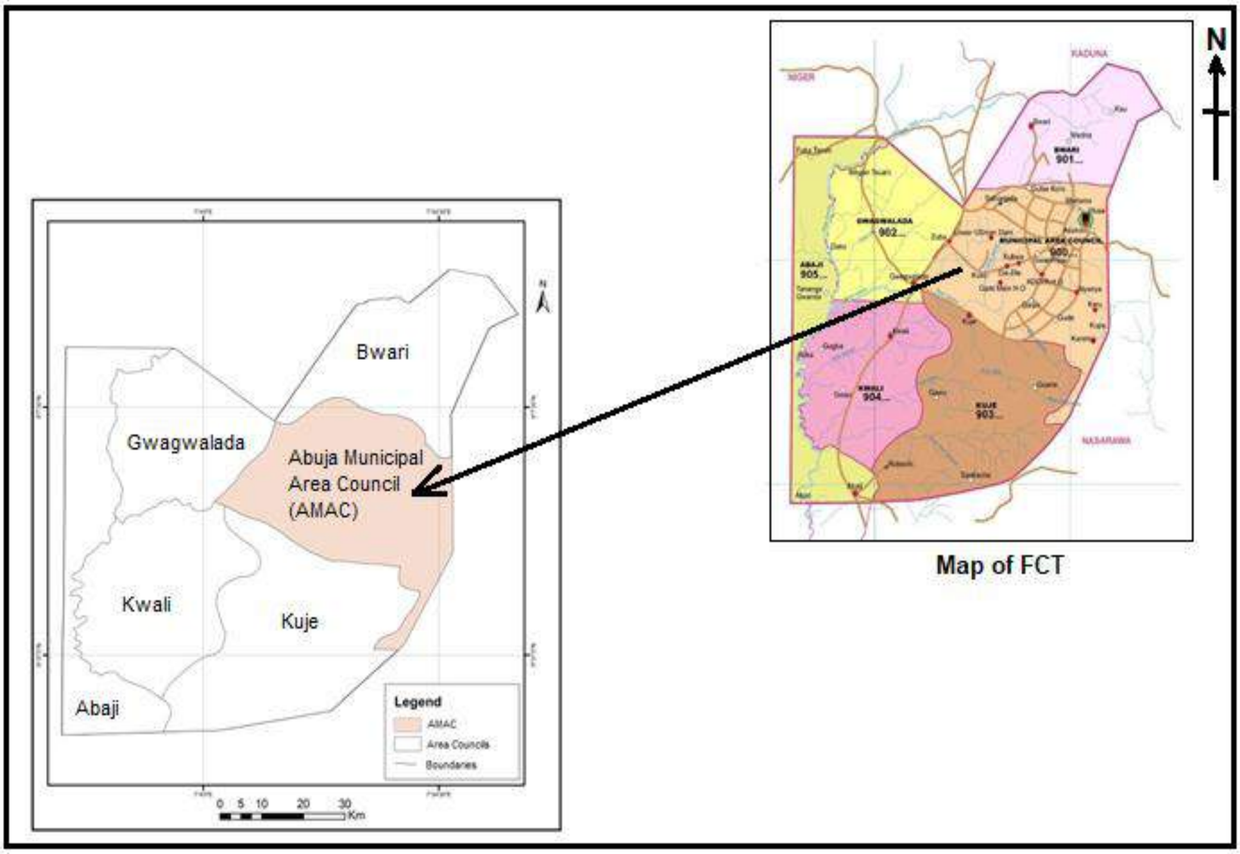

Figure 1: Map of the Federal Capital Territory Showing Abuja Municipal Area Council

2.1 Climate

The climate of the Abuja Municipal Area Council is quite similar to that of the entire Federal Capital Territory. It is the hot, humid, and tropical type. The climate is such that its major elements have regimes that are transitional from those of the Southern and the Northern parts of the FCT.

The available information extrapolated from adjacent weather stations, showed that the study area has temperatures ranging from 21^0C – 26.7^0C yearly and a total annual rainfall of approximately 1,650mm. About 60% of the annual rains fall during the month of July, August and September (Nigeria Metrological Agency NIMET, 2010). The temperatures are higher during the dry season months, when the mean minimum and maximum temperatures are 30^0C and 35^oC. During the rainy seasons on the other hand, the mean temperature ranges between 21ºC and 33ºC (NIMET, 2015). A crucial climatic characteristic of this area is the frequent occurrence of squall lines heralded by thunderstorms, lightening, strong winds and rainfall of high intensity (Hassan and Okobia, 2008).

3.0 Materials and Methods

3.1 Field Data Collection

The field data collection was done between year 2015 and 2018 using selective sampling techniques, concentrating on the key settlements (residential and commercial) within the urban areas during the dry seasons (December to February). The pollutants gases (H_2S, CO, O_2, CH_4 and CO_2) were acquired directly from the field, at eight specific residential and commercial locations in the study area as shown in Figure 2 at 6.00hour, 10.00hour, 18.00hour and 22.00hour (WAT), with over 576 observations. These precision and calibrated instruments; Garmin® GPSMAP® 60Cx, global positioning system, was used to obtain the point location coordinates, GasAlert® MicroClip, RKI GX-2009 Multi-Gas, MSA ALTAIR® 4X, for H_2S, CO, O_2 and CH_4, while AMPROBE CO2-100, gas detection instrument with a self-calibration capability of ±30 ppm ±5%rdg (0–5000) accuracy was used to detect CO_2 gases. These instruments meet World Health Organisation, United States Environmental Protection Agency and Nigerian Air Quality Standards Table 1. The field observations were done in compliance with local and global regulations.

3.2 Health Data Collection

Hospital records for a period of eleven years (2007 to 2017) for respiratory tract diseases, cardiovascular diseases, Asthma and cancer were obtained from two specialist hospitals within the urban areas.

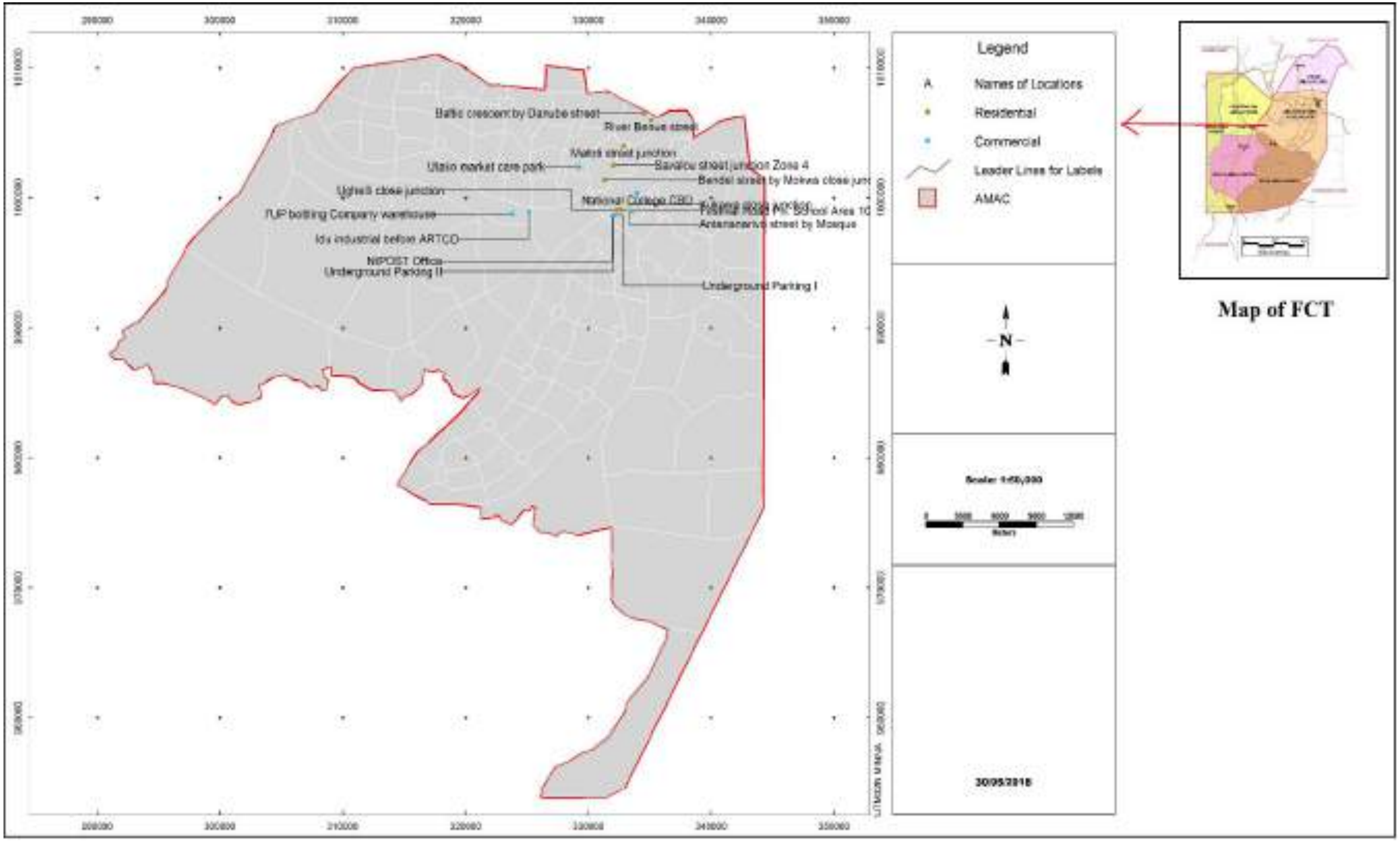

Figure 2: Map Showing Abuja Municipal Area Council Showing the points from which Air Measurements were Taken.

4.0 Results

The results of the air quality measurements for the residential and commercial areas in Abuja Municipal Area Council (AMAC) are as presented in Table 2 and Table 3, with Table 1 showing the air quality standards

Table 1: Air Quality Standards

STANDARDS	**H_2S (ppm)**	**CO (ppm)**	**O_2 (%)**	**LEL (Methane) (%)**	**OSHA & ASHRAE CO_2 (ppm)**
Time	HR Mean	Hr Mean	Hr Mean	Hr Mean	24hr
WHO (AQG)	0.005	10	20.9	0.005	-
FRN NESREA (NAQS)	0.008	20	20.9	0.7	-
US EPA (AQI)	0.005	20	20.9	0.008	350-450
NIOSH	-	-	-	0.1	-

Table 1. Residential Districts in AMAC Mean Dry Season Air Pollutants Field Data Results

Sampling Points	X	Y	Location	H_2S	CO	O_2	CH_4	CO_2	Outdoor Air Pollutants hours	Land Use
P1	332671	999116	Ughelli close junction Garki Area 2	2.00	25.00	20.90	0.00	516.00	6.00	Residential
P2	332294	999081	Bendel street by Mokwa close junction	1.00	8.00	20.90	0.00	487.00	6.00	Residential
P3	333317	999520	Kukawa close junction Area 10	0.00	6.00	20.90	0.00	544.00	6.00	Residential
P4	331309	1001402	Antananarivo street by Mosque	0.00	11.00	20.90	0.00	460.00	6.00	Residential
P5	332051	1002538	Mbala street junction Wuse Zone 4	1.00	6.00	20.90	0.00	466.00	6.00	Residential
P6	332860	1004002	Mafoti street junction Wuse II	0.00	12.00	20.90	0.00	563.00	6.00	Residential
P7	334556	1006543	Baltic crescent by Danube street Maitama	1.00	4.00	20.90	0.00	528.00	6.00	Residential
P8	335118	1006001	River Benue street Maitama	0.00	3.00	20.90	0.00	515.00	6.00	Residential
P1	332671	999116	Ughelli close junction Garki Area 2	0.00	0.00	20.90	0.00	512.00	10.00	Residential
P2	332294	999081	Bendel street by Mokwa close junction	0.00	4.00	20.90	0.00	526.00	10.00	Residential
P3	333317	999520	Kukawa close junction Wuse Zone 2	0.00	0.00	20.90	0.00	465.00	10.00	Residential
P4	331309	1001402	Antananarivo street by Mosque	0.00	3.00	20.90	0.00	476.00	10.00	Residential
P5	332051	1002538	Savalou street junction Wuse Zone 4	0.00	8.00	20.90	0.00	504.00	10.00	Residential
P6	332860	1004002	Mafoti street junction Wuse II	0.00	3.00	20.90	0.00	465.00	10.00	Residential
P7	334556	1006543	Baltic crescent by Danube street Maitama	0.00	2.00	20.90	0.00	429.00	10.00	Residential
P8	335118	1006001	River Benue street Maitama	0.00	1.00	20.90	0.00	425.00	10.00	Residential
P1	332671	999116	Ughelli close junction Garki Area 2	0.00	0.00	20.90	0.00	513.00	18.00	Residential
P2	332294	999081	Bendel street by Mokwa close junction	0.00	2.00	20.90	0.00	486.00	18.00	Residential
P3	333317	999520	Kukawa close junction Wuse Zone 2	0.00	0.00	20.90	0.00	479.00	18.00	Residential
P4	331309	1001402	Antananarivo street by Mosque	0.00	3.70	20.90	0.00	492.00	18.00	Residential
P5	332051	1002538	Savalou street junction Wuse Zone 4	0.00	12.00	20.90	0.00	503.00	18.00	Residential
P6	332860	1004002	Mafoti street junction Wuse II	0.00	4.30	20.90	0.00	471.00	18.00	Residential
P7	334556	1006543	Baltic crescent by Danube street Maitama	0.00	3.70	20.90	0.00	441.00	18.00	Residential
P8	335118	1006001	River Benue street Maitama	0.00	2.00	20.90	0.00	435.00	18.00	Residential
P1	332671	999116	Ughelli close junction Garki Area 2	0.00	0.00	20.90	0.00	536.00	22.00	Residential
P2	332294	999081	Bendel street by Mokwa close junction	0.00	0.00	20.90	0.00	570.00	22.00	Residential
P3	333317	999520	Kukawa close junction Wuse Zone 2	0.00	0.00	20.90	0.00	481.00	22.00	Residential
P4	331309	1001402	Antananarivo street by Mosque	0.00	3.00	20.90	0.00	492.00	22.00	Residential
P5	332051	1002538	Savalou street junction Wuse Zone 4	0.00	3.00	20.90	0.00	501.00	22.00	Residential
P6	332860	1004002	Mafoti street junction Wuse II	0.00	4.00	20.90	0.00	473.00	22.00	Residential
P7	334556	1006543	Baltic crescent by Danube street Maitama	0.00	2.00	20.90	0.00	413.00	22.00	Residential
P8	335118	1006001	River Benue street Maitama	0.00	2.00	20.90	0.00	435.00	22.00	Residential

Table 2. Commercial Districts in AMAC Mean Dry Season Air Pollutants Field Data Results

Sampling Points	X	Y	Location	H_2S	CO	O_2	CH_4	CO_2	Outdoor Air Pollutants hours	Land Use
P1	332073	998657	Underground Parking, I Garki Area 1	0.00	7.00	20.90	0.00	411.00	6.00	Commercial
P2	332081	998616	Underground Parking II	0.00	0.00	20.90	0.00	424.00	6.00	Commercial
P3	331954	998616	NIPOST Office	0.00	0.00	20.90	0.00	400.00	6.00	Commercial
P4	333582	998992	Festival Road Primary School Garki Area 10	1.00	12.00	20.90	0.00	516.00	6.00	Commercial
P5	333957	1000370	National College Central Business District	1.00	9.00	20.90	0.00	434.00	6.00	Commercial
P6	329237	1002414	Utako market care park	1.00	0.00	20.90	0.00	501.00	6.00	Commercial
P7	325183	998933	Idu industrial before ARTCO	1.00	4.00	20.90	0.00	580.00	6.00	Commercial
P8	323827	998760	7UP bottling Company warehouse	1.00	0.00	20.90	0.00	517.00	6.00	Commercial
P1	332073	998657	Underground Parking I Garki Area 1	0.00	4.00	20.90	0.00	400.00	10.00	Commercial
P2	332081	998616	Underground Parking II	0.00	0.20	20.90	0.00	419.00	10.00	Commercial
P3	331954	998616	NIPOST Office	0.00	0.00	20.90	0.00	402.00	10.00	Commercial
P4	333582	998992	Festival Road Primary School Garki Area 10	0.10	8.60	20.90	0.00	477.00	10.00	Commercial
P5	333957	1000370	National College Central Business District	0.10	2.00	20.90	0.00	415.00	10.00	Commercial
P6	329237	1002414	Utako market care park	0.00	1.00	20.90	0.00	408.00	10.00	Commercial
P7	325183	998933	Idu industrial before ARTCO	0.10	0.60	20.90	0.00	499.00	10.00	Commercial
P8	323827	998760	7UP bottling Company warehouse	0.20	0.00	20.90	0.00	428.00	10.00	Commercial
P1	332073	998657	Underground Parking I Garki Area 1	0.50	15.00	20.90	0.00	405.00	18.00	Commercial
P2	332081	998616	Underground Parking II	0.50	0.00	20.90	0.00	434.00	18.00	Commercial
P3	331954	998616	NIPOST Office	0.00	0.00	20.90	0.00	406.00	18.00	Commercial
P4	333582	998992	Festival Road Primary School Garki Area 10	0.50	7.00	20.90	0.00	501.00	18.00	Commercial
P5	333957	1000370	National College Central Business District	0.50	1.00	20.90	0.00	448.00	18.00	Commercial
P6	329237	1002414	Utako market care park	0.00	0.00	20.90	0.00	395.00	18.00	Commercial
P7	325183	998933	Idu industrial before ARTCO	0.00	1.00	20.90	0.00	515.00	18.00	Commercial
P8	323827	998760	7UP bottling Company warehouse	0.00	0.00	20.90	0.00	419.00	18.00	Commercial
P1	332073	998657	Underground Parking I Garki Area 1	0.00	2.00	20.90	0.00	383.00	22.00	Commercial
P2	332081	998616	Underground Parking II	0.00	0.00	20.90	0.00	383.00	22.00	Commercial
P3	331954	998616	NIPOST Office	0.00	0.00	20.90	0.00	400.00	22.00	Commercial
P4	333582	998992	Festival Road Primary School Garki Area 10	0.00	7.00	20.90	0.00	458.00	22.00	Commercial
P5	333957	1000370	National College Central Business District	0.00	1.00	20.90	0.00	407.00	22.00	Commercial
P6	329237	1002414	Utako market care park	0.00	2.00	20.90	0.00	413.00	22.00	Commercial
P7	325183	998933	Idu industrial before ARTCO	0.50	1.00	20.90	0.00	478.00	22.00	Commercial
P8	323827	998760	7UP bottling Company warehouse	0.00	2.00	20.90	0.00	413.00	22.00	Commercial

4.1 Spatial Concentration of Pollutants

4.1.1 Residential Area

The mean dry season air pollutants result for the residential district sample locations in the study area are as presented in Table 2. The pollutant gases mean emission values are as follows:

CO: At the 6.00hours off-peak observation time, mean CO emission values were recorded at points P1 (Garki Area 2), P4 (Antananarivo Street by Mosque) and P6 (Wuse II) with values as 25ppm, 11ppm and 12ppm respectively. These are higher than the World Health Organisation recommended standard values of 10ppm. The CO values at points P4 and P6 are however within 20ppm recommendations of NESREA and USEPA. The 12ppm mean CO emission recorded at the 18.00hours (peak period) observation time at point P5 (Wuse Zone 4) is also higher than the WHO standard but within the recommendations of NESREA and USEPA. The CO emission values at the 10.00hours and 22.00hours observation time are within normal at all the selected measuring points. Garki Area 2 therefore has the highest residential area CO emission across the points (Table 2).

CO_2: The residential mean carbon dioxide (CO_2) emission level is higher than the OSHA (1996) and ASHRAE (1989) recommended standard values of 350 – 450ppm (Table 1) across the different sampling points at the different observation times (6.00hour – 22.00hours), with the highest values of 563ppm recorded at 6.00hrs at P6 (Mafoti Street Junction Wuse II), 526ppm recorded at 10.00hours at P2 (Bendel Street by Mokwa close junction), 513ppm recorded at 18.00hours at P1 (Ugheli close junction Garki Area 2) and 570ppm recorded at 22.00hours at P2 (Bendel Street by Mokwa close junction) (see Table 2). These are high population density residential areas within the Federal Capita City. The results in Table 2 however showed that the mean CO_2 emission at 10.00hours, 18.00hours and 22.00hours observation times for points P7 and P8 in Maitama, a low population density area, are within the OSHA (1996) and ASHRAE (1989) recommended standard values of 350 – 450ppm.

H_2S: The mean Hydrogen Sulphide (H_2S) emission level values were higher than the WHO, NESREA and USEPA (Table 1) recommended standard values at points P1, P2, P5 and P7, with values ranging from 1ppm to 2ppm at the 6.00hours observation time. However, the mean Hydrogen Sulphide (H_2S) emission level values were within the recommended standard value at all the sampling points from 10.00hours to 22.00hours.

O_2 and CH_4: Oxygen (O_2) and Methane (CH_4) levels were within normal at all the residential locations. The National Institute for Occupational Safety and Health's (NIOSH) maximum recommended safe methane concentration for workers during an 8-hour period is 1,000 ppm (0.1%).

4.1.2 Commercial Area

The mean dry season air pollutants result for the commercial district sample locations in the study area is as presented in Table 3. The pollutant gases mean emission values are as follows:

CO: The carbon monoxide mean emission level across the commercial areas at all the observation times (6.00hours, 10.00hours, 18.00hours and 22.00hours) were predominantly within the recommended standard values, except for point P4 (12ppm) at 6.00hours and point P1 (15ppm) at 18.00hours (Table 3), which were higher than the WHO recommended standards but still within the NESREA and USEPA recommended standards (Table 1).

CO_2: The mean carbon dioxide emission level at the 6.00hours observation time band are higher than the OSHA (1996) and ASHRAE (1989) recommended standard values of 350 – 450ppm (Table 1) at sampling points P4 (Gatrki Area 10), P6 (Utako market car park), P7 (Idu Industrial Area) and P8 (7UP company warehouse), with emission values ranging from 501ppm to 580ppm. At the observation time bands of 10.00hours, 18.00hours and 22.00hours, the mean CO_2 emission level remained higher than the recommended standard values at points P4 and P7, but are predominantly normal at the rest of the sampling locations (Table 3). Points P4 and P7 are very busy commercial areas in the Federal Capital City and this explains the consistently high CO_2 emission level in those areas.

H_2S: The mean Hydrogen Sulphide emission level in the commercial districts at all observation time bands (6.00hrs, 10.00hrs, 18.00hrs and 22.00hrs) are higher than the recommended standard value at most of the sampling points (Table 3).

O_2 and CH_4: Oxygen (O_2) was normal at 20.9%, while Methane (CH_4) recorded no emission value at all locations and times. It is therefore within the NIOSH recommended standard.

4.2 Pollutant Dispersion

The spatial concentration of the pollutants (H_2S, CO and CO_2) are as presented in Figure 3 while the dispersed concentration of each pollutant are presented in Figure 4, Figure 5 and Figure 6 respectively. The concentration of H_2S is not only centred on the commercial activity areas such as Utako market and Idu industrial layout areas, but also in residential areas such as Garki Areas 1 and 2, where commercial activities from Area 1 shopping centre, shopping complex and Area 2 corner shops are within 100m to 200m of residential districts, thus warranting the emission of H_2S as air pollutant (Figure 4).

The concentration of carbon dioxide, presented in Figure 5, has a dispersion emission trend across all settlement types; residential, industrial, schools, markets, commercial business centres, etc. This calls for concern owing to CO_2 categorization as Green House Gas (GHG) and the global threats of GHGs to the environment, human health, biodiversity and climate change.

Also worthy of concern is the high concentration of carbon monoxide in residential areas in Wuse II, Wuse Zone 4, Garki Area 1 and Garki Area 2 among other areas (Figure 6). The emission trend is similar to that of H_2S, as CO in these areas were concentrated around residential areas with high volume of commercial activities.

Generally the Carbon monoxide emission is lower than the recommended standards at most of the sampling locations. The highest Carbon dioxide mean emission value was 580ppm at ARTCO factory in Idu Industrial layout (P7) and the lowest was 383ppm at Area 1 shopping centre underground car parks (P1 and P2) during the 10.00pm observation time period.

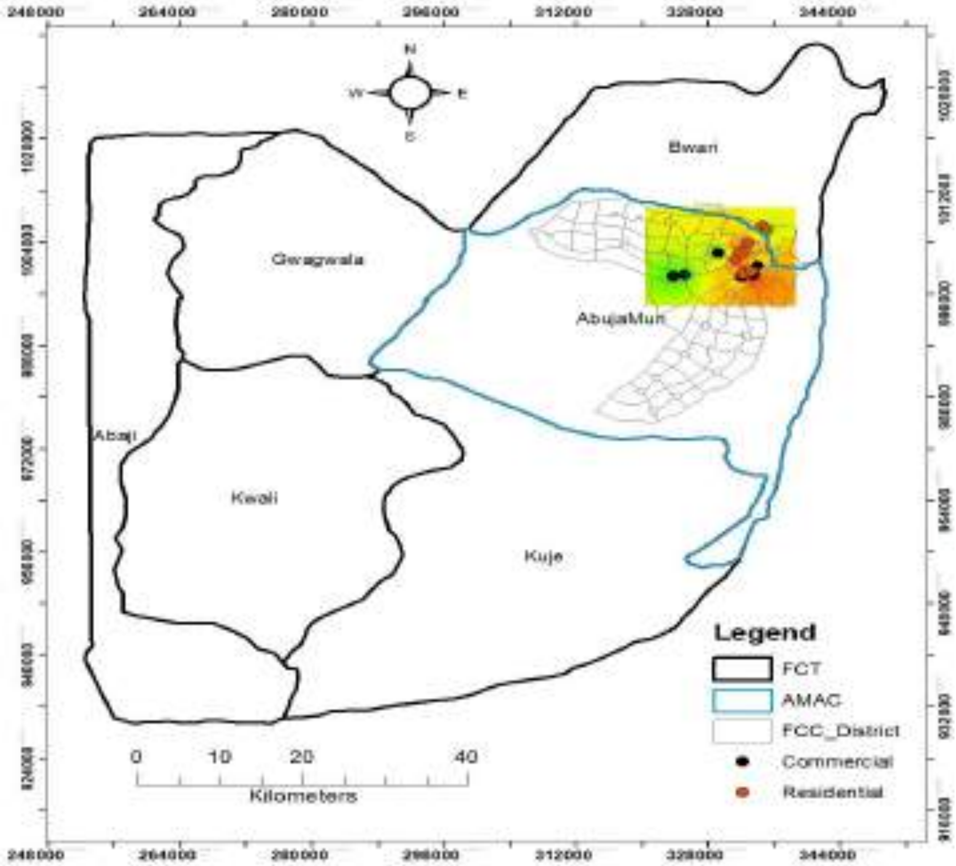

Figure 3: Inset map of pollutants concentration within residential and commercial District in Abuja Municipal Area Council in the Federal Capital Territory, Nigeria

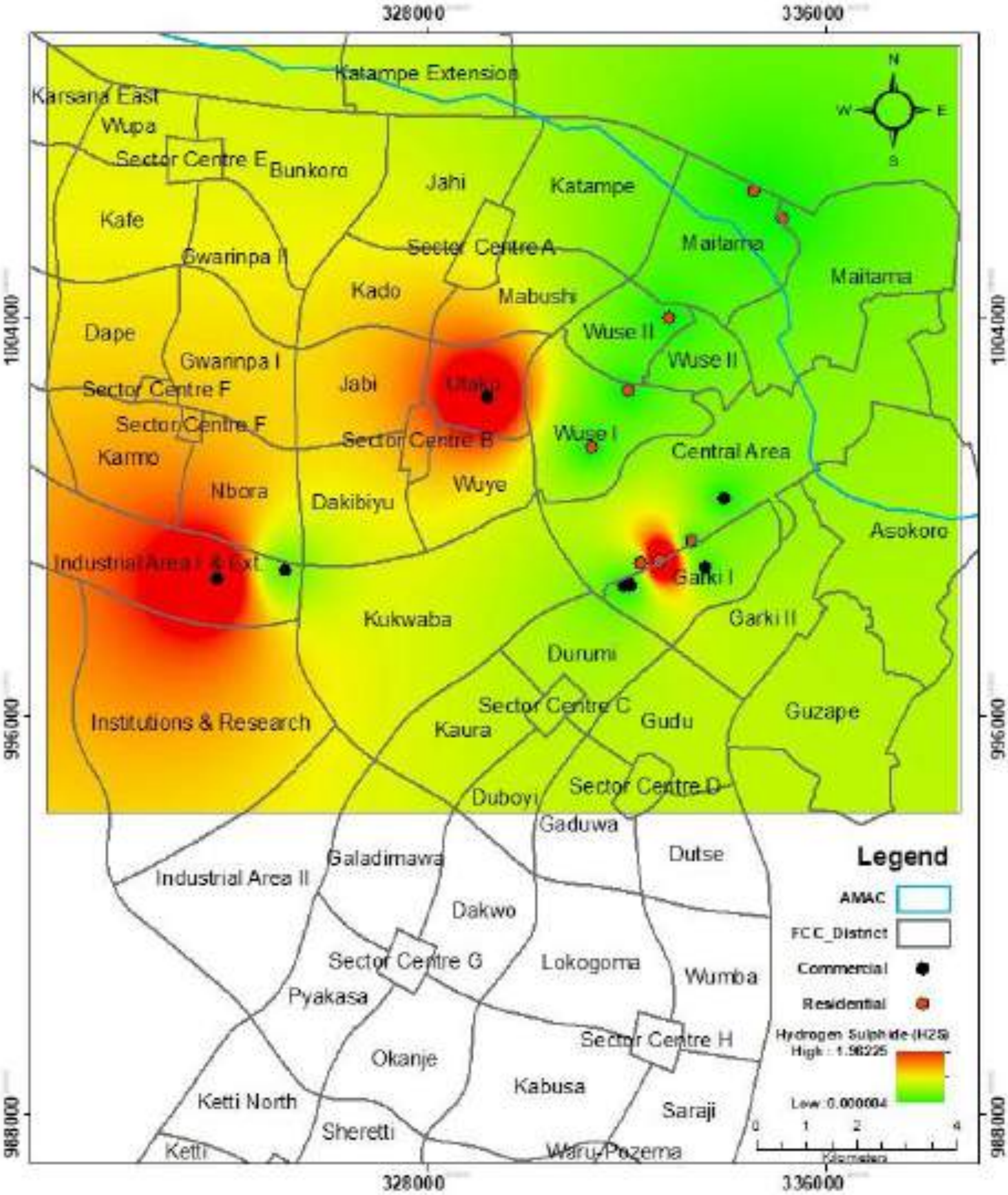

Figure 4: Concentration of H_2S within residential and commercial District in Abuja Municipal Area Council in the Federal Capital Territory, Nigeria

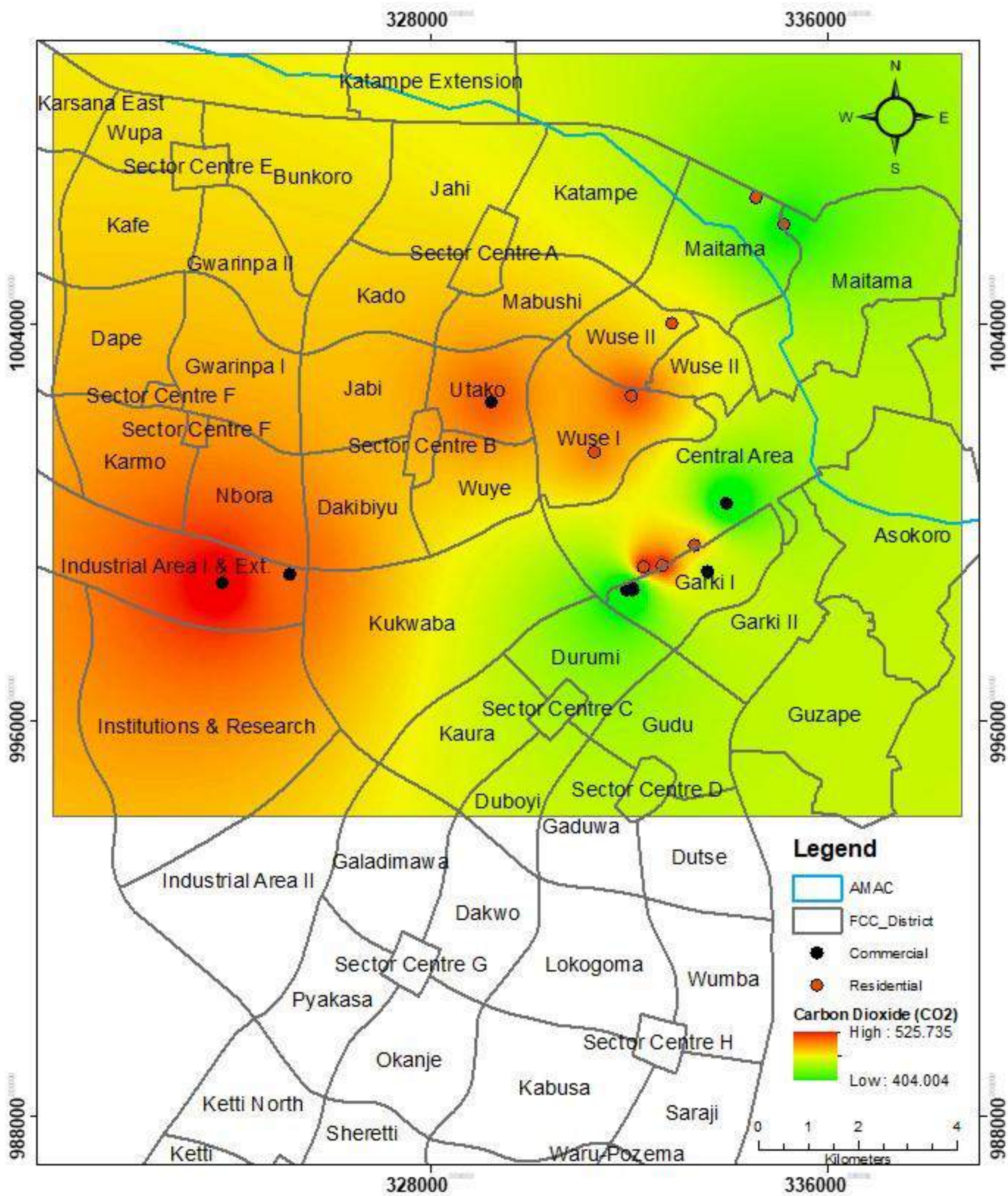

Figure 5: Concentration of Carbon dioxide within residential and commercial District in Abuja Municipal Area Council in the Federal Capital Territory, Nigeria

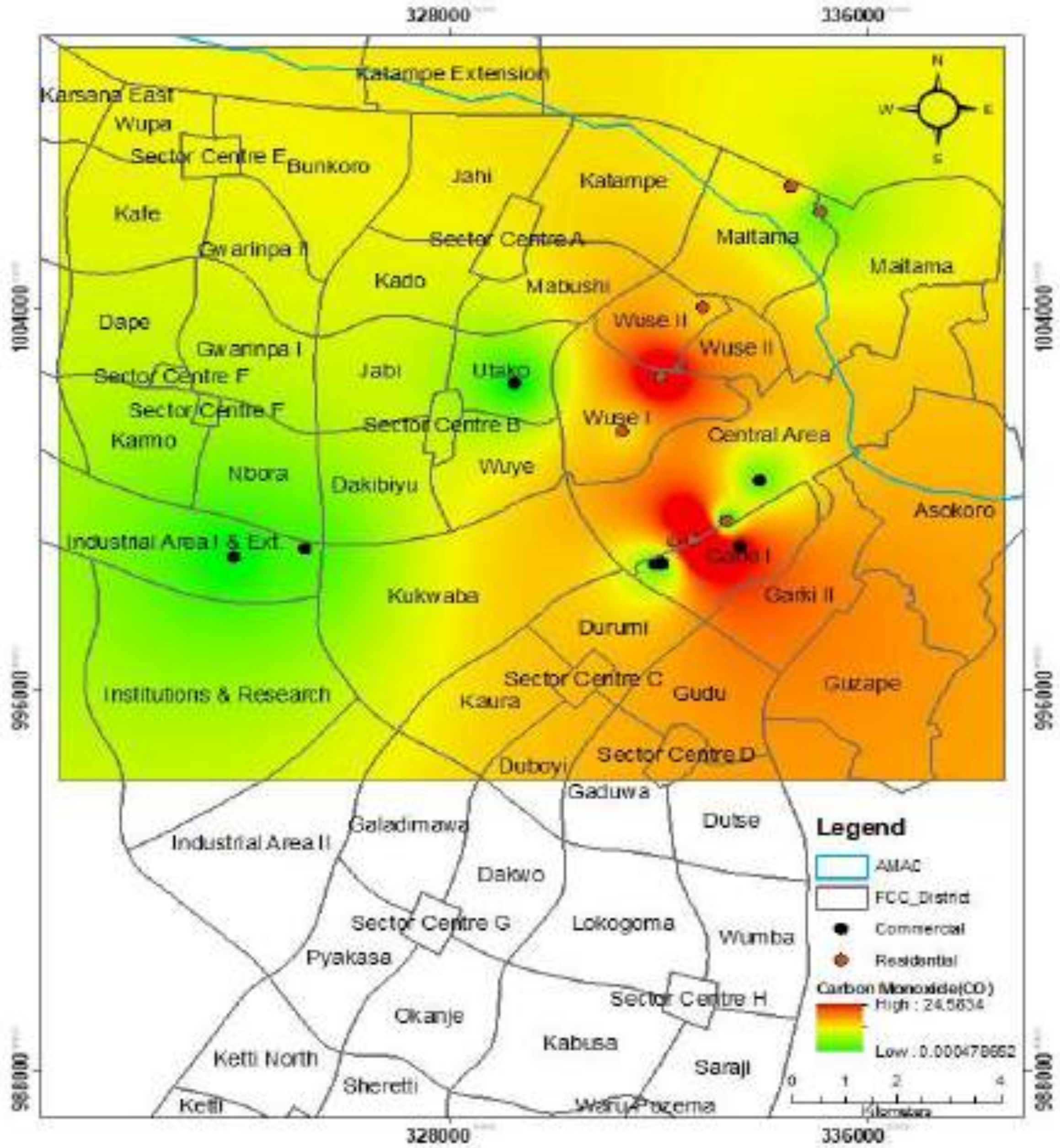

Figure 6: Concentration of CO within residential and commercial District in Abuja Municipal Area Council in the Federal Capital Territory Nigeria

Health Implications

The medical records from National Hospital, Abuja, showed higher cases of Respiratory diseases, Asthma, Cardiovascular diseases and Cancer (Table 4). Cases of respiratory diseases had the second highest medical concerns after cancer. Females (all ages) had higher medical records in all cases than males.

Table 3. Air Pollution related diseases from National Hospital year 2007 to 2017

DISEASES	MALE	FEMALE
Respiratory	7231	7999
Asthma	188	199
Cardiovascular	1879	1939
Cancer	13698	33221

Source: National Hospital Abuja FCT, 2018

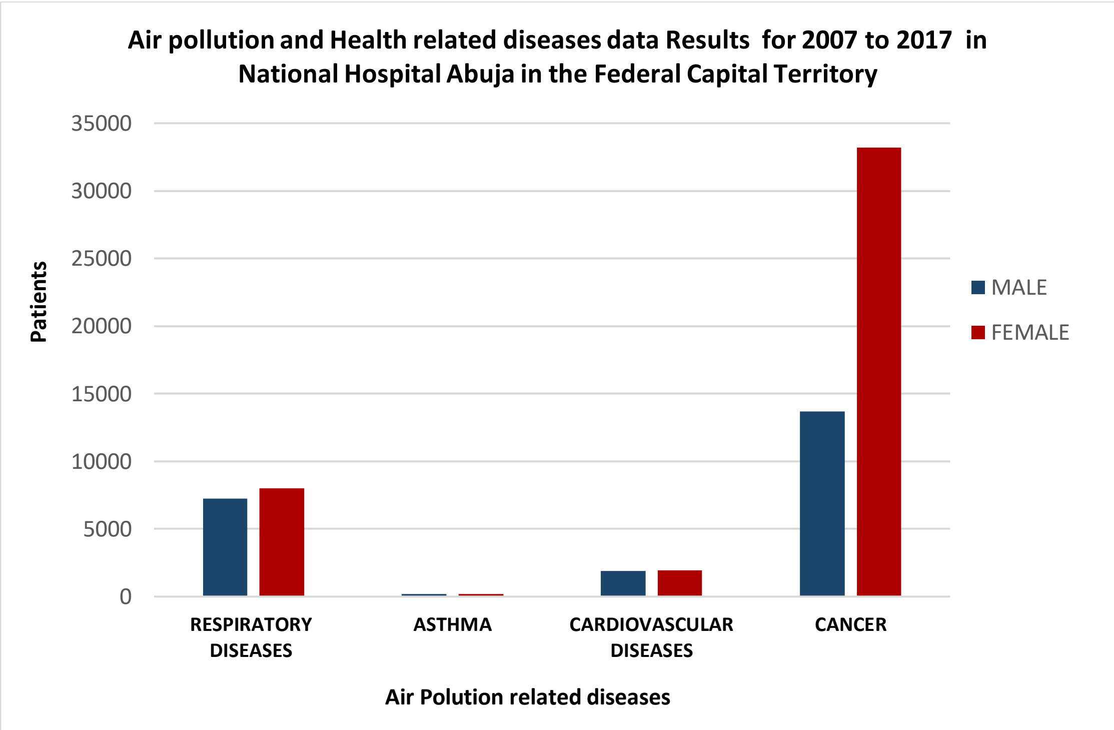

Figure 7. Health records for male and female patients in 11 years in National Hospital.

The bar chart (Figure 7), gives a visual representation of the medical records of the health-related diseases attributed to air pollution. The cancer medical records had the highest number of patients (46,919) of which 33,221 were females. This accounts for about 60% of the total medical concerns (Figure 8), followed by Respiratory disease, which accounted for 31%. Asthma had the lowest number of patients and accounted for 1% of the total number of the patients for the air pollution related diseases.

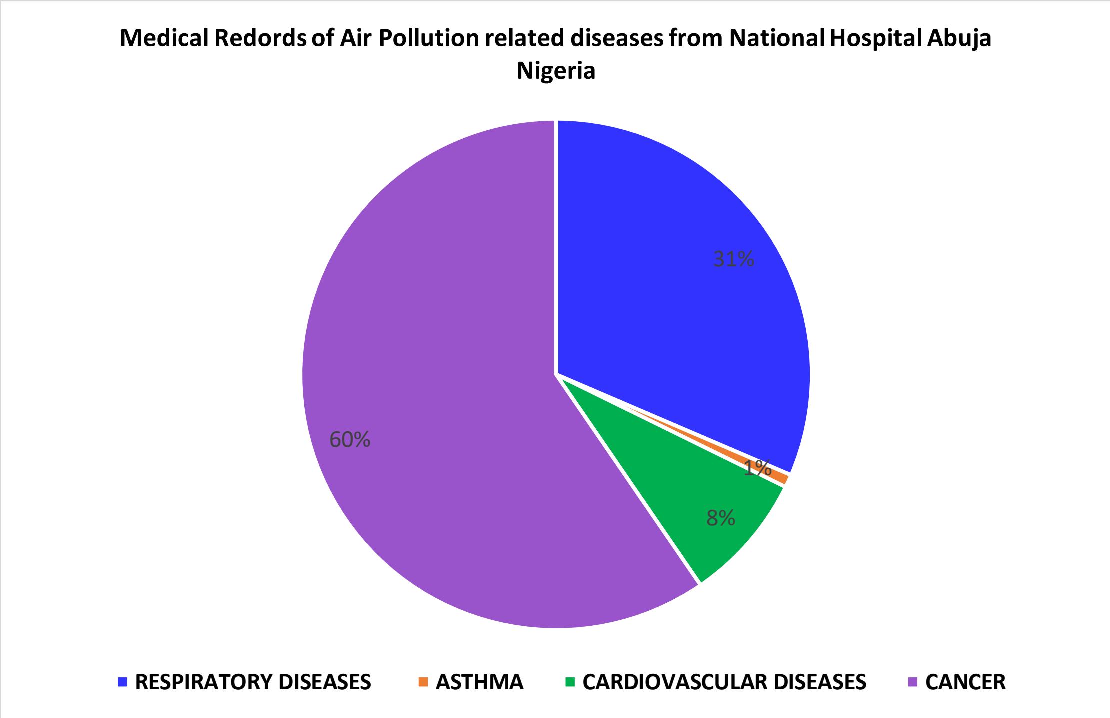

Figure 8. Pie Chart of Medical Records of Air Pollution related diseases from National Hospital Abuja, Nigeria

Figure 9 shows bar graphs (a, b, c and d) of mean field carbon dioxide data for the different observation time bands (6.00hours, 10.00hours, 18.00hours and 22.00hours) at the residential areas. They gives a visual representation of CO_2 emission pattern during the various observation times. The graphs showed higher emission levels above 400ppm at the low-peak period of 6.00am (6.00hrs), the same is shown during the peak periods of 10.00am (10.00hrs) and 6.00pm (18.00hrs). This was practically the trend during all observation times in the residential districts. The highest emission value of 570ppm at point P2 Bendel Street by Mokwa close junction around the Area 2 shopping centre is at a high population density residential area (Figure 9(d)) in the FCC.

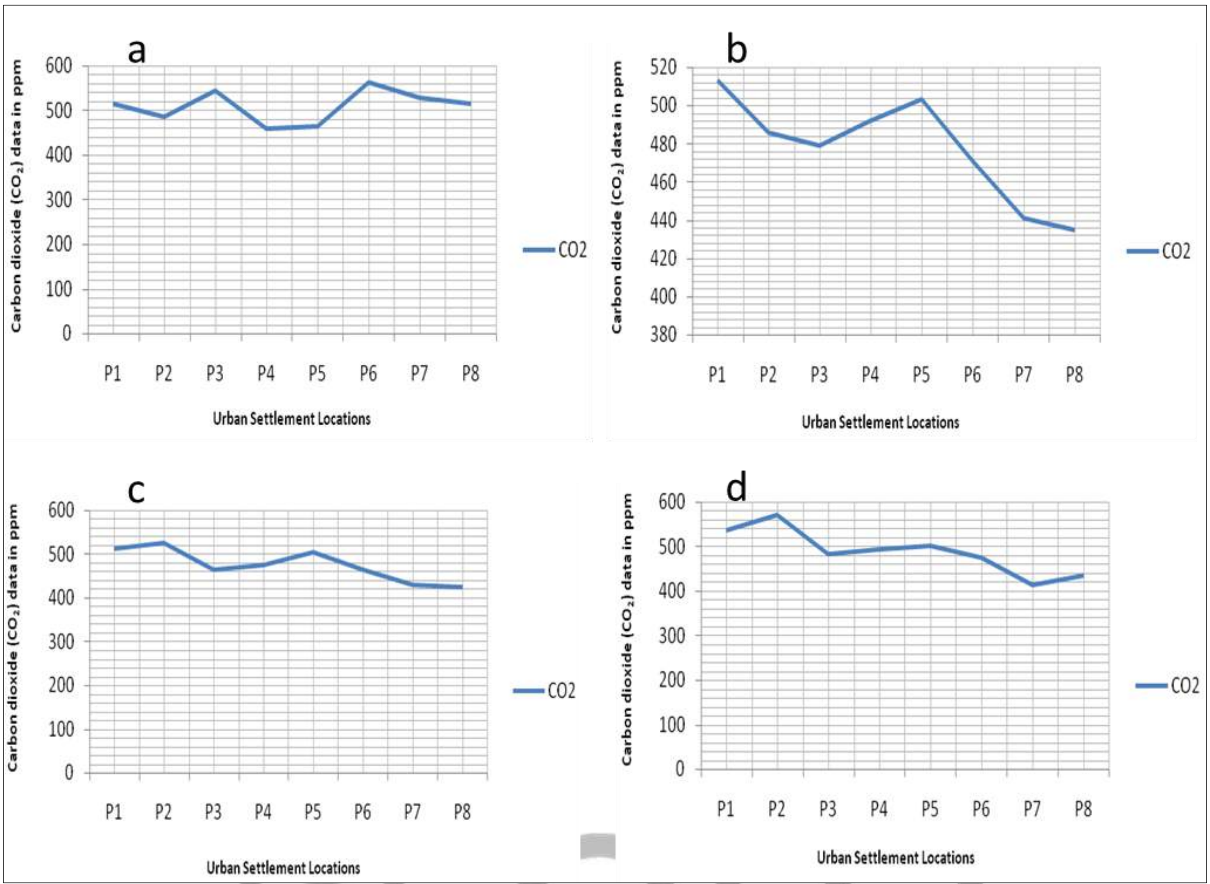

Figure 9: Bar Graphs of Mean CO2 Emission for Residential Areas for 6hrs(a), 10hrs(b), 18hrs(c) and 22hrs(d) West African Time in Abuja Municipal Area Council in the Federal Capital Territory Nigeria

The pollutant gases (H_2S, CO, CH_4) and Oxygen (O_2) graphs in Figure 10 shows stability in mean O_2 level and zero methane (CH_4) emission in all the residential districts. The carbon monoxide (CO) emission level also showed stability below 20ppm (NESREA and USEPA), except at point P1with mean emission value of 25ppm, during the off-peak period at 6.00am (6.00hrs). The highest H_2S emissions were also observed and recorded during this time with highest mean emission value of 2ppm as presented in Figure 10(a).

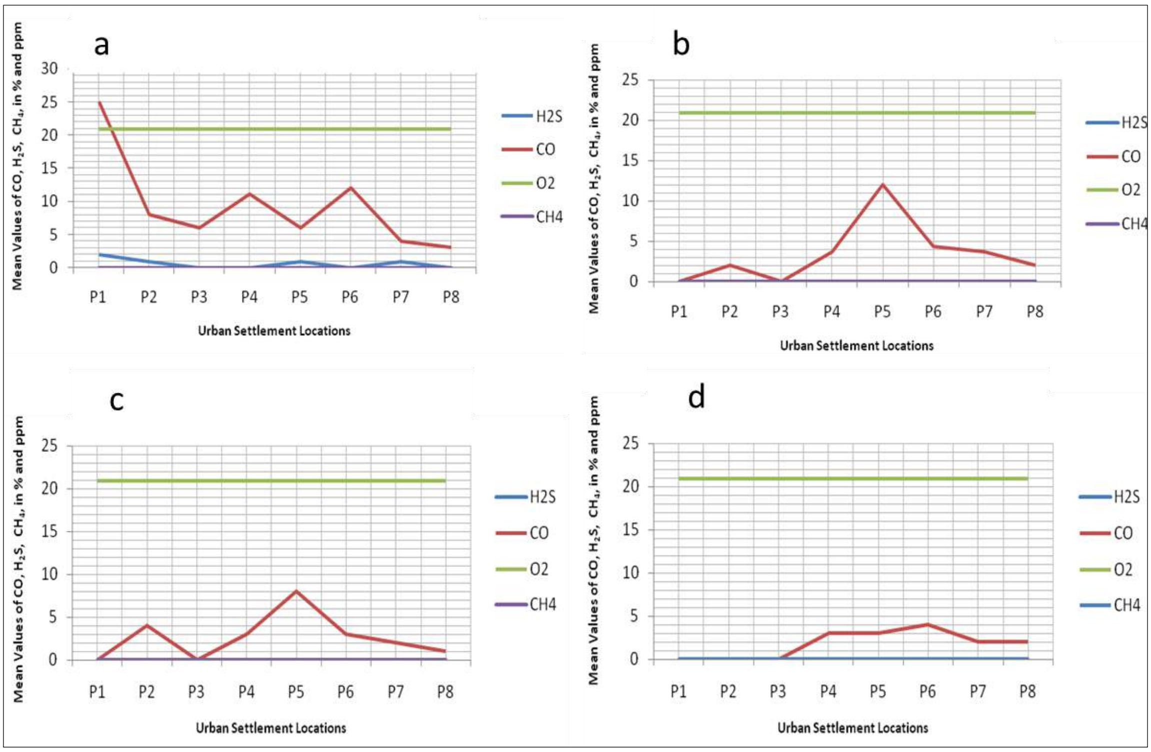

Figure 10: Residential Districts CO, H_2S CH_4 and O_2 Air Pollution Data results for 6hrs(a), 10hrs(b), 18hrs(c) and 22hrs(d) West African Time.

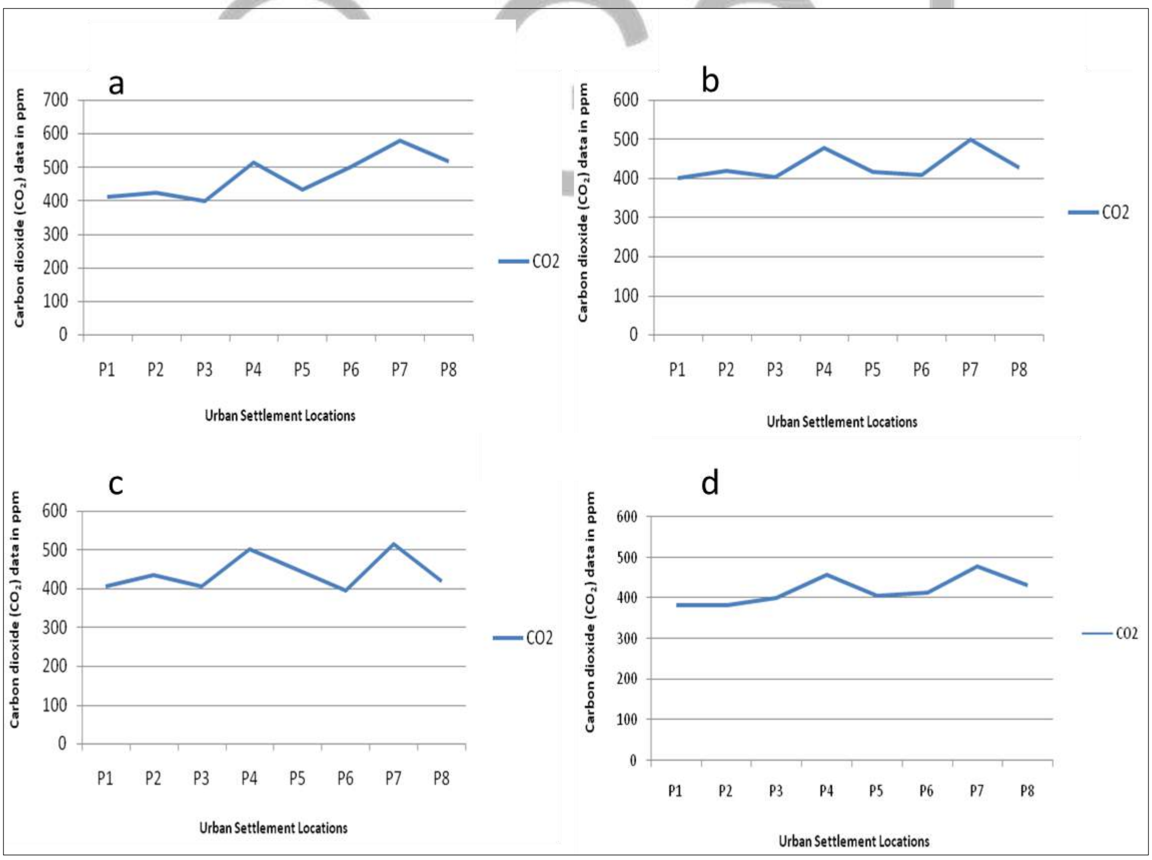

Figure 11: Commercial Districts Carbon dioxide graphs results for 6hrs(a), 10hrs(b), 18hrs(c) and 22hrs(d) West African Time.

Figure 11 shows the commercial districts mean carbon dioxide (CO_2) emission level, with high emission values of 516ppm at Festival Road primary school in Garki Area 10 (P4), 501ppm at Utako market (P6), 580ppm at the Idu Industrial layout (P7), and 517ppm at 7UP Company warehouse (P8) during the 6.00hr observation off-peak period (Figure 11(a)). The CO_2 emission values were therefore highest in four specific locations (P4, P6, P7 and P8) at the 6.00hrs observation time but remained consistently high at points P4 and P7 all through the different observation times in the commercial districts.

The commercial districts pollutant gases emissions (H_2S, CO, CH_4) and Oxygen (O_2) are as presented in Figure 12. It shows an interesting stable emission pattern. The mean carbon monoxide emission gases at all observation times were within standards as recommended by NESREA and USEPA (see Table 1). The highest mean CO emission value obtained was 15ppm (Figure 11(c)), at the 6.00pm (18.00hrs) observation time period at point P1, Area 1 Shopping centre underground car park. CO values above 10ppm are higher than the WHO recommended standard value. Hydrogen Sulphide gases emission were predominantly high in most the commercial districts during peak and off-peak periods with highest emission value of 1ppm.

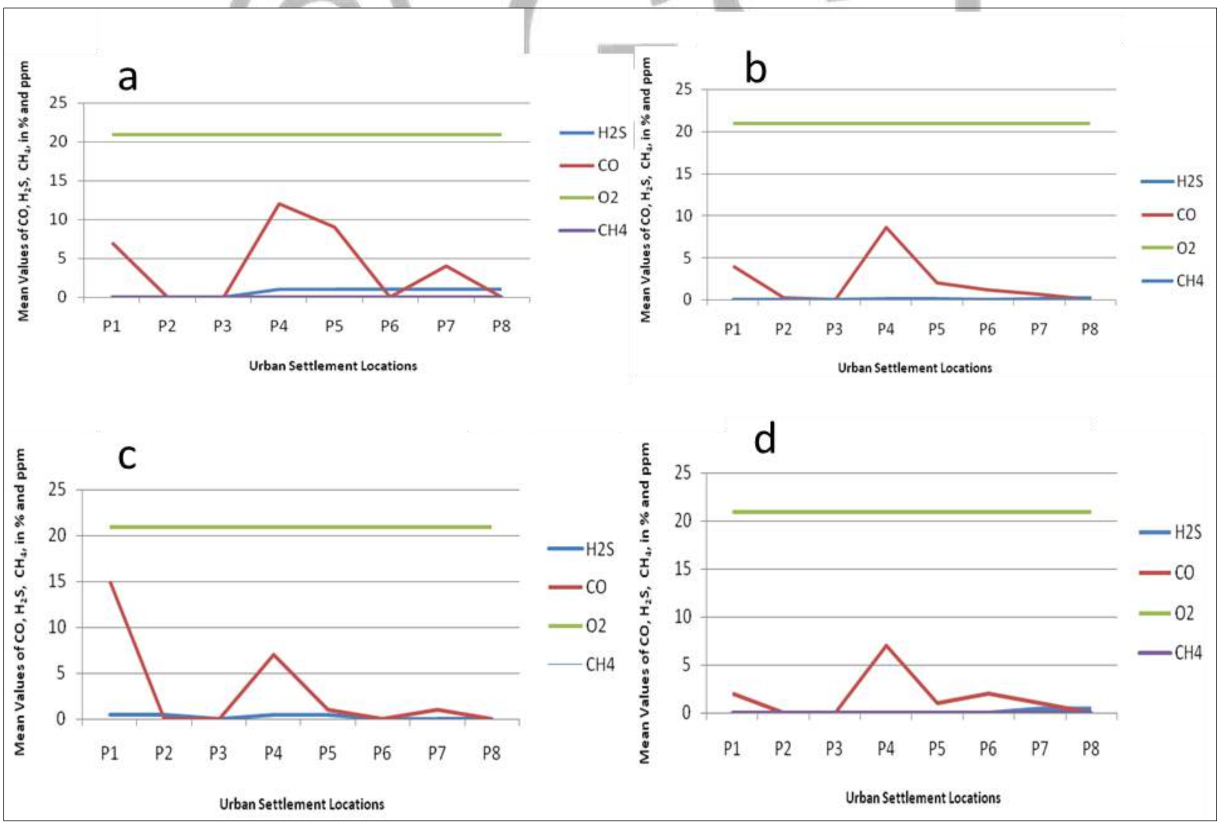

Figure 12: Commercial Districts Air Pollution Data results for 6hrs(a), 10hrs(b), 18hrs(c) and 22hrs(d) West African Time

5.0 Discussions

The mean emission level results revealed that during the period under observation (December to February), Residential district mean at 6.00am showed higher pollutants emission of H_2S, CO and CO_2 compared to the other observation times (10.00am, 6.00pm and 10.00pm). These emissions are higher than the recommended standards and therefore calls for concern. However, O_2 was normal at 20.9%. The mean Carbon dioxide emission at all observation times revealed higher emissions above the United States of America OSHA (1996) and ASHRAE (1989) outdoor standards of 350ppm – 450ppm. The mean CO emission at point P1, at the 6.00hrs observation time was the highest across all residential district at 25ppm, while H_2S was 2ppm, which were above the WHO, NESREA and USEPA standards for CO and H_2S. The reasons for these high emissions can be attributed to the early morning movement of residents to work, increased vehicular movements and other social-economic activities. In addition, the location P1 is closer to the Area 2 shopping centre in Garki district, where several environmental challenges were observed, including accumulated municipal solid waste, pollution from decomposing waste and leakages from broken sewage pipelines. There were no traces of CH_4 gases and the Oxygen gas level was normal at 20.9% during all inventory period.

There were no gaseous pollutant emissions of H_2S and CH_4 during the 10.00hours, 18.00 hours and 22.00 hours inventory time in the residential areas and the spatial minimal CO emissions were predominantly within the recommended standards. The mean CO_2 emission were predominantly high at all inventory times with emissions >400ppm, this call for concerns as there are possibilities of increase in CO_2 emission in the residential areas above the OSHA and ASHRAE outdoor standards of 350ppm – 450ppm.

The mean emission field data in the Commercial districts for Oxygen was normal at 20.9% at all inventory times, there were no emission of methane gas (CH_4), while the highest mean emission of CO was 15ppm at point P1 underground parking garage in Garki Area 1 district, during the 6.00pm (18.00 hour) inventory time. The gaseous pollutant emissions from the underground parking is characterised by the use of over 30 power generating sets during electricity power outages in the Area 1 shopping plaza and pockets of catering activities. It was observed that ***spot pollution*** emission data were higher during electricity outages.

There were geospatial mean emissions of H_2S ranging between 0.1ppm – 1.0ppm in all commercial districts, higher than all the recommended standards. This call for concern as continuous emission and exposure to high concentration of H_2S can result in neurological, ocular, cardiovascular, carcinogenic and respiratory health effects and cause asthmatic attack. These effects may also lead to eye irritation, coughing, difficulty in breathing, fluid in lungs, nausea, headaches, rapid unconsciousness and may result to death in severe cases.

CO_2 emission values were highest in four specific locations at different observation times in the commercial districts: P6, P7 and P8 at 6.00am; P4 and P7 at 10.00am, (P4 and P7) at 6.00pm and (P4 and P7) at 10.00pm.

6.0 Conclusion and Recommendations

There were consistency in the results showing that outdoor emission levels are likely to increase in the Residential and Commercial districts in the FCC. The medical data on diseases such as Cancer, Respiratory and cadiovascular diseases were higher compared to that of asthma. This implies that apart from the increased H_2S, CO, CO_2 emission, there may be other contributory factors to the high incidence of the diseases. A total of 46,919 residents were affected by air pollution related diseases, which constitutes 2.38% of the projected population of Abuja Municipal Area Council (AMAC) in 2016. There are possibilities of residents who could not have visited the hospital but have had air pollution related health challenges. There is therefore the need for more proactive control and preventive measures to be taken in order to avoid increase in air pollution related health challenges. Hence the enforcement of air pollution laws should be effected in the FCT. Policies on sustainable green transport and energy should be enacted and implemented; and compulsory tree planting within and around the FCC should be intensified.

Declaration of Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper

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