# Evaluation of Pollutants in Ambient Air: A Case Study of Abuja-Nigeria

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***Abstract-*** Air samples from densely and less densely populated areas of Abuja Municipal Area Council, Kuje and Dobi Village in Gwagwalada Area council were analyzed using BW Technology GasAlaert® Microclip (gas detection instrument). The results showed varying concentrations of hydrogen sulphide, carbon monoxide and low explosive limit gases. The high concentrations of pollutants detected in Abuja municipal area council can be attributed to increased population growth, increased production of gaseous wastes and increased number of industries. However, no low explosive limit gas was detected in Kuje area council and with only emission of low explosive limit gases in Dobi, Gwagwalada area council which was due to decomposed refuse around the market and rice milling waste within settlements, in Dobi village.

***Index Terms****- ambient air, pollutant, hydrogen sulphide, carbon monoxide, low explosive limit gases*

## I. INTRODUCTION

Clean air is one of the basic requirements of human existence. However, air pollution continues to pose significant threats to human and environmental health worldwide. According to World Health Organization, more than 2 million premature deaths each year can be attributed to the effects of urban outdoor and indoor air pollution and these effects are more prominent in developing countries [1]**.** Outdoor air pollution sometimes called ambient air pollution occurs in both urban and rural areas. However, the intensity and type of pollution depends on the available pollution sources. The monitoring of air pollutants such as low explosive limit gases, hydrogen sulphide and carbon monoxide in ambient air has received substantial attention over the past several years because they are among the major pollutants which significantly affect the chemistry of atmosphere and human health [2].

Hydrogen sulfide ($H_2S$) is a colourless gas, soluble in various liquids including water and alcohol. Most of the atmospheric hydrogen sulfide has natural origins. They are mostly found around sulfur springs and lakes, geothermally active areas and Saline marshes [3]. The estimated global release of hydrogen sulfide from saline marshes into the atmosphere is $8.3 \times 10^5$ tonnes per year. Human activities can release naturally occurring hydrogen sulfide into ambient air. For instance, some natural gas wells in Hungary contain from 50 to 3000ppm of hydrogen sulphide [4] . Natural gas is used as domestic and industrial fuel in Nigeria.

Carbon monoxide (CO) is one of the most common air pollutants. It has no colour, odour or taste. It has a low reactivity and low water solubility. It is mainly emitted into the atmosphere as a product of incomplete combustion. Annually, a large number of individuals die as a result of exposure to very high indoor CO levels, far above ambient outdoor levels. In Flanders, for example, in 1987-1988 about 100 people died, mostly as a result of accidental exposure [5] (Magnus 1995). For ambient outdoor air, CO is one of the "classical" air pollutants, for which many countries have set air quality limit values. CO is brought into the atmosphere by two different mechanisms: emission of CO and chemical formation from other pollutants [6] (EU 1999). Table 1 gives an overview of the global anthropogenic emissions of CO. From the table it appears that burning of forest, savannah and agricultural waste accounts for half the global CO emissions. The chemical formation of CO is due to the oxidation of hydrocarbons, and it adds 600 - 1600 Mtonnes to the atmosphere. Two-third of it stems from methane. It is a slow process, and does not give rise to local peak concentrations. However, being a source of the same magnitude of the direct emission, CO formation contributes considerably to the global background level. It is estimated that about one-third of CO results from natural sources, including that derived from hydrocarbon oxidation [6].

***Table 1: Global anthropogenic emissions of CO by sector in 1990[6]***

| SECTOR | EMISSION | |
|---|---|---|
| | Mtonnes/year | % |
| Road Transport | 206.7 | 21 |
| Non Road Transport | 1.7 | 0.2 |
| Residual | 218.9 | 22 |
| Industrial and power generation | 51.2 | 5 |
| Deforestation | 111.4 | 11 |
| Savannah burning | 177.0 | 18 |
| Agricultural waste burning | 207.6 | 21 |
| Total | 974.5 | 100 |

Figure 1 summarises the emissions by source sector for the EU member states. It shows that far the largest source is road transport, which accounts for two-thirds of the emissions of the EU. The contribution from traffic is seen to vary considerably between the member States (from 30 to 89%). CO levels in busy city streets are higher than CO near highways, since the amount of CO emitted per kilometer strongly decreases with vehicle speed and also because the ventilation in city streets is less. Also, ambient CO levels are usually highest in winter, because cold engines emit much more CO than hot engines and also because the atmosphere tends to be more stable than in summer [6].

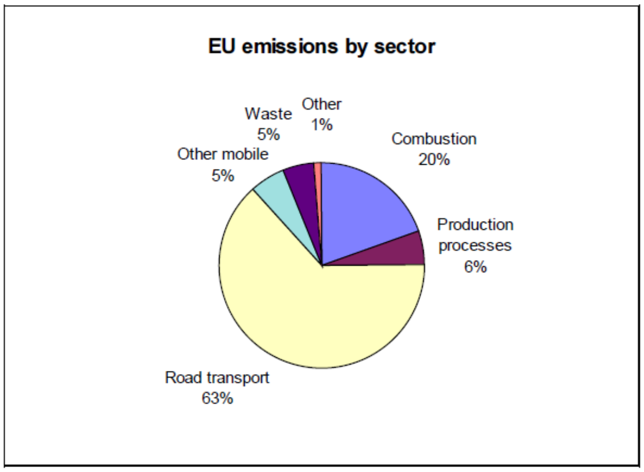


*Figure 1: EU emission of CO by sector in 1994 [6]*

In general, the dominant anthropogenic CO sources are vehicular and industrial emissions from fossil fuel combustion, liquefied petroleum gas (LPG), leakages, fuel evaporation, petroleum distillation and industrial solvent [7-8]. Interest on traffic-related sources of air pollution from exposure assessors, epidemiologists, as well as toxicologists is on the increase. Ground-level traffic vehicles in urban areas are typically natural gas fueled, gasoline fueled or diesel-fueled. The physical characteristics and chemical compositions of natural gas, gasoline and diesel differ from one region of the world to the other. These include benzene content which hampers the generalization of findings in one location to other locations. This complexity in generalization across studies is further complicated by different meteorological conditions, different percentage of heavy polluters (more motorcycles in the developing world), design of motor ways (graded or non-graded roads), driving habits, different maintenance as well as quality of and control measures for vehicles, and exposure profiles of people [7-9].

Low explosive limit gases may also be defined as organic chemicals with high vapour pressure at ordinary room temperature conditions [10-11]. Some common examples include: methane, acetone, benzene, ethylene glycol etc. The lower explosive limit (LEL) or lower flammable limit (LFL) of a combustible gas is the smallest amount of the gas that supports a self-propagating flame when mixed with air (or oxygen) and ignited. In gas-detection systems, the amount of gas present is specified as a percentage (%) LEL. Zero percent (0%) LEL denotes a combustible gas-free atmosphere. One hundred percent (100%) lower explosive limit denotes an atmosphere in which gas is at its lower flammable limit. The relationship between percent LEL and percent by volume differs from gas to gas [12]. According to Abdullahi et al. [7], the asphyxiant effects of methane may enhance cardiac sensitization. Methane displaces oxygen to 18% in air when present at 14% (140000ppm).

The city of Abuja is the new Federal Capital Territory (FCT) of Nigeria with fast urbanization and industrialization. The need to assess the air quality in FCT cannot be taken out of context owing to the rapid growing population in the Federal Capital City, usage of power generating plants, emission of carbon monoxide, hydrocarbons, bush burning, use of fuel wood by house-holds, open mine quarries, methane gas from solid waste sites, etc. The city is also characterized with high flow of traffic during the daytime especially during morning and evening rush hours with each vehicle emitting VOCs depending on the type of fuels used, type and age of the vehicles, flow rate and speed of the traffic as well as environmental conditions in the city and these vehicle exhausts contribute substantially to the CO concentration in the air. The aim of this paper is to determine the hydrogen sulphide and carbon monoxide concentrations in the ambient air at various locations of Abuja-Nigeria which will serve as an analytical basis for long term strategies for reducing air pollution; given the changing demographics, in terms of increasing population and a rapid growing urbanization and industrialization.

## II. METHODOLOGY

### a. Reconnaissance Survey

A reconnaissance study was conducted to determine the sample points putting into consideration the population density. This was done to help the researcher have an overview of the area under study, to assist in the feasibility and logistics plans for the field work. During the preliminary inspection, areas of dense human population, residential and industrial areas where mapped out. Figure 2 shows the study area.

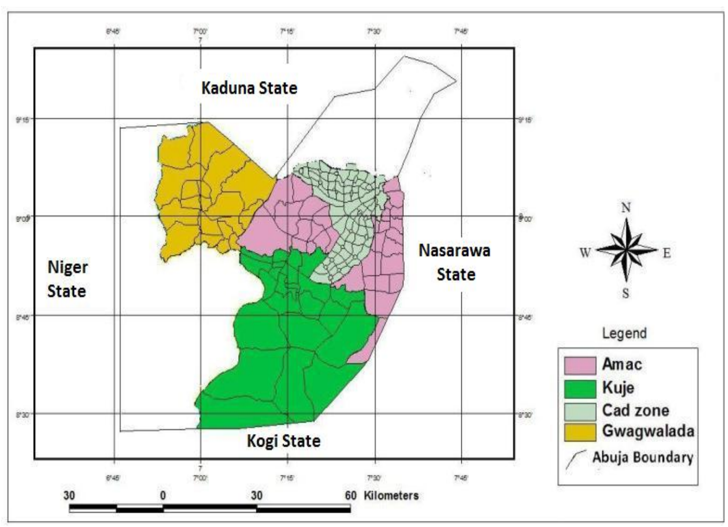


***Figure 2: Map Showing Abuja Municipal, Kuje and Gwagwalada Area Councils of FCT Nigeria***

***Source: Adapted from Department of Geography and Environmental Management, University of Abuja, FCT, Nigeria 2010***

### b. Sampling Procedure

Low explosive limit gases, hydrogen sulphide and carbon monoxide in air sample were analyzed using BW Technology GasAlaert® Microclip (gas detection instrument) from densely and less densely populated area of AMAC. This equipment was earlier calibrated with instrument setting and factory alarm setting according to WHO guideline, USEPA guideline and Federal Republic of Nigeria standards. When powered the GasAlaert® Monitor will show the various gases and their calibration setting. Similar procedure was also repeated for Kuje and Dobi in Gwagwalada area council. The field observations were done in compliance with the eight hourly intervals in strict compliance meeting all regulatory world standards. Three different readings were taken each day (morning, afternoon and evening) for three different days in a week with the time and dates duly noted. This was done for all sample points, 50 observations three times each day for three times in a week was taken for all locations (2,700 data collected). Data were taken in both wet season and dry seasons.

## III. RESULTS AND DISCUSSION

The field data were analysed to determine the level of low explosive limit gases, hydrogen sulphide, carbon monoxides gases in the air. The obtained data from 100 locations in Kuje and Abuja Municipal Area Councils were compared with the data from 50 locational/sample points in the control location (Dobi Village in Gwagwalada Area Council) to determine the level of pollution and also ascertain whether it exceeds World Health Organization standards, other International Standards and National Air Quality Standards.

### a. Wet Season Mean Results for Abuja Municipal Area Council

The Wet season mean results for Abuja Municipal Area Council is as presented in Figure 1.

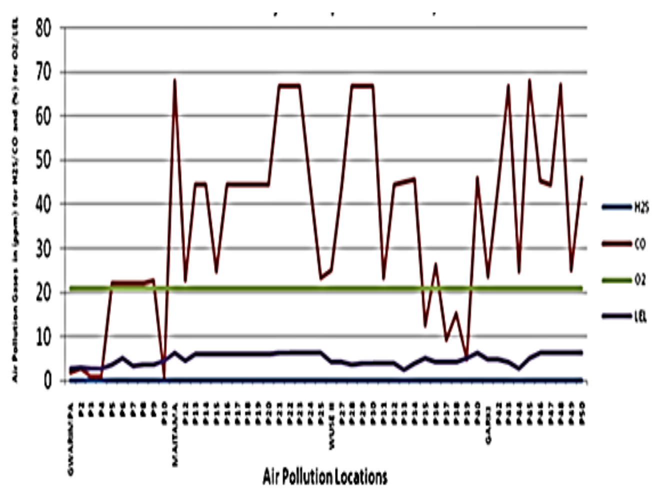


*Figure 1: Graph showing all gases obtained in AMAC F.C.T during Wet Season*

The result showed a high pollution level due to high presence of LEL and CO in the atmosphere. These could be attributed to many sources. The city of Abuja being the administrative capital of Nigeria is characterized by high flow of traffic during the daytime especially during morning and evening rush hours with each vehicle emitting gases depending on the type of fuels used, type and age of the vehicles, traffic flow rate and speed of the traffic as well as environmental conditions in the city. Other sources may include liquefied petroleum gas (LPG), leakages, fuel evaporation, petroleum distillation and industrial solvent [13-14]. The variations across the city are due to the degree of availability of emission sources and different meteorological conditions.

### b. Dry Season Mean Results for AMAC

The Dry season results (figure 3) from AMAC showed quite different gaseous atmospheric characteristics.

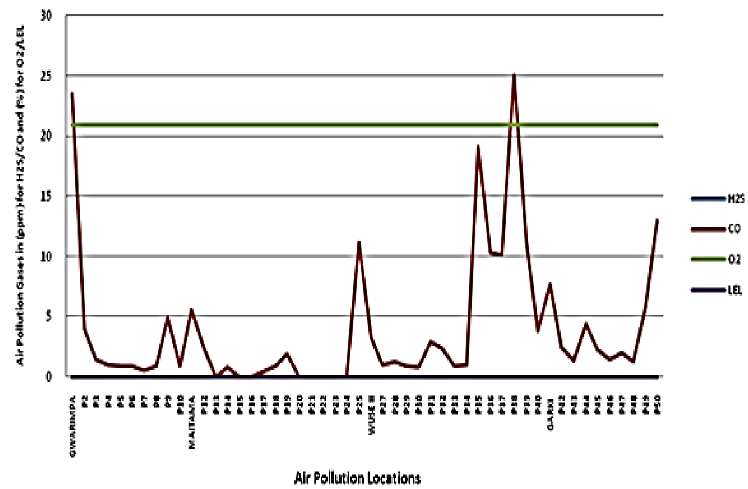


*Figure 3: Graph showing all gases obtained in AMAC in the dry Season*

The dry season mean observation values showed that carbon monoxide (CO) was prominent in the atmosphere but allowable limits for WHO and Nigeria Air Quality Standard. Hydrogen Sulphide ($H_2S$) gas was not detected, Oxygen ($O_2$) was normal at 20.9% while LEL gases were not detected. The graph clearly shows that Low Explosive Limit (LEL) gases were not emitted in Abuja Municipal Area Council during the dry season. This may be attributed to the North-East trade wind which blows across the Federal Capital Territory during the dry season and lowers the time these gases remain in the atmosphere once emitted. Also, the organic decomposition processes are more favoured during raining season.

### c. Wet Season Pollution Results for Kuje Area Council

The result from Kuje Area Council for Wet season (Figure 4) shows that Kuje area council is less polluted with highest concentration of Carbon Monoxide as 4.89ppm.

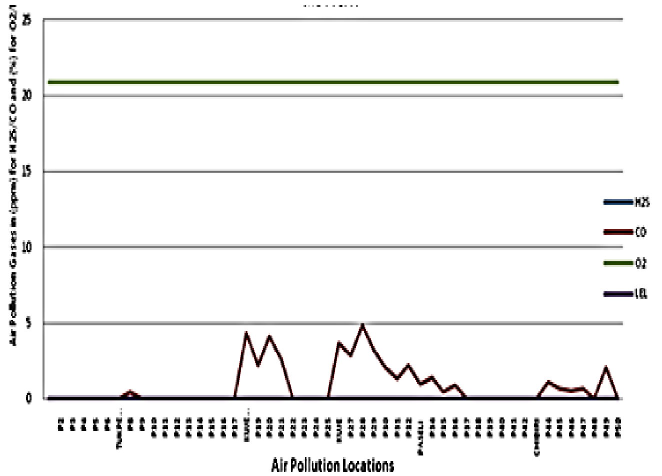


*Figure 4: Graph showing all gases obtained in Kuje Area Council during wet season*

This result is as expected because Kuje, being a satellite town is still less populated as compared to AMAC. This is also coupled with the absence of industrial activities, hence less pollution sources.

**d. Dry Season Pollution Results for Kuje Area Council**

The dry season mean emissions observed in Kuje Area Council as shown Figure 5 indicates that hydrogen Sulphide ($H_2S$) gas was not detected. Carbon monoxide (CO) is highest at location points P9 (17.33ppm) Tukpechi village, P26 (9.33ppm) Kuje town and P41 (10.22ppm) Paseli district. Oxygen ($O_2$) is normal at 20.9%, while Low Explosive Limit (LEL) gases were also not detected in Kuje Area council. The high quantities of CO observed as compared to the rainy season may be attributed to emission from vehicles coupled with bush burning particularly in Tukpechi.

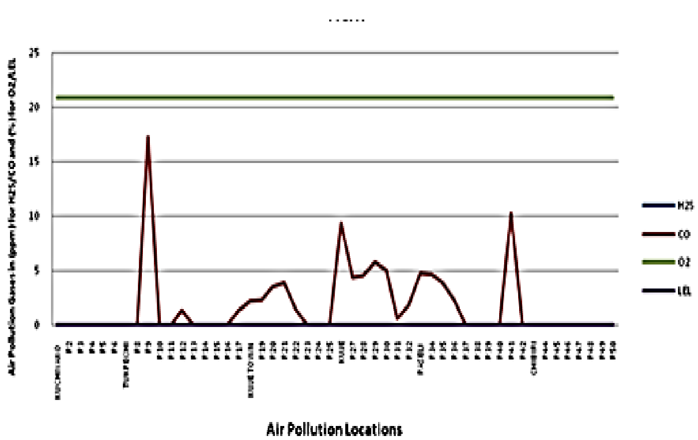


*Figure 5: Graph showing all gases obtained in Kuje Area Council F.C.T during dry season*

**e. Wet Season Pollution Results for Control Point in Dobi Village of Gwagwalada Area Council**

The results obtained from Dobi village, in Gwagwalada Area Council (Figures 6) were different from that of Kuje and Abuja Municipal Area Councils. The results showed no detection of hydrogen sulphide ($H_2S$) gases in Dobi village. Carbon monoxide was very low with mean highest emission of 0.67ppm at location point P30 Dobi market in Dobi town. Oxygen ($O_2$) was stable and normal but dropped below 20.9% from location points P7 and P16. Low Explosive Limit (LEL) gases were also emitted from location points P26. This could be attributed to the presence of decomposed refuse around the market and rice milling machines waste within settlements in Dobi village. The biological sources emit an estimated 1150 teragrams of carbon per year in the form of VOCs. The majority of VOCs are produced by plants with isoprene as the main compound [15]. Other biological sources are animals, microbes and fungi such as molds.

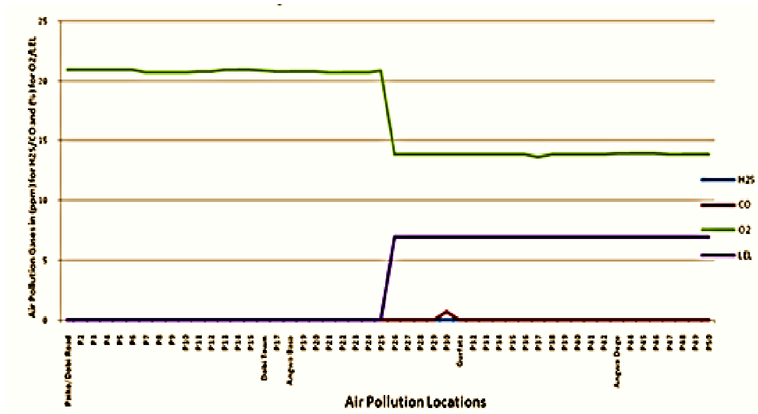


*Figure 6: Graph showing all gases obtained in Dobi Village, Gwagwalada Area Council F.C.T during Wet Season*

**f. Dry Season Pollution Results for Control Location in Dobi Village of Gwagwalada Area Council**

The dry season gases results are as presented in Figure 7. The dry season results for Dobi village showed that emission was very minimal with less pollution. Carbon monoxide (CO) gas emission was highest (3.89ppm) at location point P20. This emission showed practically no pollution as it is lower the acceptable air pollution standard. Hydrogen Sulphide ($H_2S$) and Low Explosive Limit (LEL) gases mean values obtained were not detected, while Oxygen ($O_2$) was normal at 20.9% for all districts.

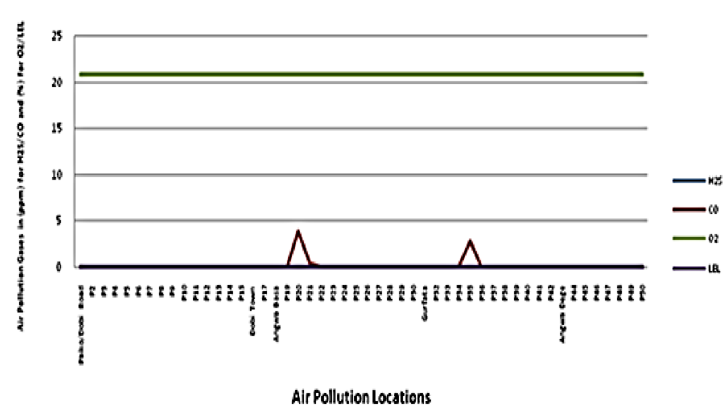


*Figure 7: Graph showing all gases obtained in Dobi Village, Gwagwalada Area Council during Dry Season*

## IV. CONCLUSION

An analysis of low explosive limit gases, hydrogen sulphide and carbon monoxide in ambient air of Abuja showed various degrees of presence of these pollutants. Higher quantities of these gases were detected in AMAC which is the metropolitan area of Abuja. It is imperative therefore that with the expansion of the FCT Abuja, standard control measures and proper waste disposal methods should be quickly put in place to avoid continuous emission that may lead to increased concentration of these pollutants. It is recommended that extensive awareness campaigns be carried out and further study is required to ascertain and proffer mitigation measures on their effects on humans and the environment.

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