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MEASUREMENTS OF NITROGEN DIOXIDE IN EWOHIMI, EDO STATE, NIGERIA USING DIFFUSION TUBES.

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ABSTRACT

The NO_2 load across five rural villages in Ewohimi, Edo Central region of Nigeria have been monitored. Measurement was done using passive sampling approach: - Palmes Diffusion tube for NO_2. 14 days sampling duration was observed and a triethanolamine (TEA) coated mesh present in the diffusion tubes trapped the NO_2 which was determined colorimetrically as nitrite with Saltzmann reagent. Low load of NO_2 was obtained at all the sampling locations. A mean annual range of 3.62 - 5.25 μgm^{-3} NO_2 was calculated for the monitoring sites. Data obtained in this study when compared with results obtained previously in urban centers in Nigeria and similar measurements carried out across United Kingdom and Greenland in Denmark, a pristine condition with respect to NO_2 pollution can be inferred for these rural sites. No significant spatial and temporal variation was noticed for the NO_2 load and the measured values were very far from the air quality standard for NO_2 set nationally.

KEY WORDS: Nitrogen dioxide, diffusion tubes, rural.

INTRODUCTION

The few reported cases of ambient level of air pollutants in Nigeria have been conducted in the urban centers (Baumbach et al., 1995; Ikamaise et al., 2001; Asubiojo et al., 1993; Ukpebor and Ahonkhai 2000) etc. So far, little or no research has been conducted in the rural areas to evaluate the sources, levels, characterizations and health effects of air pollution in rural areas. Air quality assessment in rural areas of some European countries (Atkins and Lee 1995, Campbell 1988) revealed significant quantities of the pollutant monitored in these areas. Nigeria has about 70% of its over 120million population living in rural areas (National Population Commission 1999). There is a great variation of life style, economic condition, living patterns, cooking habits simply distinguished from urban situations. Consequently, field studies are therefore urgently needed to assess the health risk of exposure of the population to rural air pollutants.

Attention is focused on NO_2 in this preliminary investigation because of the role of NO_2 in the formation of the photochemical oxidants and its contribution together with its oxidation products to wet and dry deposited acidity and the formation of aerosols (RGAR 1987, 1990). Toxicological studies have also shown that NO_2 reduces the efficacy of lung defense mechanism against infection (Marrow 1984). Furthermore, NO_2 is an important indicator of air pollution, because the concentration of NO_2 is well correlated with the concentration of carbon monoxide, particulates, polycyclic aromatic hydrocarbons (Lewis et al., 1995) and soot (Bower et al., 1991).

NO_2 is a minor component of the mixture of nitrogen oxides ($NO_X = NO + NO_2$) formed during combustion processes and emitted (Atkins and Lee 1995). Nitric oxide (NO) predominates in the emission mixture, and most of the NO_2 in the atmosphere is formed by the oxidation of NO by ozone (O_3). In the rural environment, soils may be either sources or sinks of NO and NO_2 (Hargreaves et al., 1992; Skiba et al., 1992). Emissions of NO from soils result from microbial nitrification or denitrification, with emission estimates ranging from 0.1 to 80 $ngNm^{-2}s^{-1}$ for UK and other soils (PORG 1990). If fluxes of 10$ngNm^{-2}s^{-1}$ are taken as typical for rural areas and are sustained for significant periods, annual emissions of 1t NO $km^{-2}yr^{-1}$ is possible. These estimates were considered by PORG (1990) to have an uncertainty of ± 40% but suggested that emissions from this source averaged about 10% of those from combustion. NO_2 is produced majorly in the rural areas during the combustion of biomass material such as firewood, surplus straw and other vegetation (Fowler et al., 1985; Levine 1991). Other sundry sources of NO_2 in these rural villages monitored include exhaust emission from the few motorized vehicles, petty industrial practices such as cassava milling machines and the use of kerosene lamps.

This paper summarizes the results from a survey of NO_2 levels at rural locations across the Edo central region of Nigeria. The purpose is to obtain essential information on the levels of NO_2 in rural areas and by comparison with set National Standard ascertain its compliance. It is also aimed at developing scientific database for setting up hygienic standard for rural dwellers

MATERIALS AND METHODS

Area Description

This study was conducted in Ewohimi. Figure 1 shows the sampling points. Ewohimi is located in Edo Central region of Nigeria. It is a completely rural town with five distinct villages – Eguare, Okaigben, Owu, Ikeken and Agadaga. It has a population of about 22, 000 (twenty two thousand) inhabitants. The climate is tropical with two distinct seasons – dry and wet seasons. The dry season is experienced between mid October to March, while the wet season is from April to October. The hottest months of the year are at the end of the dry season (February to March) with a monthly temperature range of 34°C to 37°C. The temperature pattern in combination with the high rainfall and relative humidity results in climate that is warm and humid throughout the year, except during the 3 to 4 months of dry season. The vegetation is natural and consists of rain forest, farmland (mainly cassava, cocoyam etc) and bush fallowing.

NO_2 Monitoring

NO_2 measurement was carried out by using Palmes diffusion tubes. The diffusion tubes used in this study consist of small acrylic tubing, 8.20cm long with a cross sectional area of 0.82cm^2, having two stainless steel mesh as support for adsorbing material at its one end. Triethanolamine was used as adsorbent for NO_2. The sensitivity of this particular tube length and the sensitivity and selectivity of triethanolamine for

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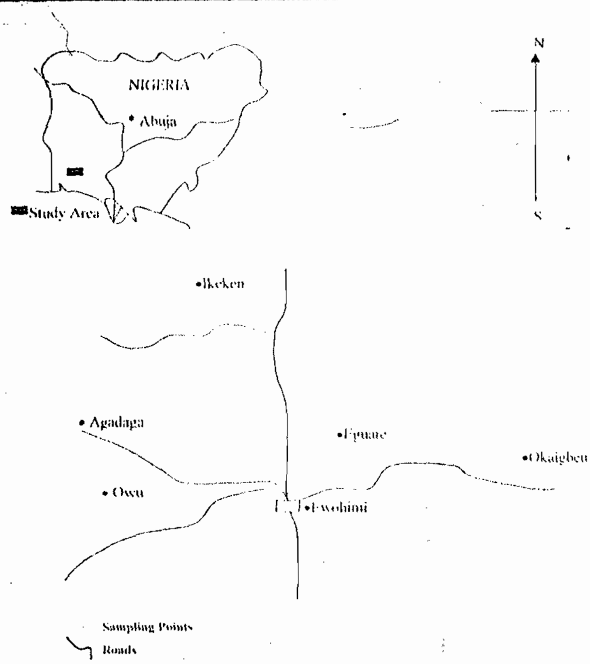

Fig: 1. Location of Ewohimi in Nigeria (insert above). Map of the Study Area showing Sampling Points

NO_2 have been reported (Ukpebor et al., 2003; Gold 1977). In preparing the tubes, uniformity was maximized, for example, the same drying time for each of the steel grids, a freshly prepared triethanolamine/ acetone mixture. The required steel grids were cleaned with acetone and dried properly. A mixture of two parts of acetone and one part of triethanolamine was prepared and stirred thoroughly. The grids were dipped in the mixture and dried for at most 20 minutes. After drying, two of the steel grids were placed at one end of the tube and the tube was capped. The prepared tubes were stored in a refrigerator and finally exposed at the different sampling sites. Two weeks sampling period was observed to allow a reasonable quantity of nitrogen dioxide to be adsorbed. Nitrogen dioxide monitoring was done for a period of 8 months to include dry season (December 1999 – March 2000) measurement and wet season (June – September 2000) measurement.

After exposing the passive samplers, the collected amount of NO_2 was determined colorimetrically as nitrite with Saltzmann reagent (Palmes et al; 1976). A visible spectrophotometer (Spectronic 21D) at zero extinction was used to determine the extinction of both blanks and the air samples at 540 nm using the reagent as referenced. The atmospheric concentration of NO_2 in the measuring period was calculated as described in Palmes et al, (1976), using Fick's first law, the dimensions of the tube and the diffusion coefficient of NO_2 in air.

RESULTS AND DISCUSSION

Data obtained from the series of air monitoring conducted at the rural villages of Eguare, Okaigben, Owu, Ikeken and Agadaga in Ewohimi, Edo Central region of Nigeria from December 1999 – September 2000 are shown in Fig.2. While the mean ambient NO_2 load for the respective months are shown in Fig. 2 , Fig.3 represents the seasonal and annual mean NO_2 concentration. Table 1 shows the dry season/wet season NO_2 concentration ratio. A near pristine atmospheric condition was recorded for NO_2 at all the rural sites monitored. This becomes glaring when NO_2 load obtained in this study are compared with daily average NO_2 limit of 75 – 113 μgm^{-3}

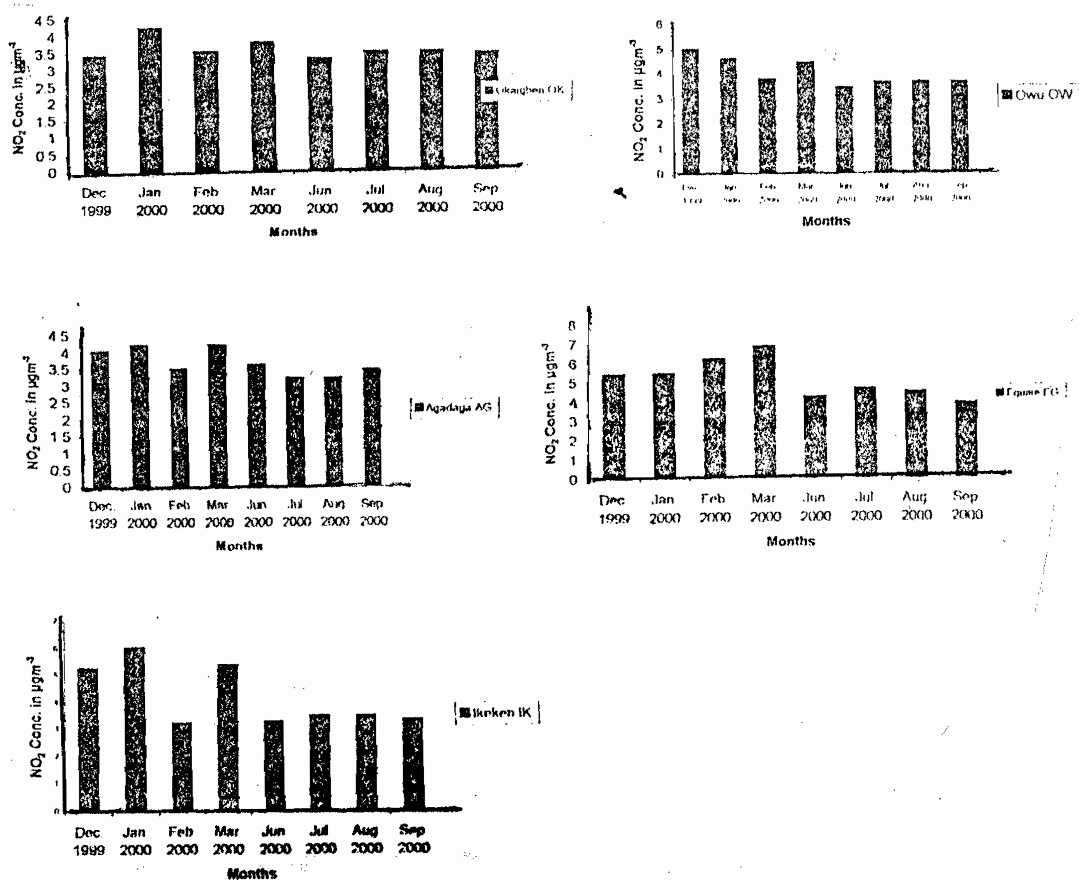

Fig 2: Measured NO_2 concentration at the different sites for the different months

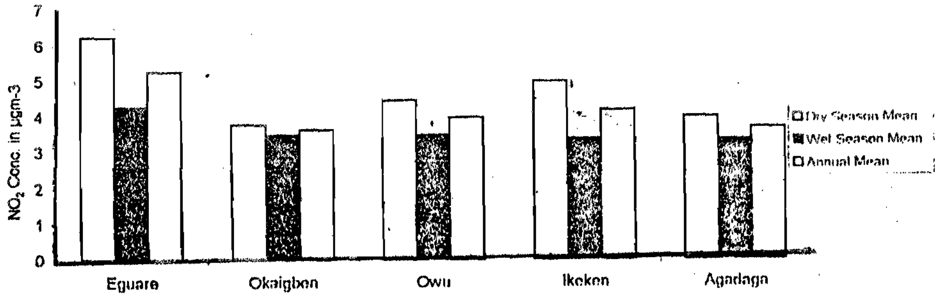

Fig 3: Seasonal and Annual mean NO_2 concentration

Table 1: Dry season/Wet season NO_2 concentration ratio

Sampling location	Tube reference	Dry season/Wet season ratio
Eguare	EG	1.46
Okaigben	OK	1.08
Owu	OW	1.28
Ikeken	IK	1.47
Agadaga	AG	1.19

set by Federal Environmental Protection Agency (FEPA 1991) and an urban background mean concentration of 6.49 μgm^{-3} obtained previously (Sadiku 1992). It suggests therefore that the man-made contribution to NO_2 load in these sites is minimal. The largest single source of NO_2 emissions to the atmosphere is from motor vehicles (D.O.E. 1991). Traffic census though not recorded were observed to be very low at all the sampling sites. Other anthropogenic sources of NO_2 in these environments include emissions from combustion of firewood (used majorly for cooking) and other vegetation, and also from the use of kerosene lamps. Other natural sources contributing to NO_2 atmospheric budget include forest fire, oxidation of atmospheric NH_3 (Crutzen 1973), production of NO in soils (Junge 1973) and NO_X production in lightning (Chameides et al., 1977).

Spatial variability in NO_2 concentration was found to be negligible. However, the highest concentration of 6.42 μgm^{-3} was measured at Eguare monitoring station in the dry season month of December. Ikeken and Agadaga monitoring stations gave the lowest load of 3.20 μgm^{-3} NO_2. The seemingly lack of spatial variability in the obtained data is a reflection of similarities in NO_2 emissions at the different locations. This is again borne out of identical living patterns, cooking habits and economic conditions. Though it is anticipated that lower concentrations of NO_2 be measured in wet season due to the wet deposition (rainout and washout) of NO_2 as HNO_3, the differences in the concentrations obtained was largely insignificant. However, while NO_2 range of 3.76 – 6.23 μgm^{-3} was obtained in dry season, a range of 3.35 – 4.28 μgm^{-3} was measured in wet season (Fig.3) To further show the similarity in the seasonal distribution of NO_2, the dry season/wet season ratio was calculated for all the sampling sites as shown in Table 1. Values close to unity were obtained for all the sites, except at Ikeken and Eguare monitoring stations where ratios of 1.47 and 1.46 were obtained respectively. While a mean annual range of 3.62 – 5.25 μgm^{-3} NO_2 was obtained in this study, a range of 3.60 – 12.45 μgm^{-3} NO_2 was measured in a previous study (Ukpebor and Ahonkhai 2000) carried out in an urban center in Nigeria. Measurements in three rural towns of Western Greenland (Denmark); Nuuk, Uummannaq and Qasiaat gave NO_2 load of 11.46 – 34.38 μgm^{-3}, 5.73 - 17.19 μgm^{-3} and 9.55 – 19.10 μgm^{-3} respectively (Hansen et al, 2001). Across rural towns in the United Kingdom, a range of 3.61 – 33.23 μgm^{-3} was obtained in a similar study (Atkins and Lee 1995). These values when compared to what was obtained in this study reinforces the pristine and completely rural nature of the sites monitored.

CONCLUSION

All sites from where air samples were collected for this study, gave very low load of NO_2. Spatial and temporal variability in the obtained NO_2 data were insignificant. It should be emphasized that the measured values are all far from the air quality standards for NO_2.

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