Ozone Pollution in the Rural Atmosphere of Ewohimi (Nigeria)

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(Received 31st January, 2004, revised January, 9th 2006)

Summary: Majority of Nigerians (about 70 % of its over 120 million population) live in the rural areas. It is therefore imperative to ascertain the quality of air they breathe. In this study, one of the criteria pollutants, tropospheric O_3 was monitored as an indicator of the degree of deterioration of rural air. Measurement was done using Passive samplers. Seven days sampling duration was observed and the quantity of pyridyaldehyde (PA) formed from the reaction of DPE (1,2-di (4-pyridyl) ethylene) and the ambient O_3 was determined using MBTH (3-methyl-2-benzothiazolinone hydrazone chloride). The distributions of O_3 were low in the rural villages with a maximum and minimum concentrations of 9.2 μgm^{-3} and 2.0 μgm^{-3} respectively. Spatial and seasonal variations were also observed in the data generated. While a mean O_3 level of 6.3 ± 0.5 μgm^{-3} was measured in dry season, and a mean of 3.3 ± 0.5 μgm^{-3} was observed in wet season.

Introduction

It is reported that more than two-thirds of the households in the world live in developing countries and about three-quarters of these are in rural areas [1], where biomass (wood, agricultural waste) is the principal fuel and where both income and energy consumption are among the lowest in the world. Biofuels yield relatively high emissions of a number of important air pollutants [2]. Generally, it has been reported that villagers experience higher exposures to indoor air pollutants than urban dwellers [3]. It has also been reported that indoor concentration of air pollutants are influenced by outdoor levels and the rate of exchange between indoor and outdoor air [4]. Consequently, ambient air quality monitoring in rural areas is therefore imperative, so that information on levels, sources, characterizations and health effects of air pollutants can be obtained.

Tropospheric ozone holds a special position among the CRITERIA pollutants and RADIATIVELY ACTIVE trace gases found in the atmosphere. It is not released into the atmosphere from either natural or anthropogenic sources; instead, it is formed by photochemical processes in the atmosphere. Unlike the other radiatively active trace gases, ozone has a very short atmospheric lifetime of few months [5]. Another particularity of ozone is that its tropospheric concentration has generally been rising. There are three reasons while tropospheric ozone is of special interest. First of all, ozone is a gas with high radiative activity which makes a major contribution towards the atmospheric greenhouse effect. Secondly, tropospheric ozone is the most important precursor of OH radicals, which play a major role in tropospheric chemistry and which have a crucial impact on the concentrations and distributions of various tropospheric trace gases, including methane. Finally, high ozone concentrations have toxic effects on both animal and plant life. In rural areas of Western and Central Europe, ozone has been demonstrated unequivocally to cause serious injury to sensitive species of vegetation [6-7]

A major source of ozone in the troposphere is its downward transport from the stratosphere. The mean annual ozone transport from the stratosphere to the troposphere is estimated at between 720 and 1220 million tones per annum [8]. In addition, considerable amounts of ozone are formed in the troposphere as a result of the photochemical oxidation of CO, CH_4 and higher hydrocarbons, a process which is catalyzed by NO and NO_2 [9]. Production of ozone due to biomass burning in rural areas in the tropics, mostly as a result of a variety of land clearing and agricultural activities have been documented [10-11]. It is estimated that 50Tg of NMHC (Non-Methane Hydrocarbon) and 5Tg of NO, precursor substances for the photochemical formation of ozone are produced each year by biomass burning.

Research/ Study objective

The work reported is a study designed to assess ozone pollution in the rural areas of Nigeria where majority of Nigerians reside. It is envisaged that the data generated would help to identify potential threats to human health and natural ecosystem.

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Results and Discussion

This study was necessitated by the urgent need to evaluate the quality of air inhaled by the teaming population of Nigerians in the rural areas. In this pilot study, one of the criteria pollutants, tropospheric O_3 was monitored as an indicator of the extent of pollution. The mean, median, minimum and maximum O_3 concentrations obtained from the series of measurements conducted in the rural villages of Okaigben, Owu, Eguare, Agadaga and Ikeken between January and August 2000 and the seasonal averages of the measured O_3, are shown in Tables 1 and 2. The distributions of O_3 levels over the rural villages were low in both seasons. A maximum and minimum concentrations of 9.2 μgm^{-3} and 2.0 μgm^{-3} respectively were obtained throughout the duration of sampling. In relative terms, these values are low. On comparison with an hourly standard of 117.5 μgm^{-3} set for a photochemical oxidant like O_3 by Nigeria Federal Environmental Protection Agency [12] and hourly value of 150-200 μgm^{-3} by World Health Organization (WHO), [13], levels obtained in this study can be inferred to be low. This finding should automatically relax the anxiety generated by the fear of possible exposure to high dose of O_3 with its attendant consequences such as phytotoxicity, respiratory distress and global warming.

Spatial variations though slight, were observed in the data generated. Monitoring sites 9, 10, 11, 12, 17, 18, 19, and 20 created at Eguare and Ikeken recorded the highest O_3 concentrations in this monitoring campaign. Sampling sites 20, 19, 10 and 18 with maximum concentrations of 9.0 μgm^{-3}, 9.2 μgm^{-3}, 8.2 μgm^{-3} and 8.9 μgm^{-3} respectively, were those sites created far away from locations with significant traffic volume and other potential sources of NO_2. The remaining fifteen monitoring sites created at Okaigben, Owu and Agadaga rural villages recorded lower levels of O_3. For instance, monitoring sites 1, 6, 15 recorded maximum concentrations of 5.4 μgm^{-3}, 5.6 μgm^{-3} and 6.4 μgm^{-3} respectively. These sites with lower O_3 levels were created in areas with slightly high traffic and close to potential sources of NO_2. The ground level distribution of O_3 is influen-ced by two independent factors; emission rates and meteorological conditions [14-15]. It is suspected that the low O_3 levels obtained in areas with slightly high traffic could be due to the vehicular exhaust. O_3 precursors such as NO_X produced by the nearby road may have modified the O_3 concentration gradients as a result of the complex physical and chemical processes [61] inherent in the dynamic NO_2-O_3 cycle.

Table-1: Mean, Median, minimum and maximum O_3 concentration of the 20 ozone-monitoring sites (μgm^{-3}) for the period January-August 2000.

Sampling location	Monitoring sites designation	Mean	Median	Minimum	Maximum
Okaigben	1	3.7	3.6	2.0	5.4
	2	3.9	3.8	2.4	5.4
	3	3.6	3.7	2.0	5.0
	4	3.9	4.0	2.2	5.4
Owu	5	3.8	3.9	2.3	5.2
	6	3.7	3.7	2.2	5.6
	7	3.7	3.8	2.2	5.2
	8	3.6	3.7	2.0	4.8
Eguare	9	5.5	5.3	3.0	8.2
	10	6.4	6.0	4.2	9.2
	11	6.0	6.2	3.3	8.0
	12	5.8	5.9	2.8	8.1
Agadaga	13	4.3	4.3	2.8	5.8
	14	3.9	4.0	2.1	5.8
	15	4.5	4.5	2.3	6.4
	16	4.5	4.6	2.6	6.0
Ikeken	17	6.2	6.0	3.8	8.8
	18	6.1	6.0	3.8	8.9
	19	6.4	6.4	3.4	9.2
	20	6.3	6.7	3.0	9.0

Table-2: Seasonal averages of the measured O_3 (μgm^{-3})

Sampling location	Monitoring sites designation	Dry Season Mean ozone concentration	Wet Season Mean Ozone Concentration
Okaigben	1	4.9 ± 0.8	2.5 ± 0.6
	2	4.7 ± 0.7	3.0 ± 0.6
	3	4.9 ± 0.1	2.2 ± 0.2
	4	4.8 ± 0.5	2.9 ± 0.7
Owu	5	4.6 ± 0.6	2.9 ± 0.7
	6	5.0 ± 0.5	2.4 ± 0.2
	7	4.5 ± 0.6	2.9 ± 0.6
	8	4.5 ± 0.5	2.8 ± 0.7
Eguare	9	7.4 ± 0.8	3.5 ± 0.5
	10	8.4 ± 0.9	4.4 ± 0.2
	11	7.8 ± 0.3	4.1 ± 0.8
	12	7.8 ± 0.3	3.7 ± 0.8
Agadaga	13	5.5 ± 0.2	3.0 ± 0.2
	14	5.3 ± 0.5	2.6 ± 0.5
	15	6.3 ± 0.1	2.6 ± 0.3
	16	5.9 ± 0.1	3.1 ± 0.4
Ikeken	17	8.1 ± 1.0	4.3 ± 0.7
	18	8.3 ± 0.5	3.9 ± 0.1
	19	8.8 ± 0.4	4.0 ± 0.5
	20	8.5 ± 0.6	4.1 ± 1.3

As expected, the mean O_3 concentrations were higher in dry season than in wet season as a result of climatic conditions. The mean O_3 levels at the 20 sites used for both of the measurement periods were 6.3 ± 0.5μgm^{-3} for dry season and 3.3 ± 0.5μgm^{-3} for

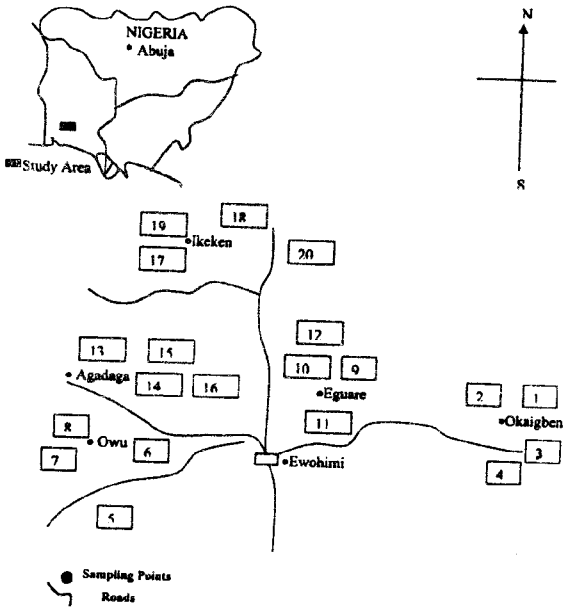

Fig 1: Location of Ewohimi in Nigeria(insert above). Map of the Study Area showing Sampling Points

wet season. A strong correlation (r = 0.96) between O_3 concentrations and sunlight has been established [21]. One of the greatest difficulties encountered in this study was the lack of meteorological information necessary for the interpretation of the data generated. However, concentrations measured in this study are comparable with concentrations in the background areas in Benin City an urban center, where annual average O_3 levels ranged from 4.9-12.2 μgm^{-3} [17].

Experimental

Passive samplers for O_3

The passive samplers for this study were procured from PASSAM AG (Switzerland). As supplied by the firm, the tubes are protected from sunlight by an opaque cylindrical box. The passive samplers consists of 4.9 cm long calibrated tubes with an inside diameter of 0.9 cm, within which air diffuses by molecular diffusion. Seven days sampling duration was observed. 1,2- Di (4-pyridyl)ethylene solution (DPE), deposited on a "Whatman EPM 2000" glass fiber filters, fixed the O_3. The other end was left open for air diffusion. The quantity of pyridyaldehyde (PA) formed from the reaction of DPE and the ambient O_3 was determined by using MBTH (3-methyl-2-benzothiazolinone hydrazone hydrochloride) [18]. This reaction produced *a* coloured complex which was measured in a spectrophotometer (Spectronic 21D) at 442 nm after stabilization in a 30 °C water bath for 1h. The reaction is specific for O_3 and has proved to be effective in measuring ozone in the ambient air [17, 19, 20].

Study area description and characteristics

This study was conducted in Ewohimi, a rural town located in Edo Central region of Nigeria. The town has five distinct villages with a population of about 52, 000 (fifty two thousand) inhabitants. There are no meteorological data available for the town due to the absence of a meteorological station. However, the climate is tropical with hot, dry and wet seasons. The dry season is experienced between mid October to March, while the wet season is from April to October. Though the level of sunlight is high all year round, 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.

Sampling Sites

These are indicated in Figure 1; 20 sites over 100m from busy roads and other identified potential NO_2 sources such as cassava milling plants, local market squares and restaurants. NO_2 distribution had previously been studied in this environment [21]. At all the sampling sites, the samplers were set up vertically, 2.0m from the ground on free - standing poles. Each tube was left in position for 7days, with the open end facing downward to avoid rain penetration. The measurement survey was conducted for 6 months to include dry season (January - March 2000) measurement and wet season (June - August 2000) measurement.

Conclusions

The monitoring of tropospheric O_3 in rural areas in Edo state has shown low levels and a good compliance with set national and international standards. Though concentrations were low, there were variations in the spatial and temporal distributions of O_3.

Acknowledgement

This work was funded by URPC division of University of Benin, Benin City.

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