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Measurement Of NO_2 And O_3 Ambient Concentrations In A Project Area In Niger Delta Region Of Nigeria.

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ABSTRACT

A pre-impact assessment of NO_2 and O_3 in a proposed project area for associated gas gathering in the Niger Delta region of Nigeria has been conducted. Passive samplers (diffusion tubes) which are devices capable of taking samples of gaseous pollutants from the atmosphere through diffusion to their interior and subsequently trapping them on an adsorbing material without the active movement of the gas through the sampler were utilized for this study. Monitoring was done for 8 months to include the rainy (May - August 2000) and dry (November 2000- February 2001) seasons. Results available indicate low levels of NO_2 and O_3 in the proposed project area with annual ranges of 4.10 - 11.48 μgm^{-3} NO_2 and of 2.72 - 3.78μgm^{-3} O_3. Temporal and spatial variations were observed in the obtained results.

INTRODUCTION

The Niger Delta region of Nigeria is endowed with natural resources like crude oil, with a proven reserve of 17.8x 10^9 barrels, and natural gas, with a proven reserve of 2.5x $10^{12}m^3$. In this region, industries related to petroleum exploration, exploitation and production are dominant and have caused a gross pollution of the air environment. In the past, much attention has been focused on aqueous and ecological monitoring in the oil producing areas[1] but little or no results have been reported on the air quality. Air quality assessment in the Niger Delta region is therefore imperative even if the emission of air pollutants is assumed to be comparatively low since high concentrations of some air pollutants have been obtained previously[2,3] at urban locations in Nigeria. Areas covered in this study are towns and villages in the Niger Delta region of Nigeria for which air quality data do not exist although they have had their own share of environment degradation resulting from petroleum exploration activities. These towns and villages have just been surveyed for the Associated Gas Gathering Project and gaseous pollutants measured in this study are NO_2 and O_3.

In Nigeria, the following sources generally contribute to air pollution[4]: traffic with high emissions from passenger cars and utility vehicles, various types of industries - primarily oil refineries with their area sources, gas flares and electrical power stations, biomass/bush burning, biomass burning for cooking purposes, uncontrolled waste burning and harmattan dust. In Niger Delta, the major sources of air pollution include gas flaring due to the large volumes of natural gas that is produced in association with crude oil and flared away, automobiles, power plants, industrial and commercial boilers and other stationery turbines and engines all of which involve

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combustion of fuels, biomass/bush burning[1].

Ozone as an ambient air pollutant has become a subject of great interest because of its effect on the respiratory system of both humans and plants. It is the most phytotoxic and widespread air pollutant affecting plants[5]. Troposphere ozone is equally a "greenhouse gas" because of its ability to absorb terrestrial thermal radiation and contributes significantly to global warming if its concentrations were increased [6,7]. The effects of ozone on plant growth and yield has been extensively reviewed[8]. Nitrogen dioxide on the other hand, is an oxidant gas which at high concentration causes lung injury. Toxicological studies have shown that nitrogen dioxide reduces the efficacy of lung defense mechanism against infection[9]. Nitrogen dioxide contributes to stratospheric ozone depletion and tropospheric ozone production. Nitrogen dioxide can equally cause serious injury to vegetation and a level of 0.3 to 5ppm for 10 to 20 days inhibits the growth of tomato and bean seedlings[10]. Because of the importance of these pollutants, the Nigerian government through its Federal Environmental Protection Agency (FEPA) has prescribed Air Quality Standards for these pollutants[11].

The purpose of this study is to ascertain the degree of pollution of the air environment of the project area with NO_2 and O_3. It is hoped that the data generated in this study will regulate public concern and be a further basis of action for pollution remediation in the region.

EXPERIMENTAL

Sampling locations

Air samples were collected at six different locations in the area proposed for associated gas gathering project. The sampling points are described below and the reference codes for the sampler tubes for the respective points are also given.

Delta Steel (DS): This sampling location was created in the forest along the proposed gas pipeline. It is remote and low in human presence.

Ughelli West (UW): This sampling site is about 100 meters from the proposed gas pipeline, about 300 meters from a flow station and about 350 meters from an electricity generating station.

Ughelli Town (UT): This sampling location was created in a city center with high traffic volume, strong human presence and activities.

Igbede Community (IC): This sampling location created in Igbede community is again remote and close to a flow station.

Ozoro Community (OC): This sampling location was created along the proposed gas pipeline in this community and is remote.

Eriemu Community (EC): This sampling site was created at Eriemu community about 1000 metres from the closest village.

Passive samplers for nitrogen dioxide

Nitrogen dioxide gas was collected by trapping it using passive diffusion tubes developed and used by Palmes and others[12,13,14.] They consist of small acrylic tubing 7.4cm long, 1cm in diameter having 3 stainless grids as support for adsorbing material at its one end. Triethanolamine was used as adsorbent for nitrogen dioxide.

Diffusion tubes preparation

In preparing the tubes, uniformity was maximized, for example; the same drying time for each of the tube grids, a freshly prepared triethanolamine/acetone mixture. A mixture of two parts of acetone and one part of triethanolamine was prepared. The grids were dipped in the mixture and allowed to dry. Three of the steel grids were pushed into the diffusion tube after

drying. The prepared tubes were mounted vertically with the coloured cap uppermost at a height of approximately 2.0m above the ground surface on the supporting stands at each sampling station.

Sampling routine

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 rainy season (May – August 2000) measurement and dry season (November 2000 – February 2001) measurement. The analytical finish was accomplished by using Saltzmann reagent and a clean visible Spectronic 21D Spectrophotometer at zero extinction to determine the extinction of both the blanks which were prepared like the exposed tubes, except that they were not exposed, and the air samples at a wavelength of 540nm. Nitrogen dioxide concentration was calculated from the amount adsorbed by using the following equation[15].

$$C = \frac{22.4 \times T/273 \times F \times Z \times E}{T \times D \times A}$$

F = Calibration factor

Z = Length of the diffusion tube (cm)

Where:

C = NO_2 conc. (ppb)

E = Extinction minus Extinction of the blank

t = Exposure time (s)

D = Diffusion coefficient of the compound in air (cm^2/sec)

A = Cross – sectional area of the tube (cm^2)

Note: 1ppb NO_2 = 1.91μgNO_2/m^3

Passive sampler for Ozone

Air samples for tropospheric ozone were collected by using passive diffusion tubes described and used by Monn and Hangatner[16] and Hauser and Bradley[17]. The tubes used are made of polystyrene, 2.9cm long and 0.9cm in diameter. 1, 2-di (4-pyridyl) ethylene (DPE) was used as the adsorbent.

Diffusion tubes preparation

The adsorbent, a solution of DPE was prepared by dissolving it in acetic acid and ethylene glycol. "Whatman EPM 200M" glass fibre filters were used as solid sorbent because of their large surface. The filters were cut on a glass dish mould into a size of 0.8cm by 0.8cm, soaked in the adsorbent solution and hung – dried for 15minutes in a light protected box. With the aid of tweezers, the filters were then transferred into the polystyrene tubes. The prepared tubes were exposed at each site at a height of approximately 2.0m. In this method, the absorption of ozone takes place by reaction with DPE, the ozonide formed undergoes cleavage and yields an aldehyde.

Sampling routine

One-week sampling duration was observed, and as in the case of NO_2 tubes, monitoring was done for 8 months. The quantity of pyridylaldehyde (PA) formed from the reaction of the adsorbent and the ambient tropospheric ozone was determined by using Methylbenzthioazolinonehydrazone (MBTH) in acetic acid. The absorbance of the azine formed was measured at 442nm using a clean UV/Visible spectronic 21D Spectrophotometer at zero extinction. This quantity of azine is proportional to ozone collection.

Table 1: Measured NO_2 concentrations

Sampling location	Tube reference	Ambient NO_2 concentration (μgm^{-3})							
		May 2000	June 2000	July 2000	Aug 2000	Nov 2000	Dec 2000	Jan 2001	Feb 2001
Delta Steel	DS	3.02	2.78	3.72	3.64	4.96	5.08	5.12	7.08
Ughelli West	UW	7 .84	8.20	8.08	7.22	9.66	10.11	11.04	12.00
Ughelli Town	UT	10.22	9.88	10.62	8.79	9.64	12.98	15.20	14.44
Igbede Community	IC	4.48	6.02	4.22	3.98	5.23	5.28	5.96	6.43
Ozoro Community	OC	5.62	5.40	5.44	4.87	6.08	6.89	7.46	8.02
Eriemu Community	EC	2.66	2.42	2.86	3.20	4.08	5.24	6.32	5.99

RESULTS AND DISCUSSION.

The time-weighted average concentrations of NO_2 and O_3 measured between May 2000 and February 2001 are presented in Tables 1, 2, 3 and 4. As can be seen from Table 1, low concentrations of NO_2 were recorded throughout the sampling duration. Spatial and temporal variations were equally noticed in the obtained results. The highest NO_2 level of 15.20μgm^{-3} was measured at Ughelli town and the lowest of 2.42μgm^{-3} recorded at Eriemu community. An annual range of 4.10 - 11.84μgm^{-3} NO_2 was observed in this study. The FEPA[11] allowed daily average limit for NO_2 is presently 75 - 113μgm^{-3}. The US National Ambient Air Quality Standard[18] for NO_2 is presently 100μgm^{-3} annual average while the World Health Organization has recommended a 1- hourly average short-term standard of 320μgm^{-3} not to be exceeded more than once per month[19]. Though levels of NO_2 obtained in this study are very much lower than the national and international limits for NO_2, higher concentrations were recorded in Ughelli Town. A NO_2 range of 8.79 - 15.20μgm^{-3} was obtained at this sampling site. Mention has already been made of the high traffic density and intense human activities prevalent at this location. The observed NO_2 level could therefore be ascribed to the heavy traffic around the location since traffic is a contributing factor to NO_2 level

Table 2: Seasonal and annual mean NO_2 concentrations

Sampling Location	Tube reference	Wet season mean (μgm^{-3})	Dry season mean (μgm^{-3})	Annual mean (μgm^{-3})
Delta Steel	DS	5.56	3.29	4.43±1.42
Ughelli West	UW	10.70	7.84	9.27±1.70
Ughelli Town	UT	13.07	9.88	11.48±2.40
Igbede Community	IC	5.73	4.68	5.21±0.91
Ozoro Community	OC	7.11	5.33	6.22±1.12
Eriemu Community	EC	5.41	2.79	4.10±1.56

in the atmosphere. The largest single source of NO_2 emissions and, therefore, NO_2 in the atmosphere is from motor vehicles[20]. The location with the second highest NO_2 concentration is Ughelli West which is about 300 metres from a flow station and about 350 metres from an electricity generating station. The increased level of NO_2 at this site may be due to the emissions of NO_2 gas from the combustion processes going on at the electricity generating station and the flow station.

Other sampling locations which are remote from vehicular and human traffic gave very low concentrations of NO_2. Temporal variations in the obtained NO_2 data were observed in all the sampling sites (Table 2). Higher NO_2 concentrations were measured in the dry season at all the locations (Tables 1 and 2). The differences in the concentrations recorded for the two seasons can be attributed to the wet deposition (rain out and washout) of NO_2 as HNO_3 in the wet season. Concentrations of O_3 recorded were equally low throughout the period of study (Table 3) with the highest concentration of 5.64μgm^{-3}measured in the month of February at Ughelli West monitoring station and the lowest concentration of 2.02 μgm^{-3} measured in the months of May and August at two different sampling locations. The ground level distribution of ozone is influenced by the two independent factors, emission rates and meteorological conditions[21]. It is believed that NO_2 is the limiting precursor for the formation of ozone, a secondary pollutant in the free troposphere[22]. Low concentrations of O_3 obtained could, to a reasonable extent, be due to the low levels of NO_2 equally measured at the different sampling locations. An annual range of 3.08 - 5.64μgm^{-3} O_3 was found. Ughelli West gave the highest concentrations of O_3 for half of the sampling months. Ughelli town gave the second highest annual mean of 3.40μgm^{-3} O_3. Other remote sampling sites gave very low levels of O_3. Ozone is a respiratory irritant. It is also the most phytotoxic air pollutant affecting plants[5]. Low levels recorded in these remote sites inside rubber plantations is therefore heart warming for the region.

Table 3: Measured O_3 concentrations

		Ambient O_3 concentration (μgm^{-3})							
Sampling location	**Tube reference**	May 2000	June 2000	July 2000	Aug 2000	Nov 2000	Dec 2000	Jan 2001	Feb 2001
Delta Steel	DS	2.86	2.89	2.00	2.37	3.29	4.12	3.99	4.02
Ughelli West	UW	3.20	2.73	2.82	2.02	4.33	4.29	5.20	5.64
Ughelli Town	UT	2.63	2.06	2.72	2.08	2.98	4.48	4.98	5.22
Igbede Community	IC	2.02	2.12	2.92	2.08	3.22	3.01	3.24	3.08
Ozoro Community	OC	2.08	2.10	2.96	2.23	3.62	4.12	4.09	4.24
Eriemu Community	EC	2.32	2.28	2.17	2.92	3.13	3.18	3.74	3.86

Table 4: Seasonal and annual mean O_3 concentrations

Sampling location	Tube reference	Dry season mean (μgm^{-3})	Wet season mean (μgm^{-3})	Annual mean (μgm^{-3})
Delta Steel	DS	3.86	2.53	3.20±0.80
Ughelli West	UW	4.87	2.69	3.78±1.28
Ughelli Town	UT	4.42	2.37	3.40±1.30
Igbede Community	IC	3.14	2.29	2.72±0.54
Ozoro Community	OC	4.02	2.23	3.18±0.95
Eriemu Community	EC	3.48	2.42	2.95±0.65

Seasonal variation in the concentration of O_3 was equally observed. Table 4 represents the annual and seasonal average ozone concentrations. For all the sampling locations, dry season gave higher ozone concentrations.

Ambient concentrations of NO_2 and O_3 obtained in this study compare favorably with levels obtained previously in studies conducted in Benin City, Nigeria[23,24]. In consideration of NO_2 values obtained in work done in United Kingdom[25] and O_3 values from previous study conducted in Frankfurt, Germany[26], communities surveyed for this associated gas-gathering project are relatively free from NO_2 and O_3 pollution.

CONCLUSION

This pre - project assessment of O_3 and NO_2 levels in the environment set aside for an associated gas gathering project indicate that ambient concentrations of NO_2 and O_3 are within the short and long term Federal Environmental Protection Agency limits.

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