Levels of Nitrogen Dioxide and Sulphur Dioxide Measured Around Roadside Gardens in Port Harcourt Metropolis

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Abstract— *Levels of nitrogen dioxide and sulphur dioxide around roadside gardens in Port Harcourt metropolis were determined at 0m and 50m from road junctions using portable hand held Multi RAE PLUS (PGM-50), a programmable multi gas monitor with an electrochemical sensor for the detection of Sulphur dioxide and ITX Multi Gas monitor for the detection of Nitrogen dioxide. The results showed that the concentrations of NO_2 and SO_2 ranged from 0 – 0.3ppm in both seasons. The mean concentration of SO_2 at 0m and high traffic density stations were higher than the mean concentration at 50m and low traffic density stations. The difference in mean concentrations between dry and rainy seasons, traffic density and distance were not significant for NO_2 but significant for SO_2. The concentration of NO_2 and SO_2 recorded at the study stations exceeded the permissible limits of 0.004ppm and 0.01ppm respectively, recommended by the Federal Ministry of Environment and therefore poses serious threat to the environment particularly small farms and gardens around major roads. The levels of NO_2 and SO_2 around the gardens were influenced by traffic density, seasonal variations and distances from major roads, therefore authorities should embark on sensitization and enlightenment campaigns; farming activities and raw consumption of exposed vegetables, crops and fruits should be discouraged in the study areas.*

Keywords— Nitrogen dioxide, Sulphur dioxide, garden, roadside, traffic density, plants.

I. INTRODUCTION

Port- Harcourt being the capital and major city of Rivers State, with rapid urbanization and an associated growth in industry and vehicle use, an increase in the emissions of sulphur dioxide, hydrocarbons, nitrogen oxide, and other industrial and automobile emissions are bound to be expected (Ideriah, 1996). If these pollutants exceed the recommended levels, then there is no doubt that they will become harmful to higher animals including humans through the soil, water and plants since their existence is in close proximity.

The study area, Port Harcourt, is a highly industrialized city in Nigeria; it has a large number of multinational firms as well as other industrial concerns, particularly businesses relating to the petroleum industry. Port Harcourt lies within latitude 4^0 43' and 4^0 54' N and longitude 6^0 56' and 7^0 03' E, 18meters (59ft) above sea level and with a mean annual rainfall of over 2000mm and mean annual temperature of about 29^0C. (NMS, 1998) (Fig. 1).

As air quality is slowly improving in developed countries, it is rapidly deteriorating in developed countries. A rapidly multiplying population and the growth of industries and car use are the main causes of air pollution today. In Asia, rapid urbanization, with the associated growth in industry and vehicle use has increased emissions of sulphur dioxide (SO_2) and nitrogen dioxide (NO_2) (PEPU, 2009).

The two main sources of pollutants in urban areas are transportation (predominantly automobiles) and fuel combustion in stationary sources, including residential, commercial and industrial heating and cooling and coal-burning power plants. Motor vehicles produce high levels of carbon monoxide (CO) and constitute a major source of hydrocarbon (HC) and nitrogen oxides (NO_x), whereas, fuel combustion in stationary sources is the dominant source of SO_2 (Socha, 2007).

Slanina and Howard (2008) reported that the transport sector is responsible for 60 to 70% of NO_2 emissions in Europe.

Nitrogen oxide (NO or NO_2) is a brown, odourless gas which is a by-product of combustion, when oxygen is used to oxidize nitrogen instead of hydrocarbon. Transportation accounts for 45-50% of total emission of nitrogen oxides (Jean-Paul, 2009). NO_2 is a gas that is emitted into the atmosphere as a result of various human activities. An excess of NO_2 is mainly from power plants in major cities and the burning of fuels due to various motor vehicles (Kashimira, 2009). Nitrogen oxides are known to prevent the growth of crops and thus reduce agricultural yields (Jean-Paul, 2009).

Air pollution affects plants and wildlife. This is why it can be more difficult for plants to thrive in city centres. SO_2 and NO_x can make water and soil more acidic and therefore harmful to some plants and animals (Direct Gov., 2010).

Air pollution injury to plants can be evident in several ways; injury to foliage may be visible in a short time and appear as necrotic lesions (dead tissues), or it can develop slowly as a yellowish or chlorosis of the leaf (Heather, 2009). There may be reduction in growth of various portions of a plant, plants may be killed outright, but they usually do not succumb until they have suffered recurrent injury (Heather, 2009). Agricultural crops can be injured when exposed to high concentration of various air pollutants. Injury ranges from visible markings on the foliage to reduced growth and yield, to premature death of the plant (Heather, 2009). The development and severity of the injury extends not only on the concentration of the particular pollutant, but also on a number of other factors. These include the length of exposure to the pollutants, the plant species and its stage of development as well as the environmental factors conducive to a build-up of the pollutants and the pre-conditioning of the plants, which makes it either susceptible or resistant to injury (Heather, 2009). Different plant species and varieties and even individuals of the same species may vary considerably in their sensitivity to SO_2. These variations occur because of the differences in geographical locations, climate, stage of growth and maturity (Heather, 2009).

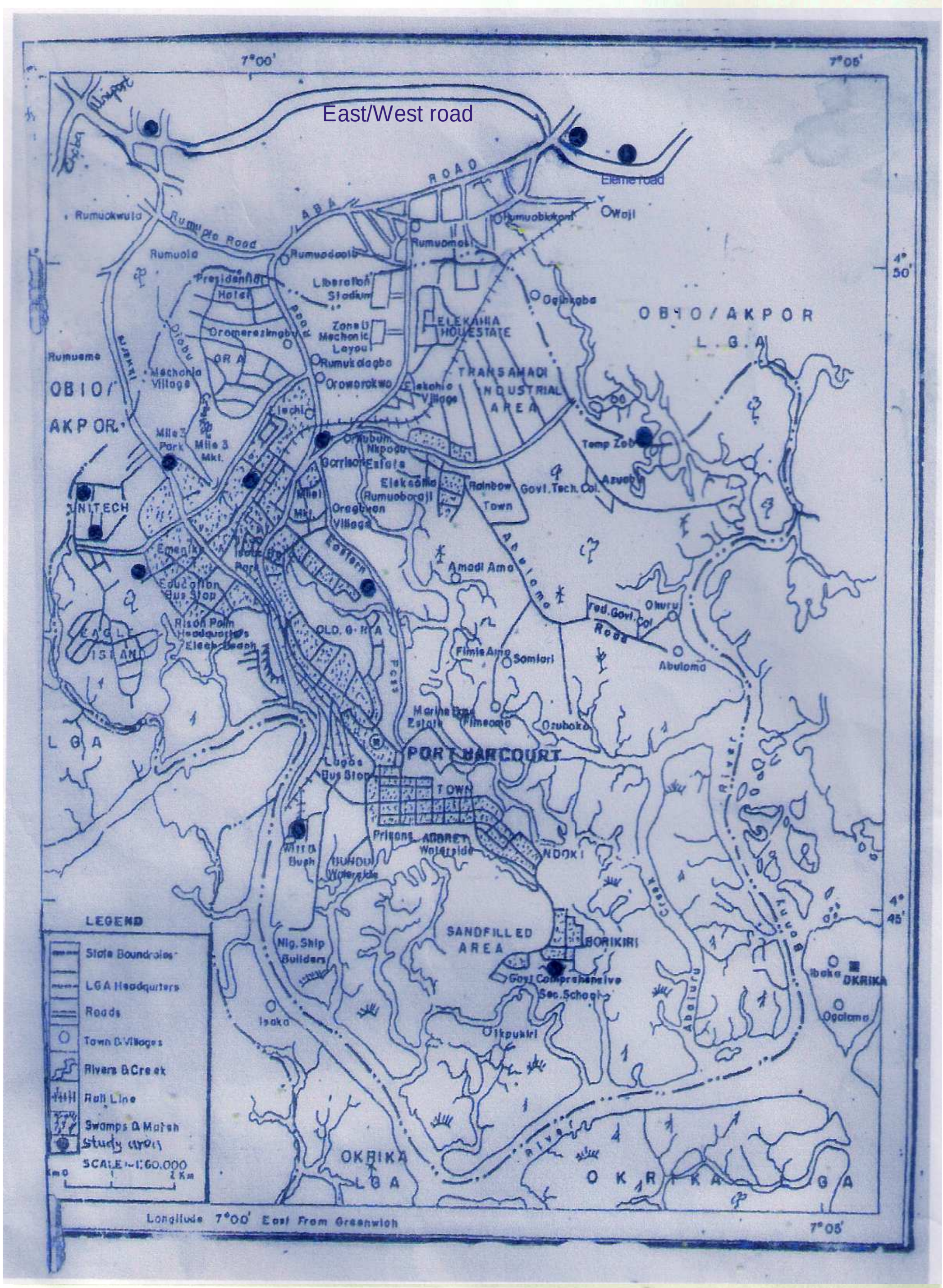
According to Jean-Paul (2009), air pollutant has serious harmful effects on plants. SO_2 causes chlorosis resulting in the death of cells and tissues, also, forest trees are worst affected by SO_2 pollutants. SO_2 is a heavy, colourless gas with a strong odour, it is the result of the combustion of fossil fuels like coal (particularly bituminous coal and hydrocarbons). Transportation accounts for about 5% of total SO_2 emissions. Sulphur is an essential nutrient for plants, but SO_2 is regarded as an inhibitor of physiological activities. Most affected plants are those having a high physiological activity like crops and commercial timber forests (Jean-Paul, 2009). SO_2 is converted to sulphuric acid in the atmosphere, which can be poisonous to both plants and animals (PEPU, 2009).

Pollutants such as SO_2, NO_x and ozone cause direct damage to leaves of crop plants and trees when they enter leaf pores (stomata). Chronic exposures of leaves and needles to air pollutants can also break down the waxy coating that helps to prevent excessive water loss and damage from diseases, pest, drought and frost (Miller, 1990).

Heather (2009) reported that SO_2 enters the leaves mainly through the stomata (microscopic openings) and the resultant injury is classified as either acute or chronic. He further explained that acute injury is caused by absorption of high concentrations of SO_2 in a relatively short time. The symptoms appear as a two sided (bifacial) lesions that usually occur between the veins and occasionally along the margins of the leaves. The colour of the necrotic area can vary from a light tan or near white to an orange-red or brown, depending on the time of the year, the plant species affected and the weather conditions. Recently expanded leaves are usually the most sensitive to acute SO_2 injury, the youngest and oldest being somewhat more resistant. Chronic injury is cursed by long-term absorption of SO_2 at sub-lethal concentrations. The symptoms appear as a yellowing or chlorosis of leaf and occasionally as a bronzing on the under surface of the leaves (Heather, 2009).

Changes in the physical appearance of vegetation are an indication that the plants' metabolism is impaired by the concentration of SO_2 (Carter, 2003). Harm caused by SO_2 is first noticeable on the leaves of the plants, injury can occur within hours or days of being exposed to high levels of sulphur dioxide and it is the leaves in the mid-growth that are most vulnerable, while the older and youngest leaves are more resistant (Carter, 2003). The effects of SO_2 are influenced by other biological and environmental factors such as plant type, age, sunlight levels, temperature, humidity and the presence of other pollutants (Ozone and NO_2) (Carter, 2003).

Ideriah, (1996) reported that mounting population pressure and urbanization has resulted in ever increasing smaller farm sizes and in some cases the complete clearing of farms for other uses. Small scale farmers are left with the option of raising home gardens where annual and perennial vegetables are grown along with the common short duration fruit crops (banana, paw-paw, pineapple, etc). Other fruit crops such as mango, guava, avocado, etc are also grown along roadsides and around the house. It is not uncommon to find people plucking and eating these unwashed raw fruits, or food hawkers displaying their stuff openly and unwrapped alongside heavy traffic roads which are apparently contaminated with air pollutants (Ideriah, 1996). The aim of this study is to determine the levels of sulphur dioxide and nitrogen around gardens along major road junctions in Port Harcourt, a fast developing city in the Niger Delta, Nigeria.



II. MATERIALS AND METHODS

SITE SELECTION

The study area was divided into thirteen stations classified according to the volume of vehicles that ply the areas (traffic density). The stations are (High traffic density (> 400,000 vehicles per day) Low traffic density (< 400,000 vehicles per day) and control (approximately 20 vehicles per day). Also the stations were selected based on the availability of farm or other forms of vegetation. A GPS was used to geo-reference the stations (Table 1).

TABLE 1
IDENTIFICATION OF STUDY STATIONS WITH GEOGRAPHICAL REFERENCES AND TRAFFIC DENSITY

Station No	Station name/ Code	GPS	Traffic Density
1	Aba road/ Garrison Junction (HD1)	N 04°48.413' E 007°00.567'	High
2	Trans-Amadi/ Port Harcourt Zoo (HD2)	N 04°48.758' E 007°02.673'	High
3	Aba road/Eleme Junction (HD3)	N 04°51.427' E 007°04.120'	High
4	East-West road/Eleme Junction (HD4)	N 04°51.418' E 007°04.170'	High
5	East-West road/ Rumuokoro (HD5)	N 04°52.052' E 006°59.780'	High
6	Ikwere road/Mile 3 Junction (HD6)	N 04°48.308' E 006°59.351'	High
7	RSUST school/Farm (C1)	N 04°48.233' E 006°58.622'	Control
8	RSUST/Road E (C1)	N 04°47.308' E 006°58.807'	Control
9	Reclamation Road/Emmanuel Close (LD1)	N 04°45.745' E 007°00.700'	Low
10	Lulumber Street Diobu (LD2)	N 04°47.516' E 006°59.346'	Low
11	Manilla-Pepple Street D/Line (LD3)	N 04°47.990' E 006°59.902'	Low
12	GCSS/Borikiri (LD4)	N 04°44.535' E 007°02.101'	Low
13	Eastern By Pass/LNG Roundabout (LD5)	N 04°47.516' E 007°00.984'	Low

Multi RAE PLUS (PGM-50), a programmable multi gas monitor with an electrochemical sensor was used for the detection of Sulphur dioxide. The range of detection was between 0-20ppm with a resolution of 0.1ppm. Measurement was done by holding the sensor to a height of about 2m in the direction of the prevailing wind and readings recorded at stability.

ITX Multi Gas monitor was used for the detection of Nitrogen dioxide. The range of detection was between 0.999ppm with a resolution of 0.1ppm. Measurement was done by holding the sensor to a height of about 2m in the direction of the prevailing wind and readings recorded at stability.

Parameters monitored are Nitrogen dioxide (NO_2) and Sulphur dioxide (SO_2). Measurements were made during the rainy season (September) and dry season (January) to determine the effect of seasonal variation on the concentrations of NO_2 and SO_2. The pollutants NO_2 and SO_2 were measured at 0m and 50m along transects away from road to determine the effect of distance on the concentrations of the pollutants.

III. RESULTS AND DISCUSSIONS

Nitrogen dioxide was detected only at stations HD6 (0.2ppm, dry and 0.1ppm, rainy), C1 and C2 (0.3ppm, dry and 0.1ppm, rainy) (Fig. 2). There was no significant difference in the mean concentrations of NO_2 at 0m (0.1833ppm) and at 50m (0.1833ppm). There was also no significant difference in the mean concentrations of NO_2 in the dry season (0.0615ppm) and in the rainy season (0.0231ppm) (Table 2).

SO_2 was detected at two high traffic density stations HD1 (0.2ppm, dry and 0.1ppm rainy) and HD6 (0.2ppm, dry and 0.1ppm, rainy) and three low traffic density stations, LD1 (0.3ppm, dry and 0.1ppm, rainy), LD4 & LD5 (0.2ppm, dry and 0.1ppm, rainy) as well as in the control stations (C1 and C2). The mean concentration of SO_2 in the high traffic density stations was significantly higher than the mean concentration in the low traffic density stations (Table 2).

The concentrations of SO_2 measured during the rainy season ranged from 0.0ppm to 0.1ppm, while the dry season concentrations ranged from 0.0ppm to 0.3ppm (Fig. 3). However, there was no significant difference in the rainy and dry seasons concentrations of SO_2.

The mean concentration of SO_2 at 0m (0.2000ppm) is significantly higher than the mean concentration at 50m (0.1250ppm).

TABLE 2
MEAN CONCENTRATION OF NO_2 AND SO_2 MEASURES AT THE STUDY STATIONS

Mean Concentrations of Pollutants Monitored (ppm)		
	NO_2	**SO_2**
Dry Season	0.0615[a]	1.1000 [a]
Rainy Season	0.0231 [a]	0.0538 [b]
High Traffic Density	0.0500 [c]	0.0833 [c]
Low Traffic Density	0.0000 [c]	0.1500 [c]
Distance (0m)	0.1833 [e]	0.2000 [e]
Distance (50m)	0.1833 [e]	0.1250 [f]

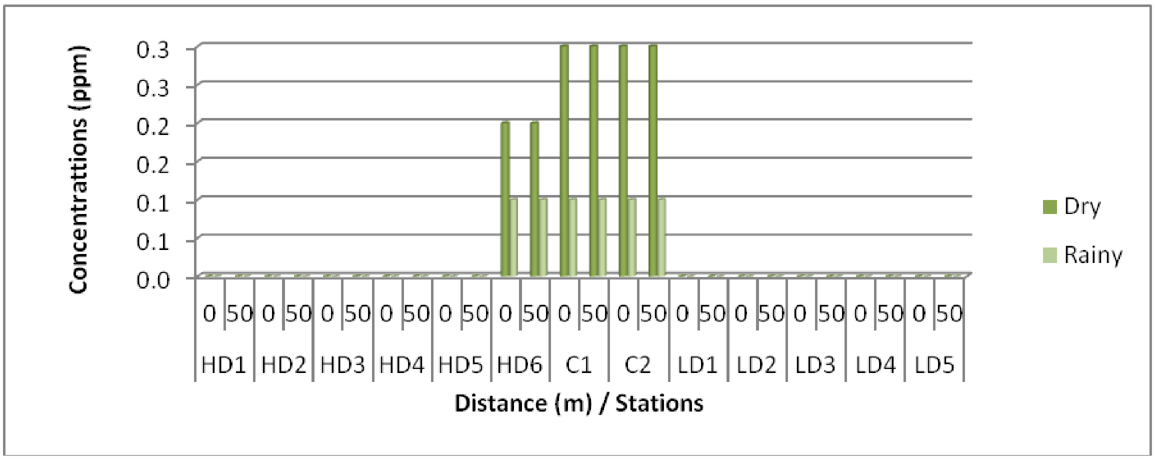


FIG. 2: VARIATION IN CONCENTRATIONS OF NO_2 WITH SEASONS, STATIONS AND DISTANCE

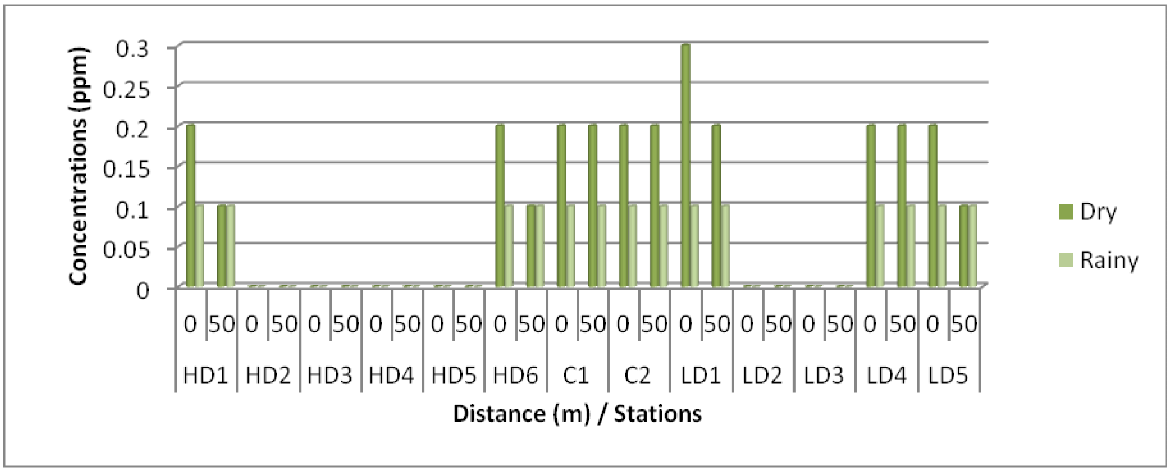


FIG. 3: VARIATION IN CONCENTRATIONS OF SO_2 WITH SEASONS, STATIONS AND DISTANCE

The concentrations of NO_2 and SO_2 at the high traffic density stations were slightly higher than the concentrations at the low traffic density stations. Statistical analysis showed no significant difference between the mean concentrations of NO_2 and SO_2 at the high traffic density stations and at the low traffic density stations. This observation is in agreement with the report by Socha, 2007, which states that the two main sources of pollutants in urban areas are transportation (predominantly automobiles) and fuel combustion in stationary sources.

The mean NO_2concentration (0.1833ppm) at 0m away from the road was not significantly different from the mean concentration (0.1833ppm)at 50m away from the road, whereas, the mean concentration (0.2000ppm) of SO_2 at 0m was significantly higher than the concentration (0.1250ppm) at 50m. This observation suggests that automobiles are not the only sources of gaseous air pollutants (NO_2 and SO_2). Socha, 2007, stated that motor vehicles produce high levels of NO_x whereas fuel combustion in stationary sources is the dominant source of SO_2.

Though the dry season mean concentration of NO_2 (0.0615ppm) was higher than the rainy season mean concentration (0.0231ppm), statistical analysis using DMRT at $P \leq 0.05$ showed no significant difference between them. The mean concentration of SO_2 in the dry season (0.1000ppm) was significantly higher than the rainy season mean concentration (0.0538ppm). The rainy season showed concentrations lower than the dry season, this can be attributed to the cleansing effect of rainfall on the atmosphere (NADP, 1982. During the rainy season, a combination of heavy rainfall and in some cases, high wind speed off the oceans significantly improves air quality (Efel *et. al.*, 2005). The percentage of calm period is higher during the dry season than during the rainy season, the higher percentage of calm periods during the dry season means high concentration of pollutants during the dry season than the rainy season (Chima and Pius, 2009).

The concentrations of NO_2 and SO_2 recorded at the study stations exceeded the permissible limits of 0.004ppm and 0.01ppm respectively, recommended by the Federal Ministry of Environment (1991). This situation calls for serious environmental concern in those stations where they were detected. NO_2 was detected in stations HD6, C1 and C2 (Ikwere road by Mile 3, Rivers State University of Science and Technology Farm and Road E, River State University of Science and Technology). Agricultural crops can be injured when exposed to high concentration of various air pollutants. Injury ranges from visible markings on the foliage to reduced growth and yield, chlorosis and premature death of plant (Miller, 1990; Heather, 2009; Jean-Paul, 2009).

Though fewer vehicles ply the control stations (C1 & C2), the high concentration of NO_2 recorded at these stations could be due to the industrial and vehicular activities of the adjacent Nigerian Agip Oil Company, while the high concentration recorded at station 6 could be from the road construction work (Agip Flyover) that was on-going at the time of the study.

IV. CONCLUSION AND RECOMMENDATIONS

This study has revealed that the concentrations of NO_2 and SO_2 in Port Harcourt metropolis exceeded their recommended limits and therefore pose serious threats to the environment and plants (stunted growth and low yields) in farms and gardens around major road junctions.

The levels of air pollutants around the gardens were influenced by traffic density, seasonal variations and distances from major roads.

There is need for sensitization and enlightenment campaigns to discourage farming activities and raw consumption of exposed vegetables, crops and fruits should be discouraged in the study areas.

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