Journal of Environment and Earth Science
ISSN 2224-3216 (Paper) ISSN 2225-0948 (Online)
Vol.4, No.19, 2014 

# Impact of Industrial Activities on the Ambient Air Quality of Bundu-Ama Environs, Port Harcourt,Nigeria

Dr Umunnakwe Johnbosco E.
Department of Environmental Technology.Federal University of Technology,Owerri Imo State, Nigeria
jnboscokwe@yahoo.com

Dr Nnaji Austin. O.
Department of Environmental Technology,Federal University of Technology, Owerri Imo State, Nigeria

**Abstract**
Studies on the impact of human and industrial activities on the ambient air quality of Bundu Ama environs, Port Harcourt was carried out in the month of september2014.Four monitoring stations were selected for measurement of the air pollutant levels according to Federal Ministry of Environment prescribed guidelines and methods. The pollutants monitored and measured were: Suspended Particulate Matter (SPM), Carbon Monoxide (CO), Hydrocarbon (HC), Volatile Organic Carbon (VOC),Nitrogen Oxides($NO_X$) and Sulphur Oxides ($SO_X$).These parameters were monitored and measured by a gas meter with sensors sensitive to their concentrations. The results showed that Suspended Particulate Matter, SPM and $SO_X$ were detected in appreciable levels during monitoring. However the levels of SPM were within the guidelines set by FEMENV while $SO_X$ exceeded the limit in some of the monitored stations. There is need for constant monitoring of the industries in the study area and enforcement of all environmental laws by the authorities.
**Keywords:** Ambient air quality, Bundu-Ama, Monitoring, Impact

## INTRODUCTION

Air pollution is the presence in the outdoor atmosphere of one or more air contaminants (i.e dust, fumes, gas, mist, odour, smoke or vapour) in sufficient quantities of such characteristics and of such duration as to be or to threaten to be injurious to human, plant or animal life or to property or which reasonably interferes with the comfortable enjoyment of life or property (Chakradhar *et al*., 2003). The knowledge of quality of ambient air plays an important role in assessing the environmental scenario of the locality (Canter,1996). The quality of ambient air depends upon the background concentrations of specific contaminants, the emission sources and meterological conditions. Air pollutants can be classified as natural contaminants (fog, pollen grains) aerosols (dust, smoke, mist), gases and vapour (SOx, NOx).The sources of air pollutants include mobile transportation, solid waste disposal and industrial sources. The air quality sampling and monitoring is one of the important aspects in establishing the baseline quality of the region of interest (Ubong and Gobo 2001). This includes identification of specific air pollution parameters expected to have significant impacts and assessing their existing levels in ambient air within the impact zone of the study area, Bundu-Ama environs. The base consideration of air sampling consists of samples collected being representative in terms of time and locations. Air pollution which consists of indoor and outdoor pollutants have been a public concern in Nigeria. In cities like Nkalagu, Gboko, Lagos, Kano, Port Harcourt and Ibadan across Nigeria, acid rain and ozone pollution create an environmental impact and affect human health unknowingly as a result of cement factories located in these areas (Otti and Ogbuagu, 2014). Indiscriminate burning of solid waste at open dumps which generates air contaminants like dust, smokes, mist and odour causes injuries to human, plant, animal and property.

Air pollution comes from many different sources; stationary sources such as factories, power plants, and smelters and smaller sources such as dry cleaners and degreasing operations; mobile sources such as cars, buses, planes, trucks, and trains; and naturally occurring sources such as windblown dust, and volcanic eruptions, all contribute to air pollution. Air quality can be affected in many ways by the pollution emitted from these sources. These pollution sources can also emit a wide variety of pollutants. The Environmental Pollution Agency (EPA) has these pollutants classified as the six principal pollutant called criteria pollutants which are monitored by the federal, state and local agencies (EPA, 2014). National ambient air quality standards are standards set for pollutants which are considered harmful to the people and the environment. National, state, tribal and local governments are responsible for ensuring that these air quality standards are met or attained through national standards and strategies to control pollutants emissions from auto mobiles, factories and other sources. There are two types of standards, primary and secondary. Primary standards protect against adverse health effects; secondary standards protect against welfare effects, such as damage to farm crops and vegetation and damage to buildings. The six criteria pollutants addressed in the National Ambient Air Quality Standards(NAAQS) are carbon monoxide, Nitrogen Dioxide, Lead, Ozone(or Smog), Particulate Matter and Sulfur Dioxide (Smith,2009). If the levels of these pollutants are higher than what is considered acceptable by regulatory agencies, then the area in which the level is too high is called a nonattainment area. Combustion of fossil fuels in stationary sources

usually leads to the production of $SO_2$, NOx, and Particulates. Domestic fuel use, mainly coal and wood, represents a significant source of the air pollution in cities, particularly cities in developing countries. Petrol-fuelled motor vehicles are responsible for the emissions of NOx, CO, and Pb (where leaded petrol is still used), whereas diesel-fuelled engines lead to significant emissions of $SO_2$, NOx, and Particulates. VOCs are emitted from various anthropogenic sources including road traffic, production and the use of organic chemicals (e.g. solvents), transport and the use of crude oil, the use and distribution of natural gas, and from waste disposal sites and waste water treatment. Combustion of fossil fuels in stationary sources usually leads to the production of $SO_2$, $NO_x$ and Particulates. Domestic fuel use, mainly coal and wood, represents a significant source of the air pollution in cities, particularly cities in developing countries.

Urban air pollution has worsened the health in the cities of both developed and developing countries. The health impacts in developing world have been driven by population growth, industrialisation and increased vehicular use (Shanker and Ramarao,2002). Apart from having human health impacts, air pollution also adversely affects the natural environment .Concentrations of such chemicals in the air affect human health. Health effects vary with the intensity and the duration of exposure and with the health status of the exposed person. Certain sectors of the population like the elderly, children, and those already suffering from respiratory and cardiovascular diseases, are usually at greater risk. Air pollutants usually affect the respiratory and cardiovascular system. $SO_2$ and SPM bring about increased mortality, morbidity, and impaired pulmonary function. $NO_2$ and $O_3$ also affect the respiratory system with acute exposures causing inflammatory and permeability responses, decreased lung function, and increases airway reactivity.$O_3$ causes headaches and eye and nose irritation. Due to its high affinity for haemoglobin, resulting in blood oxygen displacement, CO can lead to cardiovascular and neuro behavioral effects. Very high levels of CO exposure also cause death. Lead (Pb) inhibits the synthesis of haemoglobin in the red blood cells in bone marrow, impairs kidney and liver function, and causes neurological damage. Rapid industrialisation has led to a severe deterioration in water quality in the lakes and rivers of some countries (Ebenstein, 2014).

**STUDY AREA**

Bundu-Ama, a heavily populated community is one of the shanties in Port Harcourt and the people also live in squalid environment (Ikaderinyo, 2012). It is enclosed by a network of rivers and creeks traversing, dissecting the landmass; prominent among them is the Dockyard Creek, Primose Creek, Dick Fibresima Creek and Isaka River all linked to Bonny River which is the largest river in the area with an average width of 0.5km (Aisuebeogun, 1995). The community is host to many multinational industries and establishments, such as PZ Cussons, MI Drilling Fluids, Ibeto Cement Company, Oando, National Oil, Union Dicon industry, African Petroleum, Conoil, Sun and Gas Oil among others. Aside from being one of Port Harcourt's financial and commercial centre, Bundu Ama is also among the most industrialized community in the metropolis as regards the petroleum downstream and processing center. There are approximately 100 small and big industries in the community (field survey,2014), of which some have been classified as hazardous. Industries in the air-polluting category include flour mills, chemical, cement, engineering, refined petroleum distribution and foundry units. Process emissions and those from fuel consumption, constitute the main sources of air pollution. Major air pollution sources include a giant mud engineering/chemical complex, military/commercial maritime activities, giant cement bagging industry, harbour for discharge of petroleum products and domestic waste dumping centers. The city does not have a good environmental pollution data (Ogosu, 2013)

The state Ministry of Environment does not regularly and systematically monitor the air quality to measure air pollutant levels within the community. The indiscriminate waste effluents dumped into the water bodies and poor domestic waste management pollutes the area (Ajayi, S. O. and Osibanjo, O. 1981 and Oguzie, 2000).

The city of Port Harcourt had a humble beginning in 1913 as a fishing settlement with an initial population of 5000 persons (Oyegun and Adeyemo, 1999). The current population of the metropolis ( Port Harcourt and Obio – Akpor) according to the official gazette of the 2006 census final results is 1,000,908 (Fed. Republic of Nigeria Official gazette, 2009). The rapid growth of the city and its region has spatial and socio economic implications. The Port Harcourt city, capital of Rivers State, Nigeria (Fig 1) is also the hub of the oil and gas industry in Nigeria with Bundu – Ama playing host to many industries in the downstream of the petroleum sector. Bundu – Ama community experiences the injection of large quantities of effluents due to the activities of industries on one hand and improper domestic waste management that creates poor sanitary conditions. Water and air related diseases are the most critical health problems in the Port Harcourt region generally and in Bundu – Ama in particular (Oyegun and Adeyemo,1999). In their study, Moffat and Lindan (1995) observed that although few air and water quality studies exist, the data available on air and water related diseases, illustrate that water and air contamination and associated diseases are a problem in the region. Cases of acidification of rain water in the industrial areas of Port Harcourt (Bundu – Ama inclusive) are already being reported and this is a serious threat to the use of rain water as a source of water supply (Ajayi and Osibanjo 1981)

 


Fig. 1 Map of Rivers State Showing the study area

**Materials and methods**

Four sample stations were established after a reconnaissance visit to the area. The criteria for the choice of the sampling stations were to assess the impact of industrial and other human activities taking place on the ambient air quality of the study area. Station one (Ibeto) monitoring was done in three different points along coordinates N:$4^0$75'01 E:$7^0$00'45, N:$4^0$74'85 E:$7^0$00'53 and N:$4^0$74'69 E:$7^0$00'44. The industry located here is Ibeto cement company and the water body where the effluents are discharged is Dick Fibresima Creek. The premises are always contaminated by cement dusts during vehicular movements of trucks conveying the products, bagging and process operations among others. The main industrial activities taking place here is cement bagging and related operations. Station two is Bundu waterside drained by Dockyard Creek. The monitoring was done in three different points along coordinates N: $4^0$75'38 E: $7^0$01'12, N:$4^0$75'76 E:$7^0$01'60 and N:$4^0$76'14 E:$7^0$01'28. Domestic waste products are often dumped here and residents use the water as public toilet. Fishing activities take place here by local fishermen. Station three (Macoba) monitoring was done in three different points along coordinates N: $4^0$75'88 E: $7^0$00'55, N:$4^0$75'89 E:$7^0$00'75 and N:$4^0$75'92 E:$7^0$00'94. The industry located here is Macoba Drilling fluids company, MI that deals on mud engineering and also Naval operations by Nigerian Navy. Industrial fumes escape into the atmosphere from stacks. Effluents are discharged into a section of Primose Creek and Isaka River. Organic wastes and human excreta are also discharged here. The River serves as a means of marine transport and fishing activities. Station 4 (Union Dicon industry/Jetty) monitoring was done in three different points along coordinates N:$4^0$76'07 E:$7^0$00'61, N:$4^0$75'09 E:$7^0$00'78 and N:$4^0$75'99 E:$7^0$00'53. Bagging of salt takes place at the industry. The jetty serves as a loading point of petroleum products e.g. gasoline, diesel etc. Choking smells of hydrocarbon products characterize the surrounding air. Effluents from here are discharged into Primose Creek.

Measurement was done by outdoor air quality monitors (AQM 60 compact monitoring stations).This is a portable handheld pollution meter that quickly measure common air pollutants as well as noise and meteorological parameters. Each measurable parameter was detected and measured by a sensor sensitive to it. Typical applications include traffic or roadside monitoring urban air quality networks and industrial fencline monitoring in the minning, power, cement, waste, oil and gas industries. This gas meter is a real time, low cost, and compact air quality monitoring of common gas pollutants, pollutants and other environmental parameters

 

The following air pollutants were monitored and measured at the various stations according to FMENV prescribed guidelines and methods; Suspended Particulate Matter (SPM), Carbon Monoxide, Hydrocarbon, Volatile Organic Compound (VOC), NOx and SOx.

Figure: 1 Gaseous Emission from an Industrial Plant in Bundu Ama

Figure 2: Gaseous Emission from a Chemical Plant in Bundu Ama

 

Figure 3: Premises of Cement Bagging Industry (Ibeto)

Figure 4: Jetty for Off-loading Gasoline and Diesel in Bundu-Ama

 

Figure 5: Fumes emanating from Mud Engineering Industry.

Figure 7: Premises of Petroleum Products Marketing Company in Bundu-Ama

**RESULTS**

The results showed the range of Suspended Particulate Matter(SPM) at the Ibeto station monitored points to be between 0.014mg/$m^3$ and 0.033 mg/$m^3$ with mean value as 0.03 mg/$m^3$ (Table 1).The values of CO, $H_2S$, VOC, $NO_X$, $SO_X$ were <0.10 at all sampled points. At Bundu monitored station, SPM ranged between 0.031 mg/$m^3$ and 0.045 mg/$m^3$ with mean value of 0.06 mg/$m^3$.The range of $SO_X$ was between 0.10ppm and 1.10ppm, while the values of CO, $H_2S$, VOC, $NO_X$ and $SO_X$ were all <0.10 at all sampled points. The values of SPM ranged between 0.086 mg/$m^3$ and 0.096 mg/$m^3$ with mean value of 0.09 mg/$m^3$ at Macoba, while the values of CO,$H_2S$,VOC,$NO_X$ and $SO_X$ were <0.10 at all the monitored points. At Union Dicon/Jetty, the SPM ranged between 0.019 mg/$m^3$ and 0.025 mg/$m^3$,with mean of 0.020 mg/$m^3$.The mean of $SO_X$ was 0.53ppm,while other measured parameters were <0.01at all monitored points.

 

Table 1: Air Quality Measurement (IBETO)

| Parameter | Sample Station Result | | | Mean | FMENV Limits |
|---|---|---|---|---|---|
| | AQM 1 | AQM 2 | AQM 3 | | |
| Coordinates | N:4$^0$75'01<br>E:7$^0$00'45 | N:4$^0$74'85<br>E:7$^0$00'53 | N:4$^0$74'69<br>E:7$^0$00'44 | | |
| SPM (mg/m$^3$) | 0.033 | 0.031 | 0.014 | 0.03 | 0.25 |
| CO (ppm) | <0.10 | <0.10 | <0.10 | <0.10 | 10.0 |
| HC (ppm) | <0.10 | <0.10 | <0.10 | <0.10 | - |
| VOC (ppm) | <0.10 | <0.10 | <0.10 | <0.10 | - |
| $NO_X$ (ppm) | <0.10 | <0.10 | <0.10 | <0.10 | 0.04 – 0.06 |
| $SO_X$ (ppm) | <0.10 | <0.10 | <0.10 | <0.10 | 0.01 |

AQM = Air Quality Measurement
FMENV = Federal Ministry of Environment
ppm = parts per million
mg/m$^3$ = miligramme per meter cubed

Table 2: Air Quality Measurement (BUNDU )

| Parameter | Sample Station Result | | | Mean | FMENV Limits |
|---|---|---|---|---|---|
| | AQM 1 | AQM 2 | AQM 3 | | |
| Coordinates | N:4$^0$75'38<br>E:7$^0$01'12 | N:4$^0$75'76<br>E:7$^0$01'60 | N:4$^0$76'14<br>E:7$^0$01'28 | | |
| SPM (mg/m$^3$) | 0.031 | 0.104 | 0.045 | 0.06 | 0.25 |
| CO (ppm) | <0.10 | <0.10 | <0.10 | <0.10 | 10.0 |
| $H_2S$ (ppm) | <0.10 | <0.10 | <0.10 | <0.10 | - |
| VOC (ppm) | <0.10 | <0.10 | <0.10 | <0.10 | - |
| $NO_X$ (ppm) | <0.10 | <0.10 | <0.10 | <0.10 | 0.04 – 0.06 |
| $SO_X$ (ppm) | 0.80 | 1.10 | 0.10 | 0.67w | 0.01 |

AQM = Air Quality Measurement
FMENV = Federal Ministry of Environment
ppm = parts per million
mg/m$^3$ = miligramme per meter cubed

Table 3: Air Quality Measurement (MACOBA)

| Parameter | Sample Station Result | | | Mean | FMENV Limits |
|---|---|---|---|---|---|
| | AQM 1 | AQM 2 | AQM 3 | | |
| Coordinates | N:4$^0$75'88<br>E:7$^0$00'55 | N:4$^0$75'89<br>E:7$^0$00'75 | N:4$^0$75'92<br>E:7$^0$00'94 | | |
| SPM (mg/m$^3$) | 0.090 | 0.086 | 0.096 | 0.09 | 0.25 |
| CO (ppm) | <0.10 | <0.10 | <0.10 | <0.10 | 10.0 |
| $H_2S$ (ppm) | <0.10 | <0.10 | <0.10 | <0.10 | - |
| VOC (ppm) | <0.10 | <0.10 | <0.10 | <0.10 | - |
| $NO_X$ (ppm) | <0.10 | <0.10 | <0.10 | <0.10 | 0.04 – 0.06 |
| $SO_X$ (ppm) | <0.10 | <0.10 | <0.10 | <0.10 | 0.01 |

AQM = Air Quality Measurement
FMENV = Federal Ministry of Environment
ppm = parts per millions
mg/m$^3$ = miligramme per meter cubed

Table 4: Air Quality Measurement (Union Dicon industry/Jetty)

| Parameter | Sample Station Result | | | Mean | FMENV Limits |
|---|---|---|---|---|---|
| | AQM 1 | AQM 2 | AQM 3 | | |
| Coordinates | N:$4^0$76'07 E:$7^0$00'61 | N:$4^0$75'09 E:$7^0$00'78 | N:$4^0$75'99 E:$7^0$00'53 | | |
| SPM ($mg/m^3$) | 0.019 | 0.022 | 0.025 | 0.020 | 0.25 |
| CO (ppm) | <0.10 | <0.10 | <0.10 | <0.10 | 10.0 |
| $H_2S$ (ppm) | <0.10 | <0.10 | <0.10 | <0.10 | - |
| VOC (ppm) | <0.10 | <0.10 | <0.10 | <0.10 | - |
| $NO_X$ (ppm) | <0.10 | <0.10 | <0.10 | <0.10 | 0.04 – 0.06 |
| $SO_X$ (ppm) | 1.40 | <0.10 | <0.10 | 0.53 | 0.01 |

AQM = Air Quality Measurement
FMENV = Federal Ministry of Environment
ppm = parts per million
$mg/m^3$ = miligramme per meter cubed

## DISCUSSION

The results of monitoring ambient air quality of the six pollutants in the study area indicated that SPM was detected in all the sampled points. However, the concentration is not of great concern as the values did not exceed the FMENV guideline of 0.25.SPM is always associated with high levels of industrial and vehicular activities (Yadva and Singh, 2003).These pollutant particles are commonly suspended in the air near sources, such as the urban atmosphere, industrial plants, highways and power plants (Bhatia, 2011).The most obvious effect is reduction and distortion of visibility. SPM provide active surfaces upon which heterogeneous atmospheric chemical reactions can occur and nucleation bodies for the condensation of atmospheric water vapour, thereby exerting a significant influence upon weather and air pollution phenomena (Gilpin and William,1982). Particulates inhaled through the respiratory tract may damage health. The results clearly indicates that on the average the levels of $SO_X$ were high in Dicon/Jetty station and Bundu, with their means0.53ppm, 0.10ppm respectively exceeding the allowable limits of the FMENV(0.01ppm).This may be attributed to combustion of fossil fuels and from various industrial processes taking place in the study area; but particularly at Bundu refuse incineration, domestic fuel burning might be likely the reason for the level. The gas is also released from rotten eggs realising that all reptiles, fowls and birds lay eggs and some of them could rot easily during cold seasons (Ademoroti,1996). Most times and particularly during hot season, evaporating oceans and sea sprays leave tiny particles of sulphate salts such as sodium sulphate in the air (Adedokun *et al*.,1989). Sulfur dioxide (or Sulphur dioxide) has the chemical formula $SO_2$ and the gas can cause upper respiratory irritation such as nasal irritation. The gas sulfur dioxide, when burned reacts with water and atmospheric oxygen to form sulphuric acid ($H_2SO_3$) and thus acid rain(Smith,1971). The possible reasons for the detection of levels of $NO_x$, CO, HC and VOC is the tremendous growth in the number of petrol and diesel vehicles in the study area, which are contributing to the increasing levels of these parameters in the atmosphere. However their levels were below the FMENV standard limits. It should be realized that the oxygen used in internal engine combustion is a component of air which contains some percentage of nitrogen. As combustion occurs, oxides of nitrogen are formed also in addition to the following products of combustion: CO, $CO_2$, NO,$NO_2$, lead halides and divers hydrocarbons(Ademoroti,1996).They are poured into the atmosphere daily through the exhausts. They are discharged in streets and people are exposed to serious air pollution.

## CONCLUSIONS AND RECOMMENDATIONS

The activities of the industries operating in Bundu-Ama, Port Harcourt and poor management of waste contributed negatively to the ambient air quality. Industries in the air-polluting category include cement bagging, petroleum distribution, engineering and processing. Process emissions and those from fuel consumption, constituted the main sources of air pollution. The trends of pollutants in the study of ambient air quality showed differentials in their levels thereby identifying high and low polluted sampling points. It is recommended that constant monitoring of the area be undertaken to avoid the adverse health and environmental consequences.

## REFERENCES

Adedokun, J. A., Emofurieta, W. O. & Adedeji, O. A. (1989). Physical, mineralogical and chemical properties of harmattan dust at Ile-Ife, Nigeria. *Journal of Theor. Appl. Climatol, 40*,161-169.
Ademoroti, C.M.A. (1996). *Environmental Chemistry and Toxicology*. Ibadan: Foludex Press Ltd.
Aisueheogun, A. (1995). The Port Harcourt Region: Landform Characteristics of the Environment. *Journal of*

*Geographic Thought. 1,* (1),10 – 14.
Ajayi, S. O. and O. Osibanjo. (1981). Pollution Studies on Nigerian Rivers II. *Environmental Pollution Series,* 2, 87 – 95.
Bhatia, S. C. (2011). *Environmental Chemistry.* New Deihi: CBS Publishers & Distributors Pvt. Ltd.
Canter, L. W. (1996). *Environmental Impact Assessment*. New York: McGraw-Hill, Inc.
Chakradhar, B., Mudgal, M., Khan, M. A., Mishra. D. & Padmakaran. P. (2003). *Environment and Disaster Modeling and Management.* Regional Research Library, Bhopal, India.
Environmental Protection Agency (2014). EPA. National Ambient Air Quality Standard. Retrieved from http://www.epa.gov/air/criteria.html on September, 2nd 2014.
Ebenstein, A. (2014). The Consequences of industrialization: Evidence from water pollution and digestive concerns in China. *The Review of Economics and Statistics Journal, 14* (1), 86-201.
Federal Repulic of Nigerian Official Gazette., (2009) Report on the Census 2006 final results. Printed and Published by the Federal Government print, Abuja, Nigeria.
Field Survey. (2014). Environmental Field Studies and Visit to Bundu-Ama, Port Harcourt.
Gilpin, A. & Williams, A. (1982). *Dictionary of Energy Technology*. London: Camelot Press Ltd, Southampton.
Ikaderinyo, F. (2012). Bundu – Ama Community, *Port Harcourt Telegraph.*
Moffat, D. & Linden, G. (1995). Perception and reality: Assessing priorities for sustainable development in the Niger Delta. *Ambic 24* (7), 527-538.
Ogosu, A.W. (2013, July). Trends on Environmental Issues. Paper presented in a Technical Session of Nigerian Environmental Society.
Oguzie, F. A. (2000). Distribution of Heavy Metals in Water and Sediments of lower Ikpoba River, Benin City. *Nigerian Journal of Applied Science and Environmental Management, 4,* 55 – 60.
Otti, V. I. & Ogbuagu, F. U. (2014). Environmental health effects of exposure to air pollution in industrialized areas. *Journal of Civil and Environmental Research, 6* (5), 1-6.
Oyegun, C.U and Adeyemo, A.(1999). *Port Harcourt Region*. Department of Geography and Environmental Management, University of Port Harcourt.
Shankar, P. R. & Ramarao, G. (2002, June). Impact of air quality on human health: A case study of Mumbai city, India. Paper presented at the IUSSP Regional Conference on South-East Asia's Population in a changing Asian Context.
Smith- Bryce, D. (1971). Lead pollution-a growing hazard to public health. *Chemistry in Britian, 1(*1), 54-56
Smith, L. (2009). Californian Ambient Air Quality Standard. Retrieved from www.epa.gov/airquality/greenbk. on November 24th 2009.
Ubong, I. U. & Gobo, A.E. (2001). *Fundamentals of Environmental Chemistry and Meteorology.* Port Harcourt: Tom and Heavy Publications,
Yadva, R. N. & Singh, V. P. (2003). *Environmental Pollution*. New Delhi: Allied Publishers.