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Title: The impact of gas flaring on the air quality: a case study of Izombe in earstern Nigeria

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Abstract:

The impact of gas flaring on the air quality using Izombe as a case study was investigated using chemical air pollutants. The chemical pollutants investigated were Nitrogen dioxide, Sulphur dioxide, Hydrogen Sulphide, Volatile Organic Compounds, Carbon monoxide and Suspended Particulate Matter. Three samples were taken for each of the chemical pollutants at a distance of 100m, 200m and 300m away from the flare stack. Data collected at these distances were analyzed using both descriptive statistics and non-parametric technique. The analysis showed that the mean concentration of these pollutants was 0.83ppm for NO_2, 1.91ppm for SO_2, 0.95ppm for H_2S, 2.96ppm for VOCs, 1.61ppm for CO, and 7.11ppm for SPM; all exceeded Federal Environmental Protection Agency (FEPA) stipulated Standard. The adoption of current reliable and efficient technologies for emission control was recommended.

Key words: Gas flaring, air quality, emission control, FEPA, chemical air pollutants

1. INTRODUCTION

The atmosphere (air) is a protective blanket which nurtures life on the earth surface and protects it from the hostile environment of outer space. It is composed of 78.1% Nitrogen, 20.8% Oxygen and a number of other gases such as Argon, Carbon dioxide, Methane and water vapour that total about 1%, as can be seen in Table 1. Most of the air is held close to the earth surface by the gravitational force (Enger and Smith, 2004).

1.1 Background of study

Air pollution is the presence in the outer door atmosphere of one or more contaminants such as dust, mist, Odour, smoke or vapour in such quantities, characteristics and duration as to make them actually harmful or potentially injurious to human, plants and animals or property or which unreasonably interfere with the comfort of life and property (Villasenor et al., 2003). Man in his quest to improve his standard of living through technological development introduces substances that pollute the air and other areas of the environment (Briggs, 2005).

This concept of air pollution has been observed to cause death and respiratory disease to living things as well as damage to monuments and other archaeological structures in the past (Akpan, 2008). The major sources of air pollution are transportation engines, power and heat generation, industrial processes, burning of solid waste and flaring of natural gases associated with crude oil extraction.

In Nigeria, air pollution has been occurring long before independence. One of the major sources of air pollution in Nigeria today is the flaring of natural gas in the Niger Delta region. Nigeria is notably "the world's biggest flarer" of natural gas. There are over 1000 gas flaring points in Nigeria (Efe, 2003) with at least 10 of them visible from outer space through satellites.

Gas flaring is the controlled burning of waste natural gases associated with oil production. One of the main sources is the "solution gas" trapped in underground oil supplies, which is released when oil is brought to the surface. Gas flaring is used to eliminate gas when the volume is insufficient to warrant recovery or collecting it is not economical (UKOOA, 2005).

Shewechuk (2002, in Akpan 2008), stated that world-wide, about 115 billion cubic meters of gas are flared or vented into the atmosphere every year. Of this quantity, Nigeria alone flares almost 23billion cubic meters every year. The consequences of this act of excessive flaring is of a large contribution to global warming and climate change due to the emission of large quantities of the two major green house gases carbon dioxide and methane (Briggs, 2005). Another major consequence of gas flaring is sour gas (Hydrogen Sulphide) and sulphur oxides emission, the end product of these compounds when it combines with atmospheric oxygen and water is acid rain.

Gas flaring in Nigeria also has other direct consequences on the local environment. This can easily be seen as all vegetation surrounding is damaged and some are completely destroyed for as much as 50meters and more (Efe, 2003). The increase in temperature as well as the release of sooth and other toxic gases emanating from the flare site causes immense health problems and infrastructural damage in the communities nearest to flare sites (Nwaugo et al., 2006). In local Nigerian communities such as Izombe in Oguta Local Government Area of

Imo state, two flare sites exist and associated gases have been flared for over 20 years now, the impact of gas flaring on the lives of the inhabitants and their environment are profound.

1.2 Statement of problem

There has been a phenomenal damage to the quality of air in Izombe community in Oguta Local Government Area of Imo state, due to high level of gas flaring emission into the air. The gases released into the atmosphere as a result of gas flaring includes; Carbon monoxide (CO), Sulphur dioxide (SO_2), Nitrogen dioxide (NO_2), Hydrogen Sulphide (H_2S), Methane, Soot, and Suspended Particulate Matter (SPM) have resulted to damages in the quality of air and human health in the community.

1.3 Aims and objectives

The aim of this work is to investigate and assess the impact of gas flaring on the air quality. This aim will be achieved through the following objectives:

- To determine the level of air pollutants such as carbon monoxide (CO), sulphur dioxide (SO_2), Nitrogen dioxide (NO_2), Particulate matter (soot) and Hydrogen Sulphide (H_2S) in Izombe community in Oguta Local Government Area of Imo state,
- To assess the impact of the pollutant on the physical environment such as vegetation, structures and monuments.
- To provide useful guide and suggestion that will help in the cleanliness and improvement of aesthetic nature of the affected environment.
- To recommend existing technologies for curbing gas flaring to protect our atmosphere.

1.4 Significance of the study

Air pollution through gas flaring emissions is a serious problem confronting the inhabitants of Izombe community in Oguta Local Government Area of Imo state. There is need to highlight the hazardous levels of air pollutants concentration in the air. This will help to enlighten people on the present and future effects of the pollutants on their air quality.

The study will also provide reference material for further research work in areas with similar problems.

1.5 Scope of the study

The major area of concentration of this study is Izombe community in Oguta Local Government Area of Imo State, Nigeria.

The study will cover sampling various air pollutants at the flare sites and interpreting the sample results. It will also include observations of the effects of the pollutants in the area.

2. MATERIAL AND METHOD

Izombe is situated in Oguta, Imo, Nigeria. Its geographical co-ordinates are 5^{0}52’00” North, 6^{0}52’0’’ East (Fig. 1). Izombe is a community in Oguta (Fig. 2) local government Area of Imo state, covering a land mass of 8,665.6 hectares of land. It covers a land mass of 8,665.6 hectares of land. However figure 3 shows the particular area of the study which was Izombe and its neighboring towns.

2.1 Climatic condition

Izombe community has a humid tropical climate. The climate is extremely influenced by its nearness to the Atlantic Ocean. Two seasons are experienced in this community (wet and dry). The dry seasons runs from November to March of the following year while Wet season starts April to October of the same year.

The area experiences high annual rainfall of 2200mm. Rainfall peaks are June and September and a short break of low rainfall in August.
Relative humidity of Izombe community is usually about 85% in the rainy season and decreases to 45% in dry season with ambient temperature ranging from 24.5^{o}C to 33^{o}C in wet season and 25.5^{o}C to 37^{o}C in dry season (Nwaugo et al., 2006)

The winds in Izombe community are south Westerly and North Eastly. The south Westerly, wind are experienced in the area in the rainy season and wind speed ranges from $0.3ms^{-1}$ to $1.5ms^{-1}$ in rainy season and $0.3ms^{-1}$ to $45ms^{-1}$ in dry season.

The south Westerly wind is from the Atlantic Ocean while the East and West Easterly winds are variants of the North-Eastern air mass from the Sahara desert (Ministry of Aviation Imo state, 2004).

2.2 Reasearch methodology

A reconnaissance survey was carried out around the community and at the sites where the natural gas is flared. The survey was conducted at production periods. This survey was based on the direct participation and observation. During the reconnaissance survey, the various points at which gas is flared were identified. Also another sample was identified at the community itself where the impact of the flare is paramount.

The approximate distance of the flaring site from the community is 1000meter. The samples were taken from a distance of 100m, 200m, 300m and a control outside the flare area. The readings were taken and the average noted.

2.3 Types of data needed

The types of data needed by the researchers are the chemical aspect of the gaseous pollutants and the atmospheric particulate quality in the area. The pollutants needed by the researcher include:

1. Carbon monoxide
2. Nitrogen dioxide
3. Nitrous oxides
4. Sulphur dioxide
5. Hydrogen sulphide
6. Volatile Organic Compounds (VOCs)
7. Suspended particulate matter

The above are the atmospheric particulate quality and chemical pollutants needed by the researcher for the purpose of analyzing the effect of gas flaring on Izombe Community.

2.4 Method of data collection

Data was collected through primary and secondary sources.

2.4.1 Primary sources: Primary sources are means through which raw and original research data can be generated for analysis and interpretation. The primary sources used are direct observations and sampling done with the multiple gas monitor equipment.

During the reconnaissance survey, visibilities through the sky were observed; notes were taken in the following area;

- Roofs of buildings in the community and neighbouring communities like Ngbele.
- Sing post and status that are vulnerable to industrial (gas flare) emission impact.
- The effects of pollutants on leaves of the plants within the site were gas is flared.

2.4.2 Secondary sources: The secondary data sources were obtained from works by other researcher fgathered in:

- Environmental Journals
- Environmental Text Books
- Scientific Magazines
- Seminars

2.5 Method of sampling and analysis

The analysis was dependent on an in-situ test carried out using the Multi-Gas monitor and a suspended particulate matter meter.

These two machines mentioned above are used by Environmental Agencies (FEPA) to detect gases and particulate matter in hazardous environments. It is programmed to provide continuous exposure monitoring of toxic organic and inorganic gases, oxygen combustible gases and suspended particulate matter for workers in hazardous environment.

The location was approximately three quarters of the way down along straight run of ductwork (Bodger, 2003). The flow was relatively calm in the study location and as a result, the sample was more representative for stationary sources such as stack emission, the sampling site and the number of traverse points used for the collection affects the quality of data. Depending on the stack geometry, a cross section of the stack perpendicular to the gas flow was divided into specified number of equal area. The required number and location of traverse points was determined by gas velocity measurement and sample extraction.

2.5.1 Sampling operation: Izombe gas flaring station was chosen for this work. Air samples were collected from three spots of the station. These were 100, 200 and 300 meters away from the flare site and a control taken much outside the flow station area.

After confirming the battery level of the portable Multi-gas monitor (Fig. 4) and suspended particulate matter meter (Fig. 5), the instruments were switched on and exposed up into the atmosphere to a height of about 2 meters in the direction of the prevailing wind and readings were taken and recorded at stability.

At each sampling point, three readings were taken within an interval of 5-10 minutes as soon as the readings on the LCD screen normalize and were static. The values of the sample were recorded and the instrument switched off. For each point three samples where taken and the average recorded to remove bias.

3. RESULTS PRESENTATION

In table 2, three locations were tested for which are 100m, 200m and 300m away from the flare point at the flow station. A control sample was collected at an area outside the flow station for comparison. The concentration of NO_2 varied with increase in distance away from the flare point.

In table 3, the values for the concentration of sulphur dioxide gas emitted decreased as the distance increased away from the flare point at the flow station. The control has the least value of SO_2 gas with value 0.61ppm.

In table 4, the values for the concentration of sulphur dioxide gas emitted decreased as the distance increased away from the flare point at the flow station. H_2S gas was not present at the control.

In table 5, the values for the concentration of sulphur dioxide gas emitted decreased as the distance increased away from the flare point at the flow station. VOCs gases were not present at the control.

In table 6, the values for the concentration of Carbon monoxide gas emitted decreased as the distance increased away from the flare point at the flow station. The control has the least value of CO gas with value 0.67ppm which is below the FEPA standard.

In table 7, all the readings exceeded FEPA stipulated standard including the control. The concentration of suspended Particulate matter decreased with an increase in distance away from the flare jets. The highest concentration was at a distance of 100m away from the flare jet followed by 200m and 300m respectively.

From table 8, the mean concentration for NO_2 in Izombe community is 0.83ppm, for SO_2 the mean concentration value is 1.91ppm, for H_2S, the mean concentration value is 0.95ppm, for CO, the mean concentration value is 2.96ppm, for VOCs, the mean concentration value is 1.61ppm and for SPM, the mean concentration value is 7.11ppm. Also the concentration of Suspended particulate Matter (SPM) was found to be the highest with a value of 7.11ppm. NO_2 and H_2S were found to be the lowest with a value of 0.83ppm and 0.95ppm respectively.

3.1 Discussion

The results obtained are presented in the previously mentioned tables (see tables 2-8), the analysis of the results showed that the concentration level of all pollutants sampled exceeded the legal stipulated FEPA standard.

However, at the flow station examined, the highest concentration of NO_2 was the samples collected at a distance of 100m away from the flare jets, followed by 200m and 300m (see table 2). There was not much difference between the 300m samples and the control.

A similar trend was also observed with the concentration of SO_2 emitted. As expected, the highest concentration of sulphur dioxide released was observed at a distance of 100m away from the flare point. It gradually decreased away from the flare point. The difference between 300m and the control was significant (see table 3).

The same trends were observed in the concentration of H_2S emitted. The concentration of Hydrogen sulphide released at a distance of 100m was the highest followed by 200m and the 300m. The difference between the samples collected at a distance of 300m and the control in the flow station examined was not significant (see table 4).

Table 5 shows that the gas flaring contributes the quality of volatile organic compounds (VOCs) in the atmosphere as values obtained from 100m samples were the highest 3.01ppm. At a distance of 200m (2.21ppm) of VOCs was detected. The valued reduced to 1.21ppm at a distance of 300m away from the flare jet.

The results shown in table 6 prove that gas flaring contributes to the quantity of carbon in the atmosphere. At a distance of 100m away from the flare jet, 5.31ppm of carbon monoxide was emitted. The concentration reduced as I moved away from the flare jet. At a distance of 200m (3.20ppm) of CO was obtained followed by 2.63ppm at a distance of 300m. The difference between the sample collected at a distance of 300m away from the flare jet and the control was significant.

The effect of Suspended Particulate Matter (SPM) when it's above the FEPA permissible limit on the atmosphere is experience in the (Izombe) community near the flare site. Table 7 reveals that SPM in Izombe flare site is above the FEPA standard for air. At a distance of 100m, (11.89ppm) of Suspended Particulate matter was emitted against 0.25ppm of FEPA stipulated standard. Suspended Particulate Matter contributes to haze in the atmosphere there by reducing visibility.

The results obtained in this work show a marked trend as all parameter considered showed a gradient away from the flare points in the flow station. This picture indicates that crude oil though is of high economic value to Nigeria has adverse gas flaring effect accompanying it (Adeninye et al., 2003; Akpan, 2008; Atevure, 2005).

The high value of sulphur dioxide (SO_2), Nitrogen dioxide (NO_2) and Carbon monoxide (CO) can be attributed to the constant flaring of natural gas. Atmospheric Sulphur, Nitrogen and Carbon one force to combine with elemental Oxygen forming acidic oxides which dissolves in rain water to produce dilute Sulphuric, Nitrous/Nitric and Carbonic acids (Nwaugo et al., 2006; Botkin and Keller 1998). Similarly the SPM observed is highest at the flare point as expected. The high particles emitted are as a direct effect of the heat (Leachey et al., 2008). Gas flaring contributes to the quantity of the atmospheric pollutant examined in the study area.

4. CONCLUSION

Gas flaring is a globally unacceptable act, which has a great number of implications on the environment. This study has revealed yet another aspect of pollution on our environment. It has shown that the air quality in Izombe Community has been affected by the activities of the flow station in the area. The increase in the presence of all the air pollutants examined is as a result of gases (fumes) emitted from the flaring jets at in the flow station.

Undoubtedly, man's environment is continually suffering from different forms of environmental abuse owing to man's economic and technological activities. One of such is the situation of Izombe ambient air as revealed by this research.

Acidification, loss of vegetation and health impairment (mostly respiratory problems and sometimes cancer) are the outcome of these activities. Izombe community is not exempted from these problems.

The worst is that this resultant impact will increase as the population continues to grow especially in developing countries like Nigeria and Oil producing communities like Izombe. Since the rise in the concentration levels of these pollutants is an "evil wind" that blows both the local and global environment no good and since all evidence obtained in this study suggests that air pollutants from Izombe ambient air are at high concentration levels and as such are potential threat to human health and well being. The necessity is now overdue to embark upon aggressive campaign from minimization and control of these pollutants.

It is expected in addition that this work will be improved upon by more sophisticated and detailed studies and even taken further to examination of the health impacts of these pollutants on people. And oil companies should not be opaque to funding of studies of this kind but instead should be responsive and encourage more researchers by individuals and Non Governmental Organizations (NGO's).

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Table 1. Composition of unpolluted dry air and the approximate total masses of the different constitutens of the atmosphere (Many trace gases are not listed)

Constituent	Molecular Formula	Volume/Fraction	Total Mass (millions metric tonnes)
Nitrogen	N_2	78.09%	3,850,000,000
Oxygen	O_2	20.8%	1,180,000,000
Argon	Ar	0.93%	65,000,000
Carbon dioxide	CO_2	0.038%	8,500,000
Neon	Ne	18ppm	64,000
Helium	He	5.8ppm	37,000
Methane	CH_4	1.3ppm	37,000
Krypton	Kr	1ppm	15,000
Hydrogen	H_2	0.5ppm	180
Nitrous Oxide	N_2O	0.85ppm	1,900
Carbon monoxide	CO	0.1ppm	5,00
Ozone	O_3	0.08ppm	8,000
Sulphur dioxide	SO_2	0.001ppm	11
Nitrogen dioxide	NO_2	0.001ppm	8

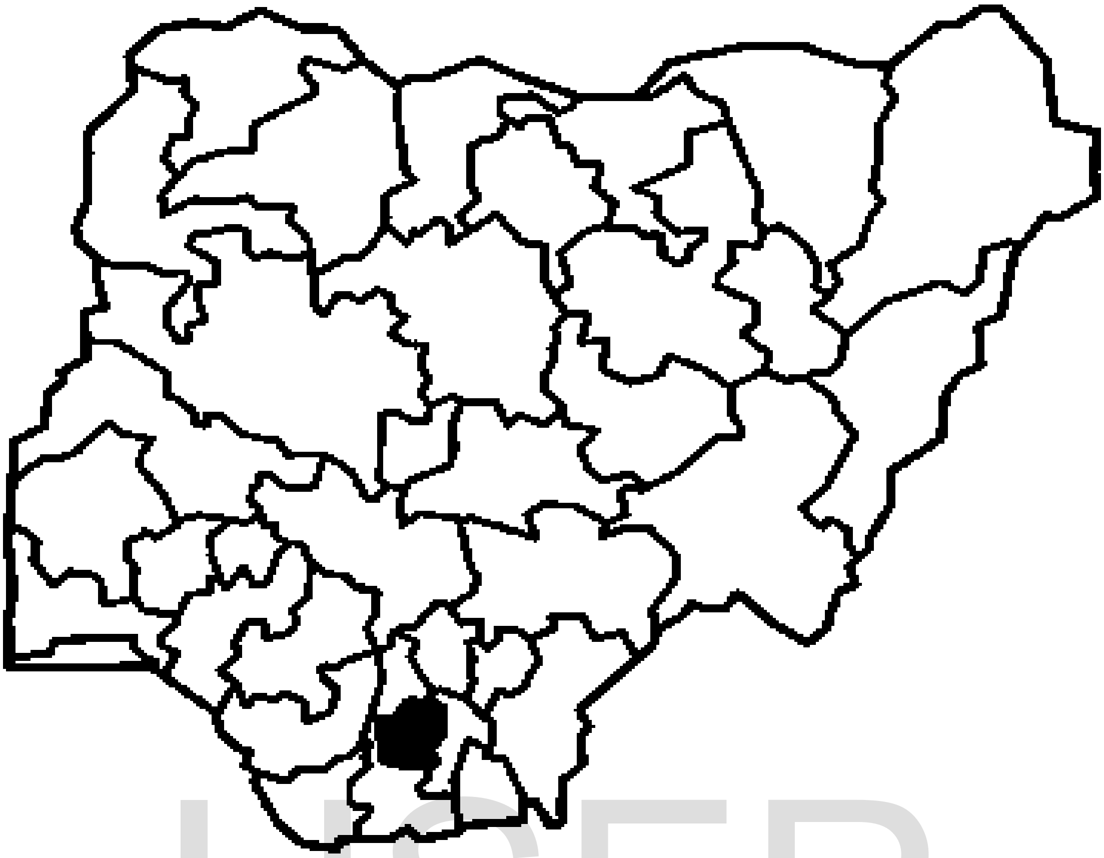

Figure 1. Map of Nigeria showing Imo state

Figure 2. Map of Imo state showing Oguta Local Government Area

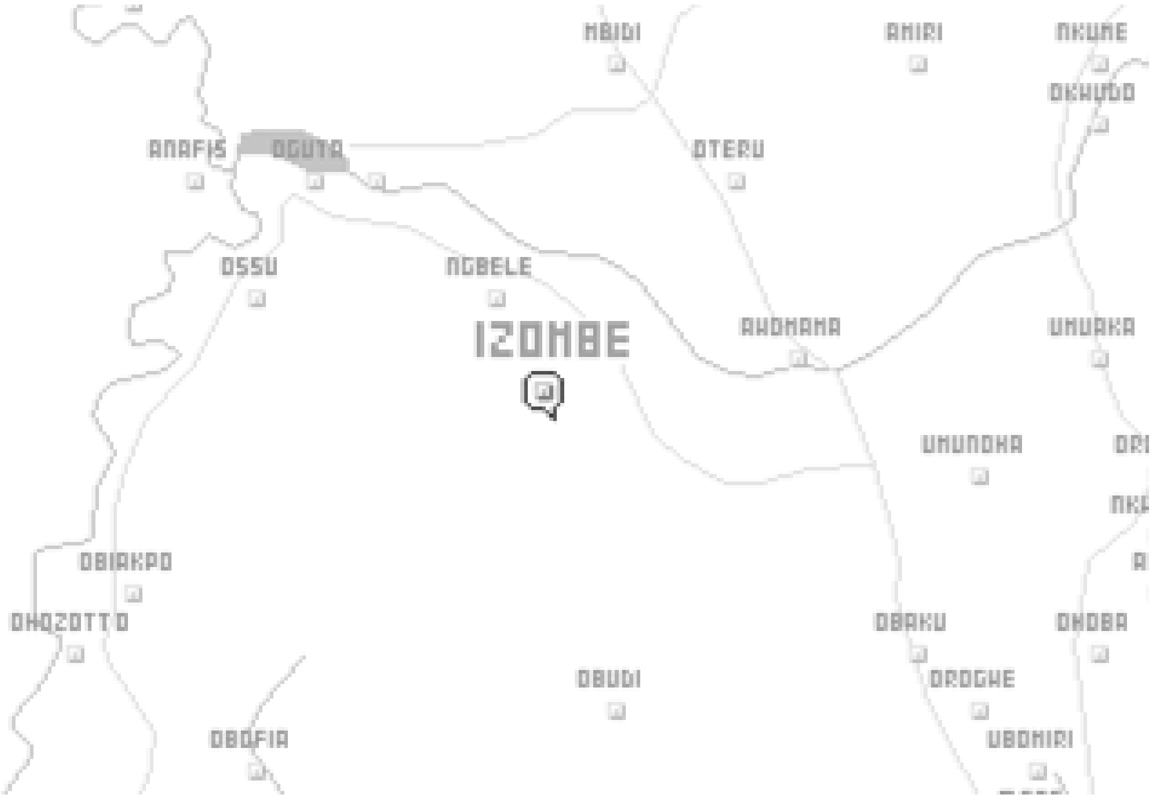

Figure 3. Map of Oguta indicating Izombe community

Figure 4. Multi-gas monitor

Figure 5. Suspended particulate matter (SPM) detector

Table 2. Result for ambient air concentration of Nitrogen dioxide

Distance (m)	**Concentration of NO_2 (ppm)**	**FEPA Standard (ppm)**
100	1.36	0.06
200	1.02	
300	0.90	
Control	0.02	

Table 3. Result for ambient air concentration of Sulphur dioxide

Distance (m)	Concentration of SO_2 (ppm)	FEPA Standard (ppm)
100	3.51	
200	2.30	0.10
300	1.23	
Control	0.61	

Table 4. Result for ambient air concentration of Hydrogen Sulphide

Distance (m)	Concentration of H_2S (ppm)	FEPA Standard (ppm)
100	2.30	
200	1.10	0.10
300	0.41	
Control	0.00	

Table 5. Result for ambient air concentration of Volatile Organic Compounds

Distance (m)	Concentration of VOCs (ppm)	FEPA Standard (ppm)
100	3.01	
200	2.21	0.50
300	1.21	
Control	0.00	

Table 6. Result for ambient air concentration of Carbon Monoxide

Distance (m)	Concentration of CO (ppm)	FEPA Standard (ppm)
100	5.31	
200	3.20	1.00
300	2.63	
Control	0.67	

Table 7. Result for ambient air concentration of Suspended Particulate Matter (SPM) on 14th October 2010

Distance (m)	Concentration of SPM (ppm)	FEPA Standard (ppm)
100	11.89	
200	8.67	0.25
300	5.67	
Control	2.21	

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Table 8. Results table of mean concentration of the six gases in parts per millioin on the 14th October 2010

Distance (m)	NO_2	SO_2	H_2S	CO	VOCs	SPM
100	1.36	3.51	2.30	5.31	3.01	11.89
200	1.02	2.30	1.10	3.21	2.21	8.67
300	0.90	1.23	0.41	2.63	1.21	5.67
Control	0.02	0.61	0.00	0.67	0.00	2.21
Mean Concentration of Pollutants	**0.83**	**1.91**	**0.95**	**2.96**	**1.61**	**7.11**
FEPA Standards	*0.06*	*0.10*	*0.10*	*0.50*	*1.00*	*0.25*