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**Research Article**

# The Air Quality Implications of the SPDC-Bomu Manifold Fire Explosion in K-Dere, Gokana LGA of Rivers State, Nigeria

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**Abstract:** This study examines the atmospheric loading of pollutants such as respirable particulate matter ($PM_1$, $PM_{2.5}$, $PM_7$, $PM_{10}$, TSP) and gaseous pollutants (such as $NO_2$, $SO_2$, VOC, $H_2S$, CO, $CH_4$) in the area arising from the Shell Petroleum Development Company (SPDC)-Bomu manifold explosion, fire and emissions. It also examines the meteorological conditions for the pollutants concentrations. Generally, the result obtained indicates significant concentration of noxious gases, such as $NO_2$, $SO_2$, VOC, $H_2S$, CO, $CH_4$; PM such as $PM_1$, $PM_{2.5}$, $PM_7$, $PM_{10}$, TSP, in the air. At the emission point, PM10 (110.7 $ug/m^3$), TSP (122.4 $ug/m^3$) and CO (25.1 $mg/m^3$), exceeded the WHO acceptable standard of 50 $ug/m^3$, 100 $ug.m^3$ and 10 $mg/m^3$ respectively. The meteorological condition enhanced the gradual dispersion of pollutants during the period of study. The implications as established by this study are explosion significantly compromised the air quality of the area with deleterious health implication, this unimaginably high concentration of pollutant requires very urgent attention.

**Keywords:** Air quality, crude oil, emission, meteorology, pollutant concentration

## INTRODUCTION

In most part of the world, reckless operational standard by oil prospecting industries continue in a manner that undermine the increasing global concerns over environmental changes and the attendant eminent danger to human race and other living species. Cases of gas flare, oil well-head blow-out, oil pipe leakages, crude oil spillages and manifold fire explosions which result in adverse environmental consequences are some seeming inevitable problems commonly associated with oil exploitation in the Niger Delta of Nigeria (Ede, 1999). Reports show that these problems affect the physical, chemical and biological properties of the recipient environment and may harmfully affect human health, agricultural productivity and the natural ecosystem (Baumbach *et al*., 1995; Dong *et al*., 1995; USEPA, 1997). The hazards imposed on the lives of the habitat can be immediate or cumulative resulting to irreparable damage to the ecosystem (Xu *et al*., 1994; Moore, 1995; Zhang *et al*., 2000; NRC, 2004). That notwithstanding, the global demand as well as the enormous foreign earnings realized from crude oil and gas sales continue to serve as motivations to the tremendous increase in reckless oil prospecting activities in the region, with the environment paying the price due to lack of effective pollution abatement implementation programmes (Dong *et al*., 1995; Somhueza *et al*., 1999; Pande *et al*., 2002; Sekha, 2003) One example of such obvious case of insentivity is the $12^{th}$ of April, 2009 (and thereafter) explosion of Bomu Manifold pipes in Kegbara Dere, Gokana Local Government Are of Rivers State. The incidence spilled huge volumes of hydrocarbons into the streams, on the land, which eventually found its way into the swamps of the adjoining environment. Explosions from such facility no doubt emit volumes of volatile organic compounds and green-house gases of high concentrations in to the atmosphere. There is no doubt that the presence of high concentrations of hydrocarbon, volatile organic compounds as well as respirable particulate in the atmospheric of the areas constitute serious health hazards to the inhabitants of the area.

Air pollution in Nigeria is not new and several scholars have attempted to examine the concentration of pollutants and their effect on our environment. Some of the studies are those of Ede (1999), Ossai *et al*. (1999), Okecha (2000), Efe (2005, 2006, 2008), Awofolu (2004), Akeredolu *et al*. (1994) and Akani (2007).

From the available literature, it is obvious that there is dearth of empirical analysis of air quality associated with hydrocarbon storage accidents which are widespread within the region. There is also paucity of information on the influence of meteorological parameters on atmospheric pollutant concentration

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especially as it affects emission from oil prospecting Plate-forms in Nigeria and in many developing countries.

This study therefore seeks to ascertain the air quality implications of the emission form the SPDC-Bomu manifold in K-Dere with a view to recommending appropriate remedial as well as abatement measures.

## LITERATURE REVIEW

It is a statement of fact that Kegbara and Kpor communities and indeed Gokana Local Government Area plays host to about 52 of SPDC oil wells, one Manifold, a flow station, numerous pipe lines and other oil exploration and exploitation activities since the discovery of oil in commercial quantities in the Area. Arising from this, there has been numerous problems such as Gas flare, oil well-head blow-out, oil pipe leakage, crude oil spillages, manifold fires explosion and emissions and emission of offensive gases with adverse environmental consequences in the area. These agrarian communities (Kegbara Dere) with population of over 30,000 hosts over 80% of all SPDC's facilities in Bomu oil field, one of the largest manifold in Africa and over 40 oil wells inclusive. The BOMU MANIFOLD (Fig. 1) is located less than 150 m to people's homes, accommodates high pressure trunk pipes that receive crude oil and gas from several SPDC's operational field in Eastern Niger Delta for transport to export terminal at Bonny (Fig. 2).

## METHODOLOGY

In order to obtain relevant and reliable data for this study, data was collected in five different zones in the community these includes the South West spill emission point, Methodist church, health center, Daily Market, Primary Schools 1and 2.

Below is the ambient air quality parameters examined in this study:

- Respirable Particulate Matter ($PM_{1-10}$)
- Total Suspended Particulate (TSP)
- Sulphur Oxides ($SO_x$)
- Carbon monoxide (CO)
- Nitrogen Oxide ($NO_x$)
- Hydrogen Sulphide ($H_2S$)
- Volatile Organic Compounds (VOC)

**Instrumentation:**

**Carbon monoxide (CO):** A potable carbon monoxide monitor, model 463-022 will be used for the detection of CO. the range of detection is between 0-1000 ppm with alarm set at 50 and150 ppm. Measurement was done by holding the sensor to a height of about two meters in the direction of the prevailing wind and readings recorded at stability.

**Sulphur Oxides ($SO_x$):** A MultiRAE PLUS (PGM-50), a programmable Multi Gas monitor with an electrochemical sensor will be used for the detection of

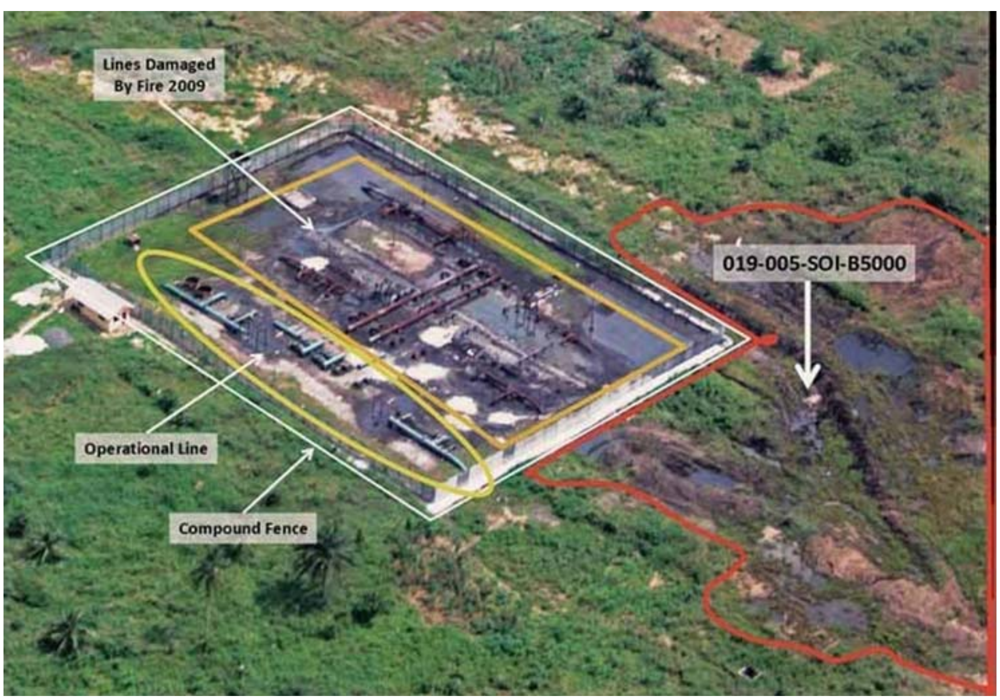


Fig. 1: Arial view of the Bomu manifold (K-Dere, Gokana LGA); UNEP report on the environmental assessment of Ogoni land, 2011

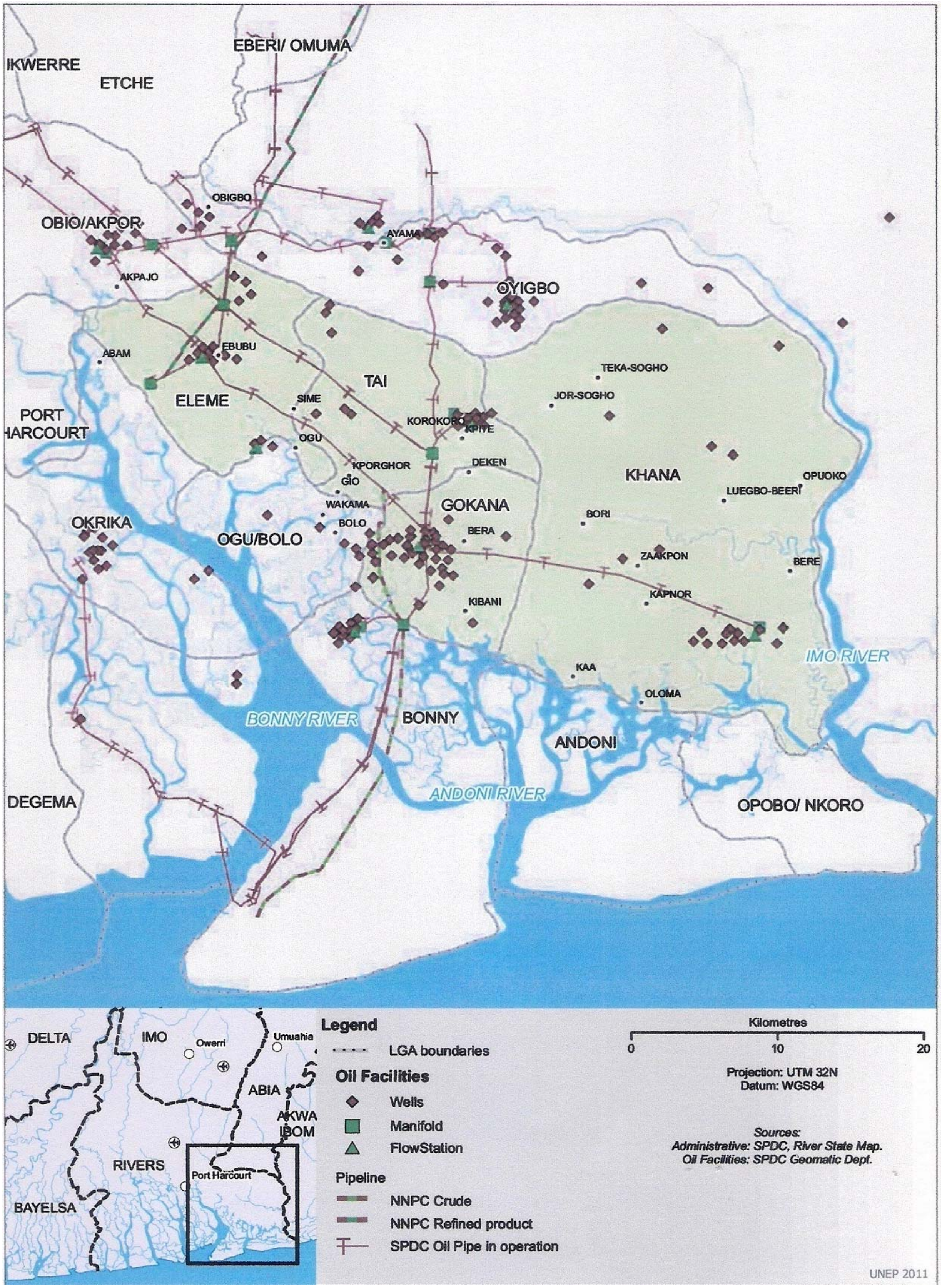


Fig. 2: Map of rivers state showing the study area (K-Dere, Gokana L.G.A); SPDC Geomatic Dept &UNEP report on the environmental assessment of Ogoni land, 2011

$SO_x$. The range of detection is between 0-20 ppm with a resolution of 0.1 ppm. The alarm set points (low/high) is at 2 and 10ppm. Measurement was done by holding the sensor to a height of about two meters in the direction of the prevailing wind and readings recorded at stability.

**Nitrogen Oxides ($NO_x$):** A MultiRAE PLUS (PGM-50), a programmable Multi Gas monitor with an electrochemical sensor was used for the detection of $NO_x$. The range of detection is between 0-20 ppm with a resolution of 0.1 ppm. The alarm set points (low/high) are at 1 and 10 ppm. Measurement was done by holding the sensor to a height of about two meters in the direction of the prevailing wind and readings recorded at stability.

**Hydrogen Sulphide ($H_2S$):** A Hydrogen Sulphide (H2S) gas monitor model 463-020 was used for the detection of $H_2S$. The range of detection is 0-100 ppm with alarm set at 10 and 30 ppm. Measurement was done by holding the senor to a height of about two meters in the direction of the prevailing wind and readings recorded at stability.

**VOCs:** A MultiRAE PLUS (PGM-50), a programmable Multi Gas monitor with an electrochemical sensor, was used for the detection of volatile organic compounds. The equipment detects the gas via a plug-in catalytic head and has a detection range of 0-100% LEL i.e., 0-5% VOCs. Measurements will be done by holding the sensor to a height of about two meters in the direction of the prevailing wind and readings recorded at stability. The limit of detection is 0.01% volatile organic compounds.

**Total Suspended Particulate matter (TSP) and respirable particulate matter:** An Aerocet-531-9800RevC, Aerosol Mass monitor with electrochemical sensor was used for the detection of respirable particulate matter ranging from 1 um to 10 um in diameter.

**Volatile Organic Compounds (VOCs):** A MultiRAE PLUS (PGM-50), a programmable Multi Gas monitor with an electrochemical sensor, will be used for the detection of volatile organic compounds. The equipment detects the gas via a plug-in catalytic head and has a detection range of 0-100% LEL i.e., 0-5% $CH_4$. Measurement was done by holding the sensor to a height of about two meters in the direction of the prevailing wind and readings recorded at stability. The limit of detection is 0.01% volatile organic compounds.

**Meteorological parameters:** Three meteorological parameters were assessed and measurements taken, including wind speed and direction and solar radiation. The values of the solar radiation and wind speed were used in the determination of the atmospheric stability. The parameters were measured using cup anemometer, wind vane and radiometer, mounted in a mobile hand held weather tracker (Kestrel, 4000) and the automatic Decagon mini- weather monitoring station. Readings were taken twice in a day (006 and 1800UTC) and at six locations away from the source of the fire as indicated in Table 1.

Table 2 shows the coordinates where air quality and meteorology samples were obtained.

## RESULTS AND DISCUSSIONS OF FINDINGS

The atmospheric condition at the period of study seemed turbid which seemed to be as a result of increased and continuous emission from the manifold. There was visible thick smoke and outright pollution of

Table 1: Showing values recorded at 20 m Northeast of emission point and acceptable daily average limits

| | Particulate matters (µg/m$^3$) | | | | | Gaseous parametrers (mg/m$^3$) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| S/W Emission point | $PM_1$ | $PM_{2.5}$ | $PM_7$ | $PM_{10}$ | TSP | $NO_2$ | $SO_2$ | VOC | $H_2S$ | CO |
| Mean day one | 84.3 | 88.1 | 201. 7 | 110.4 | 124.0 | 214 | 194.3 | 14.1 | 0.695 | 25.2 |
| Mean day two | 82.6 | 86.0 | 198.6 | 111.0 | 120.8 | 210.1 | 191.1 | 13.7 | 0.683 | 25 |
| Average | 83.45 | 87.05 | 200.65 | 110.7 | 122.4 | 212.05 | 192.7 | 13.9 | 0.689 | 25.1 |
| National limits | 65 | 65 | 150 | 50 | 100 | 150 | 100 | 0 | 0 | 10 |

Authors field work, 2009

Table 2: Field trip schedule, for air quality measurements, locations and coordinates

| | | Coordinates | | | |
|---|---|---|---|---|---|
| S/NO | Study location | Eastings | Northings | Date | Remark |
| 1 | South West Spill emission point | 0534983 | 073158 | 15-16:04:09 | Study done |
| 2 | Methodist Church premises Kegbara Dere | 0534937 | 073009 | 15-16:04:09 | Study done |
| 3 | Health center Kegbara Dere | 0534675 | 073695 | 15-16:04:09 | Study done |
| 4 | Primary SCH. 1 premises Kegbara Dere | 0534442 | 073695 | 15-16:04:09 | Study done |
| 5 | Daily Market Kegbara Dere | 0534374 | 073936 | 20-21:04:09 | Study done |
| 6 | Primary SCH. 2 premises Kegbara Dere | 0535004 | 073636 | 20-21:04:09 | Study done |

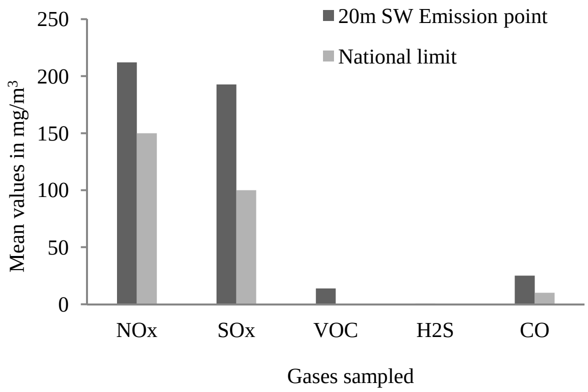


Fig. 3: A graph of gases sampled and national limits at emission point (20 m away)

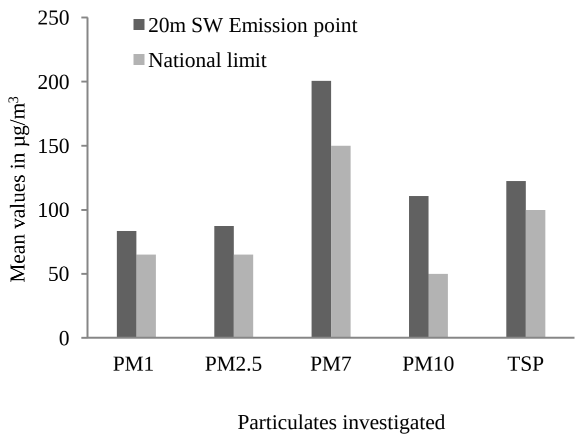


Fig. 4: A graph of particulate matter and national limits at emission point (20 m away)

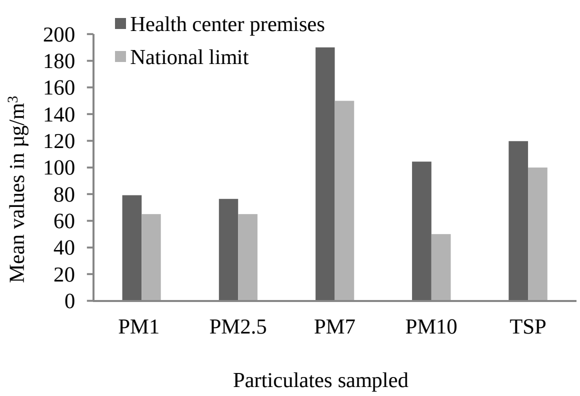


Fig. 5: A graph of Particulates and national limits at the K-Dere health centre at the prevailing wind direction

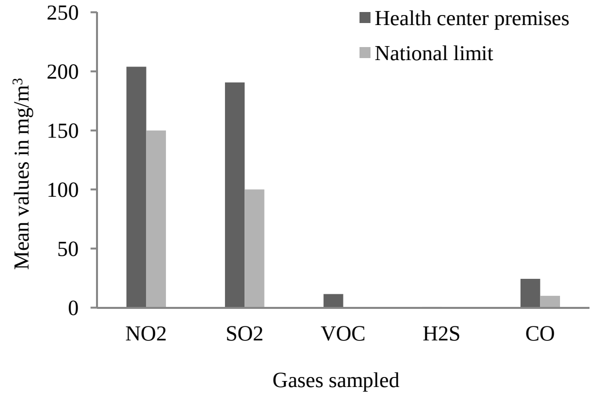


Fig. 6: A graph of sampled gases and national limits at the K-Dere health centre at the prevailing wind direction

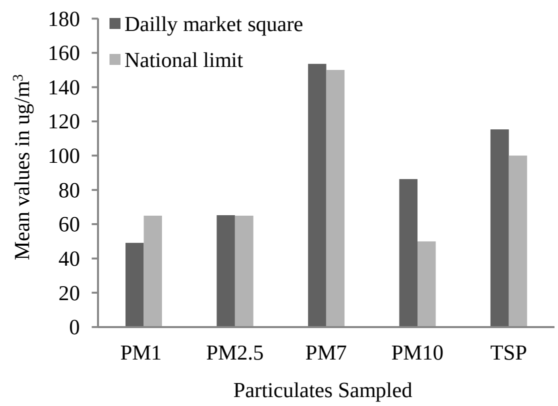


Fig. 7: A graph of particulates and national limits at the daily market at the prevailing wind direction

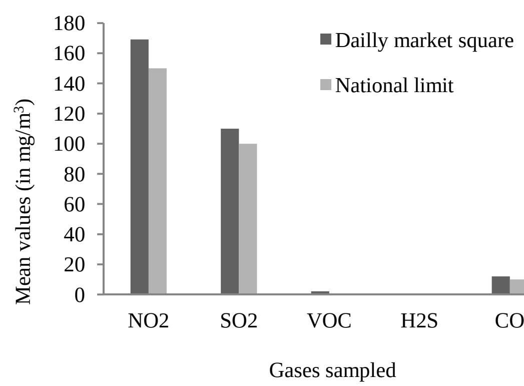


Fig. 8: A graph of gases sampled and national limits at the daily market at the prevailing wind direction

the air with various substances being conveyed over the community.

Below, are graphs showing the parameters measured against their national standards for easy visual understanding and interpretation.

Figure 3 (Table 2) shows that methane (CH4) Carbon Dioxide (CO) and volatile Organic compounds (VOCs) exceeded the WHO standards around the emission/ spill point (20 m away). Around the spill point, $PM_1$ was 6.0 ug/m$^3$, $PM_{2.5}$, 11 ug/m$^3$, $PM_7$ is 37.5 ug/m$^3$, $PM_{10}$ is 74 ug/m$^3$ and TSP was 88 ug/m$^3$ (Fig. 4). For gases, $NO_2$ was put at 0.66 mg/m$^3$, $SO_2$

Table 3: Showing values recorded at health center Kegbara Dere and acceptable daily average limits

| | Particulate matters (μg/m³) | | | | | Gaseous Parametrers (mg/m³) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Health center kegbara dere | $PM_1$ | $PM_{2.5}$ | $PM_7$ | $PM_{10}$ | TSP | $NO_2$ | $SO_2$ | VOC | $H_2S$ | CO |
| Mean day one | 80.2 | 77.6 | 190. 2 | 104.6 | 121.2 | 196.9 | 190.0 | 11.9 | 0.596 | 24.54 |
| Mean day two | 78.2 | 75.2 | 190.0 | 104.2 | 118.2 | 211.0 | 191.4 | 11.1 | 0.594 | 24.09 |
| Average | 79.2 | 76.4 | 190.1 | 104.4 | 119.7 | 203.95 | 190.7 | 11.5 | 0.595 | 24.31 |
| National limits/daily average | 65 | 65 | 150 | 50 | 100 | 150 | 100 | 0 | 0 | 10 |

Authors field work, 2009

Table 4: Showing values recorded at daily market square Kegbara Dere and daily average limits

| | Particulate matters (μg/m³) | | | | | Gaseous parametrers (mg/m³) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Daily market square kegbara dere | $PM_1$ | $PM_{2.5}$ | $PM_7$ | $PM_{10}$ | TSP | $NO_x$ | $SO_x$ | VOC | $H_2S$ | CO |
| Mean day one | 49.7 | 65.42 | 154.066 | 86.553 | 116.0 | 169.077 | 110. 95 | 2.209 | 0.265 | 12.04 |
| Mean day two | 48.6 | 65.03 | 153.11 | 86.2 | 114.6 | 169.069 | 109. 06 | 2.18 | 0.259 | 12.09 |
| Average | 49.15 | 65.225 | 153.588 | 86.3765 | 115.3 | 169.073 | 110.005 | 2.1945 | 0.262 | 12.065 |
| National limits/daily average | 65 | 65 | 150 | 50 | 100 | 150 | 100 | 0 | 0 | 10 |

Authors' field work, 2009

Table 5: Showing values recorded at Comm. Pri. Sch. 1 Kegbara and acceptable daily average limits

| | Particulate matters (μg/m³) | | | | | Gaseous parametrers (mg/m³) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Comm. pri sch. 1 kegbara dere | $PM_1$ | $PM_{2.5}$ | $PM_7$ | $PM_{10}$ | TSP | $NO_x$ | $SO_x$ | VOC | $H_2S$ | CO |
| Mean day one | 84.2 | 88.0 | 201. 2 | 119.0 | 122.1 | 212.6 | 192.1 | 12.4 | 0.692 | 24.1 |
| Mean day two | 81.4 | 85.8 | 196.4 | 114.0 | 118.5 | 210 | 190.1 | 10.2 | 0.642 | 23.1 |
| Average | 82.8 | 86.9 | 198.8 | 116.5 | 120.3 | 211.3 | 191.1 | 11.3 | 0.667 | 23.6 |
| National limits/daily average | 65 | 65 | 150 | 50 | 100 | 150 | 100 | 0 | 0 | 10 |

0.726 mg/m$^3$, VOC, 13.1 mg/m$^3$, $H_2S$, 0.695mg/m$^3$, CO, 14.375 mg/m$^3$ and $CH_4$ was 3.537 mg/m$^3$ (Fig. 3). Comparing this with the national standard reveals that $PM_{10}$ with the value of 74 ug/m$^3$ was well above the national standard of 50 ug/m$^3$ (24-hours). VOC was as high as 13.1 mg/m$^3$ and Carbon dioxide (CO) was put at 14.375 mg/m$^3$ against the value of 10 mg/m$^3$ standard.

At the health centre (Fig. 5 and Table 3), down wind direction of South-wind, $PM_1$ was put at 8.5 ug/m$^3$, $PM_{2.5}$ was 22.5 ug/m$^3$, $PM_7$ was 66.5 ug/m$^3$, $PM_{10}$ was 77.5 ug/m$^3$ and TSP was put at 82 ug/m$^3$. Others include $NO_2$, 0.28 mg/m$^3$, $SO_2$, 0.572 mg/m$^3$, VOC 10.1 mg/m$^3$, $H_2S$. 0.139, CO, 10.35 mg/m$^3$ and $CH_4$ was put at 6.55 mg/m$^3$ (Fig. 6). In comparing these values with the national standard revealed $PM_{10}$ value of 77.5ug/m$^3$ was above the 50 ug/m$^3$ standard value and CO value of 10.35 mg/m$^3$ was higher than the national standard value of 10 mg/m$^3$. The diagram critically revealed that Carbon Dioxide and $PM_{10}$ exceeded the WHO standard.

At the daily market square (Table 4, Fig. 7 and 8) the value of $PM_1$ was put at 49.15μg/m$^3$, $PM_{2.5}$ had a value of 65.2μg/m$^3$. But the values of $PM_7$ (153 μg/m$^3$), PM10 (86.38 μg/m$^3$), TSP (115.3 μg/m$^3$) exceeded the national average limit of 150 μg/m$^3$, 50 μg/m$^3$ and 100 μg/m$^3$ respectively. For the gases similarly, $NO_2$ (169.07mg/m$^3$) and $SO_2$ (110 mg/m$^3$) exceeded the national daily average limits of 150 mg/m$^3$ and 100 mg/m$^3$ respectively.

At Primary School I, $PM_1$ value of 26.5 ug/m$^3$ exceeded the WHO standard value of 25 ug/m$^3$, $PM_{10}$ value of 86.5 ug/m$^3$ was above the standard value of 50 ug/m$^3$ (Fig. 9). Also, TSP value of 105 was above the WHO value of 100 ug/m$^3$ and CO value of 15.7 mg/m$^3$ was higher than the WHO value of 10 mg/m$^3$ (Table 5, Fig. 10).

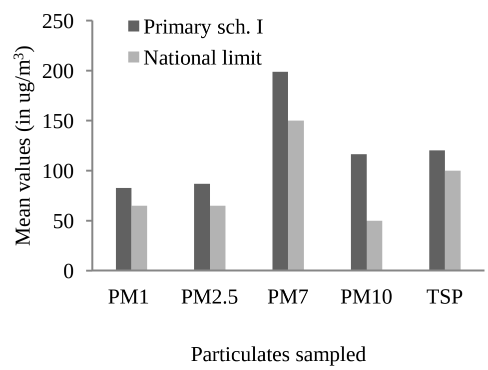


Fig. 9: A graph of particulates and national limits at primary school I at the prevailing wind direction

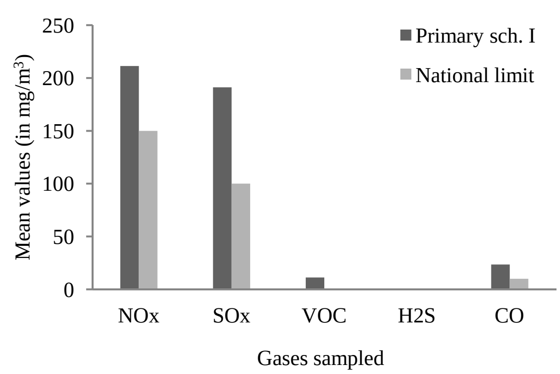


Fig. 10: A graph of sampled gases and national limits at primary school I at the prevailing wind direction

Table 6: Showing values recorded at Methodist Church Kegbara Dere and acceptable daily average limits

| | Particulate matters (µg/m$^3$) | | | | | Gaseous parametres (mg/m$^3$) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Methodist church kegbara dere | $PM_1$ | $PM_{2.5}$ | $PM_7$ | $PM_{10}$ | TSP | $NO_x$ | $SO_x$ | VOC | $H_2S$ | CO |
| Mean day one | 82.6 | 84.1 | 198. 2 | 110.0 | 120.1 | 198.8 | 190.2 | 12.1 | 0.598 | 24.6 |
| Mean day two | 80.2 | 80.3 | 192.4 | 96.0 | 114.3 | 211.2 | 191.0 | 11 | 0.596 | 24.1 |
| Average | 81.4 | 82.2 | 195.3 | 103 | 117.2 | 205 | 190.6 | 11.55 | 0.597 | 24.35 |
| National limits/daily average | 65 | 65 | 150 | 50 | 100 | 150 | 100 | 0 | 0 | 10 |

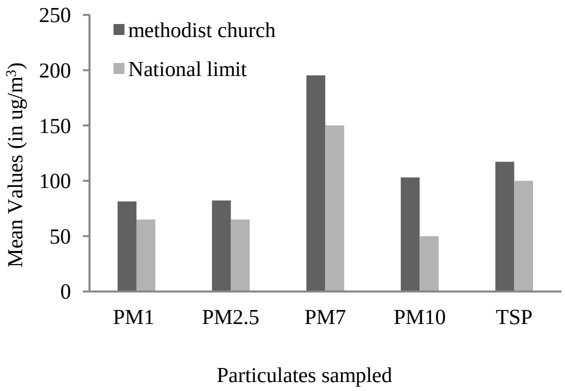


Fig. 11: A graph of particulates and national limits at the Methodist church, K-Dere

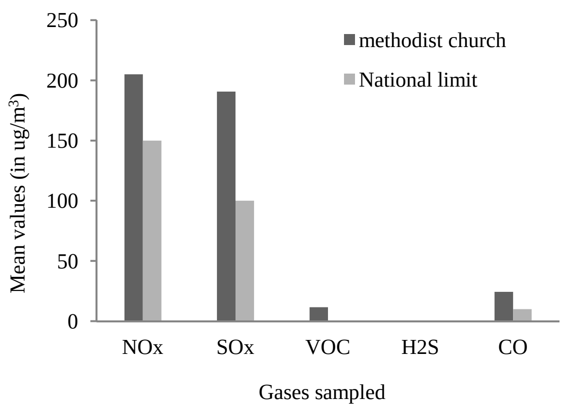


Fig. 12: A graph of samples gases and national limits at the Methodist church, K-Dere

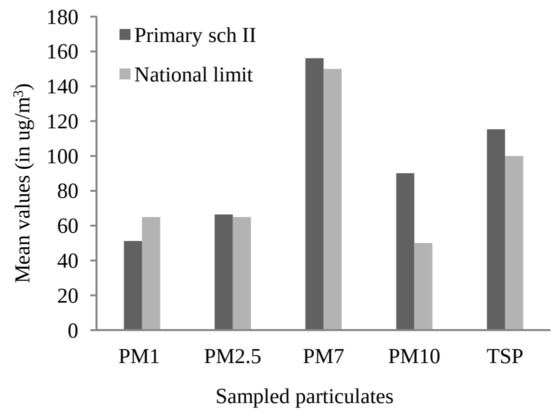


Fig. 13: A graph of particulates and national limit at the primary school 2 K-Dere

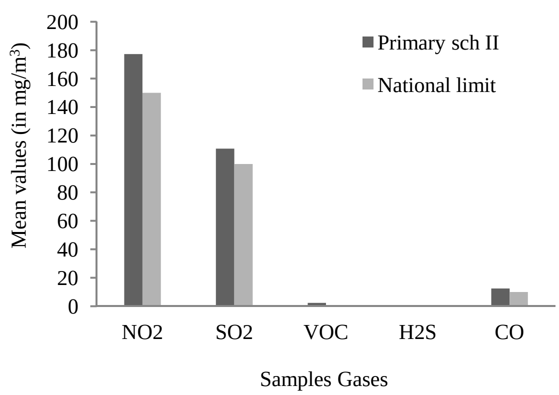


Fig. 14: A graph of gaseous parameters and national limit at the primary school II K-Dere

Around the Methodist Church (Table 6 and Fig. 11), $PM_{2.5}$ value of 28.8 ug/m$^3$ is higher that the acceptable limit of 25 ug/m$^3$, $PM_{10}$ value of 95.5 ug/m$^3$ was also above the acceptable limit of 50 ug/m$^3$, TSP value of 108 ug/m$^3$ was observed to be higher than the WHO standard of 100 ug/m$^3$. For CO, VOC and $CH_4$ whose values are 32.88, 22.1 and 9.483 mg/m$^3$, respectively indicate higher values especially for CO whose national limit is put at 10 mg/m$^3$ (Fig. 12).

The result at the community primary school II K-Dere, (Table 7, Fig. 13 and 14) as shown below, $PM_1$ was 27 ug/m$^3$, $PM_{2.5}$ was 61.5 ug/m$^3$, $PM_7$ was 121.5 ug/m$^3$, $PM_{10}$ was 116 ug/m$^3$, TSP was put at 155 ug/m$^3$, $NO_2$, was 0.0, $SO_2$ was 0.866 mg/m$^3$, VOC was put at 32.2 mg/m$^3$, $H_2S$ was 0.0 mg/m$^3$, 10 was 25.57 and $CH_4$ was 10.98 mg/m$^3$. Comparing these values with the WHO standards revealed that $PM_{2.5}$ value of 61.5 ug/m$^3$ exceeded the WHO standard value of 25 ug/m$^3$ (24-h), $PM_{10}$ value of 116.5 ug/m$^3$ was above the WHO standard value of 50 ug/m$^3$. Also, TSP value of 155 ugm/m$^3$ was above the standard limit of 100 ug/m$^3$, CO value of 25.57 mg/m$^3$ was observed to be higher than the national limit of 10 mg/m$^3$

## IMPLICATIONS OF METEOROLOGICAL CONDITIONS TO POLLUTANTS CONCENTRATIONS

Results as presented in Table 8 show that the wind speed varies between 0.8 and 1.9 m/s, while the

Table 7: Showing values recorded at COMM. PRI. SCH. II Kegbara Dere and daily average limits

| | Particulate matters (μg/m$^3$) | | | | | Gaseous parametrers (mg/m$^3$) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Comm. PRI. sch. 2 kegbara dere | $PM_1$ | $PM_{2.5}$ | $PM_7$ | $PM_{10}$ | TSP | $NO_x$ | $SO_x$ | VOC | $H_2S$ | CO |
| Mean day one | 51.6 | 66.5 | 156.3 | 90 | 115.6 | 177.3 | 111.5 | 2.4 | 0.2 | 12.4 |
| Mean day two | 50.8 | 66.3 | 156.1 | 90.2 | 115 | 177.1 | 110.1 | 2.2 | 0.1 | 12.6 |
| Average | 51.2 | 66.4 | 156.2 | 90.1 | 115.3 | 177.2 | 110.8 | 2.3 | 0.15 | 12.5 |
| National limits/daily average | 65 | 65 | 150 | 50 | 100 | 150 | 100 | 0 | 0 | 10 |

Table 8: Meteorology of Bomu oilfield and environs during field study

| | | Day 1 (19/4/09) | | | | Day 3(21/4/09) | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Day2 (20/04/09) | | | | Day 4 (22/04/09) | | | |
| Parameter | Method | 006 | 1800 | 006 | 1800 | 006 | 1800 | 006 | 1800 |
| Wind direction | Wind vane | SW | SW | SW | SW | SW | SW | SW | SW |
| Wind speed (m/s) | Anemometer | 0.98 | 1.16 | 1.07 | 0.86 | 0.9 | 0.87 | 0.7 | 1.9 |
| Wind turbulence | Anemometer | calm | unstable | do | calm | do | do | do | unstable |
| Solar radiation (W/m$^2$) | Radiometer | 440 | 700 | 700 | 400 | 403 | 401 | 400 | 610 |

Authors' field work, 2009

direction was mainly SW. The wind turbulence varied between calm (<1m/s) - unstable (1.1-1.9 m/s) and the Sun radiation varied between 400 and 700 W/m$^2$.

Results as presented in Table 8 shows that the wind speed varies between 0.8 and 1.9 m/s, while the direction was mainly SE.

The wind turbulence varied between unstable and calm. Specifically, the first day was relatively unstable (1.6-1.9 m/s), while the second day was calm (<1 m/s). These varied in spatial context, being more turbulent and unstable 20 m than 120 m away from the incidence location. Sun radiation varied between 400 and 700 W/m$^2$. The heat radiation was far in excess of the 6310 W/m$^2$ DPR limit (daily average mean) up to 60m from the source of fire for most time during the two days that measurements were taken. The stability based on Pasquil categories was between B and C during the day and D after sunset. This also varied with distance from the source of the inferno, being more unstable in the contiguous zone than 120 m away particularly the first day. The study reveals that the rate of pollutant dispersal was moderate to low, following the distance gradient; hence lower concentration within the vicinity of the fire. This consequently could lead to a gradual dispersion to the communities and higher concentration therein. This implies that the pollutants could not be rapidly diffused as they dispersed into the communities and the health and infrastructure implications could be severe. For instance, NOx and $SO_x$ could acidify the rains and cause corrosion of roofing sheets, while high CO concentration could affect both human and plant health. The atmospheric stability conditions as obtained favors gradual dispersion into the communities and slow diffusion therein. Within the communities the concentration of pollutants could persist even after the fire is put under control. The calm and less turbulent evenings accentuate these as they imply high deposition of the pollutants on the vegetation, including the contiguous and even distant cropped land, soil and surface water, hence point and non point contamination. This also has the potential to alter the soil and vegetation chemistry as well as degradation of aquatic life.

## CONCLUSION OF THE STUDY

Given the generally moderate to low wind speed and atmospheric relative instability, greenhouse gases emitted during the fire have the possibility of remaining in the local air for a long period, contributing significantly to the local/regional warming. On the whole CO and $NO_2$ are integral part of fossil fuel burning and there is no doubt that the inferno of the magnitude has released a substantial quantity of these gases as confirmed above. It is known that these have a lifetime in the atmosphere of 50-200 and 120 years, with a global warming potential of 1 and 310, respectively. The contribution of the inferno to local and global warming cannot therefore be overemphasized.

The South-west wind during the period is moisture-laden from the sea inland. Such phenomenon will quicken atmospheric transformation of the mixture of emitted substances from hydrocarbon fire. This implies that it will intensify and complicate the negative consequences of such emission thereby compounding the woes of the arising scenarios especially as the period ushers in early rain.

## RECOMMENDATIONS

- Appropriate and efficient pollution abatement implementation programme should be put in place to avoid future occurrence of this deadly tragedy
- Considering the proximity to human settlement and the risk it poses to human Health, there is the absolute need for the relocating of the manifold to a more distant location
- Periodic epidemiological surveillance to monitor long-term health hazard as they relate to cancer and the reproductive health of the people at-risk

population is needed to assess the impacts on future reproductive health needs of the communities

- Emergency units and secondary Health care facility should be established in K-Dere Health centre by SPDC to enhance rapid response to environmental disasters with a view to reducing hazardous impacts on host communities just as recently done in the case of oil spillage in Texas, USA.

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