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Gas flaring Effects around Agbada II Flow Station in Igwuruta, Rivers State, Nigeria

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Abstract*— The levels of pollutants around Agbada II Flow Station were investigated. Four sampling stations (A – D) located 500 m apart in the downwind direction and a control located 3.5 km in the upwind direction were monitored. The results showed that the air pollutant parameters varied as follows carbon monoxide 1.20 – 2.40 (1.80 ± 0.13), sulphur dioxide 0.00 – 0.01 (0.005 ± 0.001), Volatile Organic Compounds (VOC) 0.00 – 0.01 (0.002 ± 0.001 ppm), Hydrogen Sulphide (H_2S) 0.001 – 0.001 (0.001 ± 0.0004 ppm), Ozove (O_3) 0.01 – 0.01 (0.01 ± 0.005) and suspended particulate matter (SPM) 32.00 – 40.20 (36.10 ± 1.75) parts per million (ppm). The heavy metals in soil; lead (Pb) 0.01 – 0.80 (0.38 ± 0.07ppm), nickel (Ni) 70.00 – 80.20 (75.41 ± 3.68ppm), cadmium (Cd) 0.00 – 0.30 (0.05 ± 0.022 ppm), Cobalt (Co) 0.00 – 0.40 (0.08 ± 0.02 ppm), Copper (Cu) 1.20 – 2.30 (2.00 ± 0.16 ppm), Iron (Fe) 0.00 – 0.50 (0.10 ± 0.04 ppm), Zinc (Zn) 0.01 – 0.01 (0.01 ± 0.001 ppm), and meteorological parameters; wind speed 0.20 – 0.30 (0.26 ± 0.013) m/s, ambient temperature 28.6 – 36.4 (32.25 ± 0.188) ºC, relative humidity (RH) 70.00 – 75.00 (72.33 ± 1.72) %. There was a significant spatial difference in the mean values of the ambient air parameters at $P < 0.05$ and SPM contributed to the difference, though there were no significant correlations between levels of heavy metals. The mean values of all except Cobalt (Co) and Ni were above the Department of Petroleum Resource (DPR) permissible limits. It is recommended that the gases should be utilized optimally, and residential areas should be located at least 5 km from the station to reduce the detrimental effects of the pollutants.

Keywords: meteorological parameters, heavy metals, ambient air, soil, pollutants

I. INTRODUCTION

Gas flaring is an integral part of the operations associated with the exploration of crude oil since inception of the petroleum industry in Nigeria (Hassan and Konhy (2013). This activity had been in existence since 1956 in Niger Delta region of Nigeria when crude oil was first discovered in the region. De Block *et al.* (2011) estimated that the Niger Delta region has about 123 gas flaring sites, thus the largest proportion of these flared sites is located in this region. Here in the region, the industry operates over a thousand producing wells, gas plants and a network of thousands of kilometers of pipelines (Onosode, 2003).

As petroleum exploration and exploitation intensified, gas flaring is now associated with every oil producing community in the Niger Delta region (Chijioke, 2002). Gas flaring products include oxides of carbon (CO_x), nitrogen (NO_x), sulphur (SO_x), photochemical oxidants (mainly Ozone – O_3), volatile organic compounds (VOCs), precursor to photochemical oxidants, suspended particulate matter (SPM_{10}) and some heavy metals such as copper (Cu), nickel (Ni), cobalt (Co), Iron (Fe), mercury (Hg), chromium (Cr), zinc (Zn), and manganese (Mn) (Oghenejoboh, 2005; Anejionu *et al*., 2015). Incomplete combustion of flared gases can emit greenhouse gaseous pollutants such as methane (CH_4), Carbon II oxide (CO) and particulates (Ogwejiofo, 2000; Ekpoh and Obia, 2010).

Various ecological and human disasters which had occurred over the past three decades implicate gas flaring by oil companies as a major contributor to the environmental degradation and pollution of various magnitudes (Ekpoh and Obia, 2010). Gas flaring is known to have several adverse effects on human health, vegetation, agricultural crops and animals in both aquatic and terrestrial ecosystems (Okeagu, 2006; Yan-Ju and Hui 2008; De Block *et al.*, 2011; Anejionu *et al.*, 2015; Lee, *et* al. 2015; Shi *et al*., 2016).

Plants could incorporate these pollutants into their tissues and man can easily be exposed when these plant tissues are consumed owing to his position in the trophic chain (Nathanson, 2009). Consumed food however, could contain high concentration of metals thus resulting to bioaccumulation which is also an ecological concern in organisms of lower trophic levels (Chiuwah *et al.*, 2015).

Heavy metals concentration in air and soil is an issue of concern in agricultural production due to its adverse impacts on crop growth and food quality. Heavy metals due to their persistent nature in the environment tend to accumulate and magnify across the trophic levels to pose serious health hazards to man (Agbaire and Esiefarienrhe, 2009). This is a matter of serious concern since farming is the main source of livelihood of the local residents of Igwuruta community.

Environmental protection and management entail routine monitoring of pollutant outfalls from especially source points of pollution such as Agbada II flow station. This research is thus an attempt towards surveillance monitoring requirements for a sustainable development.

II. MATERIAL AND METHODS

A. *Study area*

with an entrance gate in front and surrounded by farmlands (Gobo *et al.,* 2009).

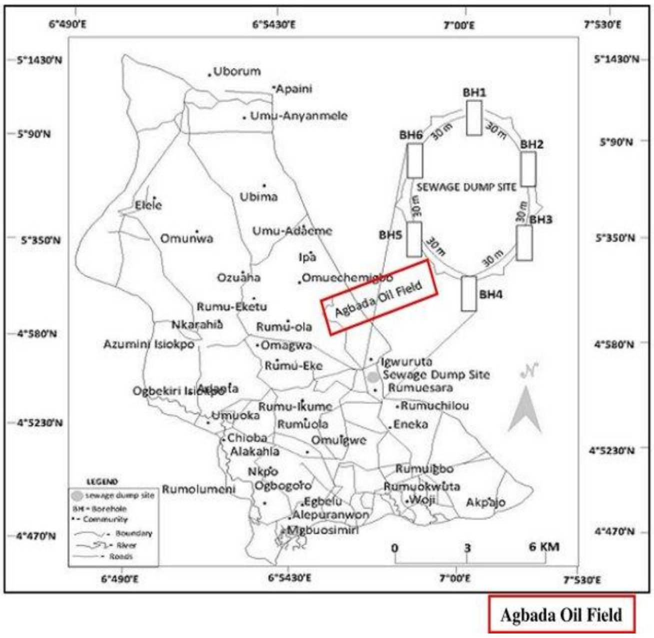


Fig. 1: Map of study area showing Agbada oil field

B. *Sampling locations*

Four sampling stations 500 m apart in the prevailing wind direction from the gas flare stack and a control sighted 3.5 Km in the upwind direction were chosen.

C. *Determination of Air Quality*

High volume sampler (HVS) was used in the collection of suspended particulates and particles were detected using Hazdust 10 µm particulate monitor. Crowcon gasman air monitor that had been pre-calibrated using air cylinder standard (SPDC, 2002) was used in direct detection of CO, NO_2, SO_2 and H_2S while calibrated digital automatic gas monitors (DAGMs) were used to determine the levels of CO, SO_2, H_2S, O_3. Volatile organic compounds (VOCs) and smoke were determined in situ while suspended particulate matter (SPM_{10}) was determined using a Hasdust 10 µm Particulate Monitor.

D. *Determination of heavy metals in soils*

Sample Collection

Soil samples were collected from the sampling locations using clean stainless soil augers at 15cm depth around the sampling stations. The soil samples were thoroughly mixed and stored in clean and labeled polythene bags and transferred to the laboratory for onward analysis.

Sample Treatment

The soil samples were oven dried for 6 hours at 105^{o}C to constant weight (Yusuf *et al*, 2015). The oven dried material was crushed and sieved through a scientific of 5mm sieve to obtain presentative samples.

Sample Digestion

2g of each oven dried soil sample was weighed a top loading balance and placed in a 250ml conical flask and digested with aqua regia, a mixture of 5 ml Nitric acid and 15 ml Hydrochloric acid, a ratio of 1:3 using a dropping pipette. The mixture was then digested in a fume cupboard by heating it continually on a hot plate until a dense white fume is formed which is then ingested for 15 minutes and allowed to cool and diluted with distilled water. Afterwards, the solution was filtered into a 50ml volumetric flask using acid washed Whatman No. 44 filter paper of capacity and diluted to mark volume with deionized water (Sahrawal *et al*, 2002). The filtrate was analysed for Co, Cd, Cu, Pb, Fe, Ni and Zn using Atomic Absorption Spectrophotometer (Agilent 200 Series AA).

E. Measurements of meteorological parameters

A hand-held Testrel 4500 weather tracker was used to determine the following meteorological data: wind speed, ambient temperature, pressure, wind turbulence, sun radiation, wind direction, relative humidity and precipitation. Measurement was made at the five sampling locations and readings were read off the liquid crystal display (LCD) screen of the equipment each time.

F. Data Analysis

Univariate and multivariate were used in the organization of data. Descriptive statistics was used to explore the mean, standard error and range of the ambient air quality parameters while a one-way analysis of variance (ANOVA) was used to explore spatial variations levels of the parameters. Pearson Correlation (r), and post-hoc tests were used for further analysis

III. RESULTS AND DISCUSSION

A. Ambient Air Quality parameters

The study revealed spatial variations in the mean levels of the ambient air quality parameters measured across the sampling stations. Sulphur dioxide (SO_2) gas had the mean value of 0.01 ppm at all the sampling stations except in station C where it was not available (Fig. 2). VOC was not detected in all the stations except in station C with the mean value of 0.01 ppm. The high levels could be attributed to gas flare stack. This is expected since any area near petroleum activities usually has higher level of pollutants which agrees with the findings of Ekpoh and Obia (2010). On the contrary, the mean value of Ozone (O_3) was constant (0.01 ppm) across the five sampling stations (Fig. 2), This could be attributed to the very low concentrations of SO_2 which is a precursor to ozone formation (Gobo *et al.*, 2009). The mean values of SO_2 at all sampling stations were all lower than the department of petroleum resource (DPR) permissible limit (10 ppm) while those of ozone at all sampling stations were all lower also compared with the department of petroleum resource (DPR) permissible limit (0.1 ppm) (Table 1). There is no significant difference in the concentrations of SO_2 and ozone between sampling stations ($P < 0.05$).

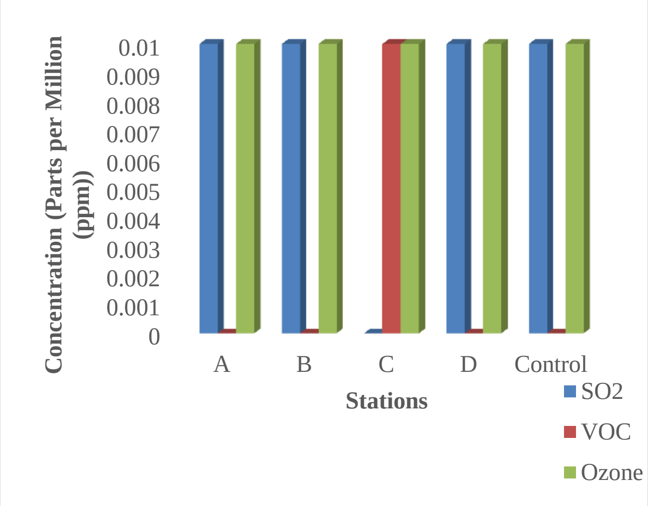


Fig. 2: Distribution of SO_2, VOC and Ozone (ppm) in the five stations.

In Fig. 3, H_2S had the mean value of 0.001 ppm at in all the sampling stations. Whereas CO and SPM recorded their minimum mean values (1.20 ppm and 70.00 ppm respectively) in the control station. Carbon monoxide (CO) gas recorded its maximum mean value of 2.40 ppm at station A while SPM recorded its maximum mean value (40.20 ppm) at station B and station D respectively (Fig. 3). The high levels of SPM in the ambient air could be attributed to low precipitation during the study period. This is because high precipitation helps in washing pollutant particles thereby helping to minimize particulate matter and other pollutants emitted into the atmosphere. This is in line with the findings of Oghenejoboh (2005), Saha *et al*., (2018) and Chweizer *et al*, (2017). The mean values of H_2S, CO and SPM at all sampling stations were all lower than the department of petroleum resource (DPR) permissible limit (0.008, 10 and 250 ppm) respectively (Table 1). There were significant differences in the concentrations of SPM compared with those of H_2S and CO within sampling stations ($P < 0.05$).

B. Concentrations of heavy metals in soil

For the heavy metals, Co recorded its minimum mean value of 0.20 ppm at station A, station B and station Control respectively and a maximum mean value of 0.40 ppm at station C. Zinc (Zn) on the other hand had the mean value of 0.001 ppm at in all the sampling stations (Fig. 4). Cadium (Cd) was not detected at station D and Control respectively and had its maximum mean values of 0.30 ppm at station C. The mean values of Co at station C and station D (0.4 and 0.3 ppm) were higher than that of the department of petroleum resource (DPR) permissible limit (0.2 ppm) while the mean values of Zn and Cd at all sampling stations were all lower than the department of petroleum resource (DPR) permissible limit (140 and 0.8 ppm respectively) (Table 1). There were significant differences in the concentrations of Co and Zn across sampling stations ($P < 0.05$).

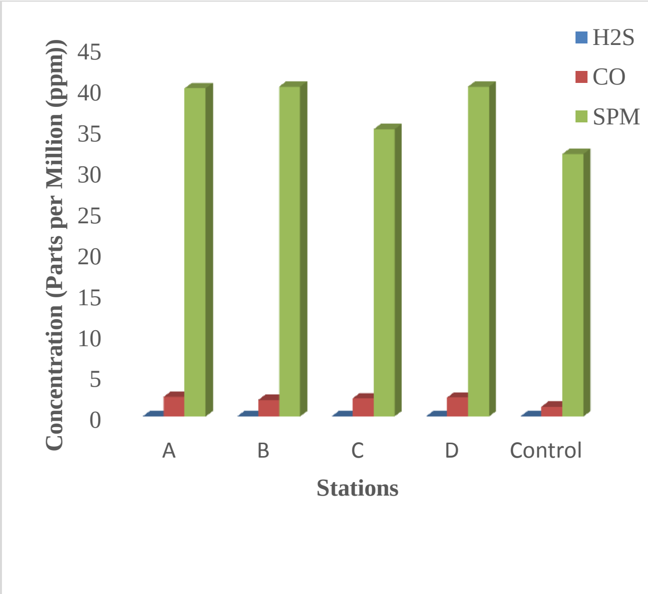


Fig. 3: Distribution of H_2S, CO and SMP (ppm) in the five stations.

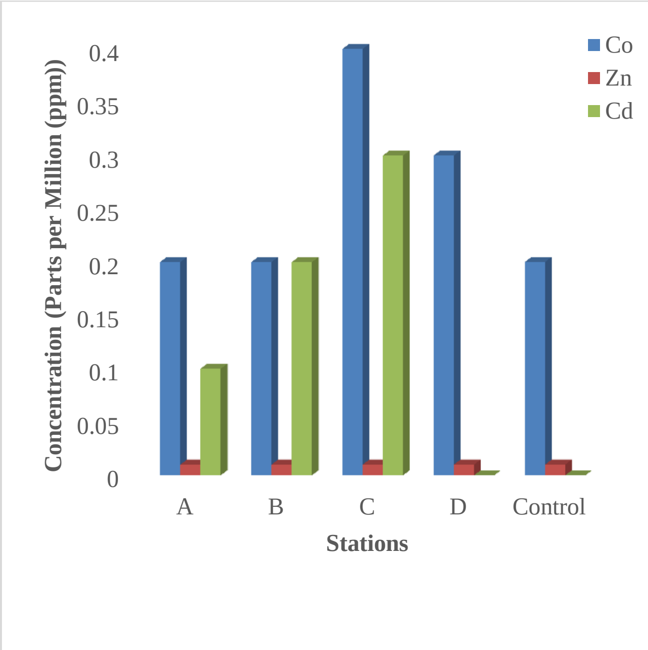
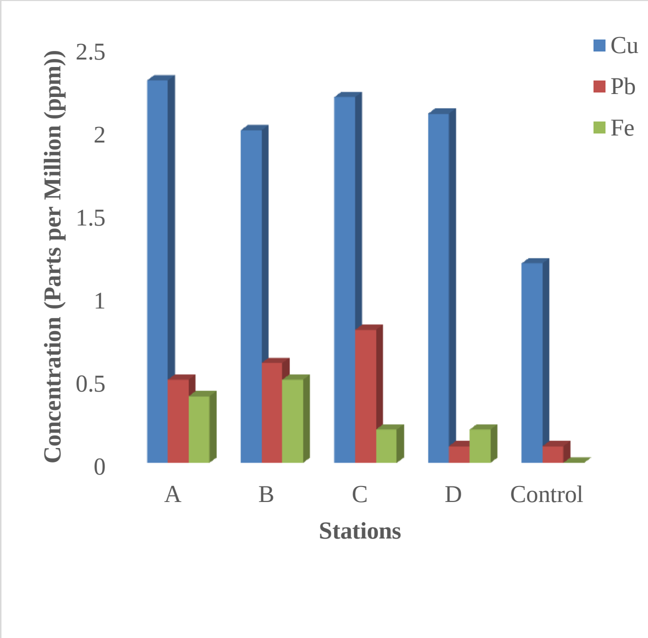


Fig. 4: Distribution of Co, Zn and Cd (ppm) in the five stations.

In Fig. 5, copper (Cu) recorded its minimum mean value of 1.20 ppm in SS Control and its maximum mean value of 2.30 ppm was recorded at station A. Element Pb recorded its minimum mean value of 0.01 ppm at station D and station Control and its maximum mean values of 0.80 ppm were each recorded at station C. On the other hand, Fe was not detected at the Control and had its maximum values of 0.50 ppm at station B (Fig. 5). The mean values of Cu, Pb and Fe at all sampling stations were all lower than the department of petroleum resource (DPR) permissible limit (36.0, 85.0 and 5000 ppm respectively, Table 1). There were significant differences in the concentrations of Cu compared with those of Pb and Fe within sampling stations ($P < 0.05$).



Fig, 5: Distribution of Cu, Pb and Fe (ppm) in the five stations.

Fig. 6 shows the distribution of Ni and RH in the sampling stations. Ni recorded its minimum value of 70 ppm at SS Control and a maximum value of 80.2 ppm at SS B and SS D respectively indicating the proximity of these sampling sites to the gas flare stack. This is in agreement with the findings of Anejionu *et al.* (2015). RH on the other hand recorded its minimum levels of 70% at station C, station D and Control respectively and its maximum values of 75% at SS A (Fig. 6). The 70-75% range of relative humidity was maintained throughout the study period. The mean values of Ni at all sampling stations were all high compared with the department of petroleum resource (DPR) permissible limit (35.0 ppm, Table 1). There was no significant difference in the concentration of Ni and RH within and between sampling stations ($P < 0.05$).

C. Meteorological Parameters

The narrow variation observed in other pollutants in the ambient air is an indication that a good gas flare reduction technique may have been used by the operators of the facility. The ambient temperature was warm (28.6 – 36.4ºC) relatively stable, thus accounting for the low-level wind speed (Table 2). This is in line with the findings of Yan-Ju and Hui (2008). This is probably because air tend to move from an area of high atmospheric temperature to that of low atmospheric temperature thus enhancing wind movement. The low wind speed probably caused the polluted air not to rise above the earth's surface and resulted to rapid cooling of the ground, thus increasing the ground level concentration of pollutants in this layer. With strong wind conditions, there was a greater dispersion and relatively low ground level concentration of the pollutants. Similar observation was made by Agbaire and Esiefarienrhe (2009).

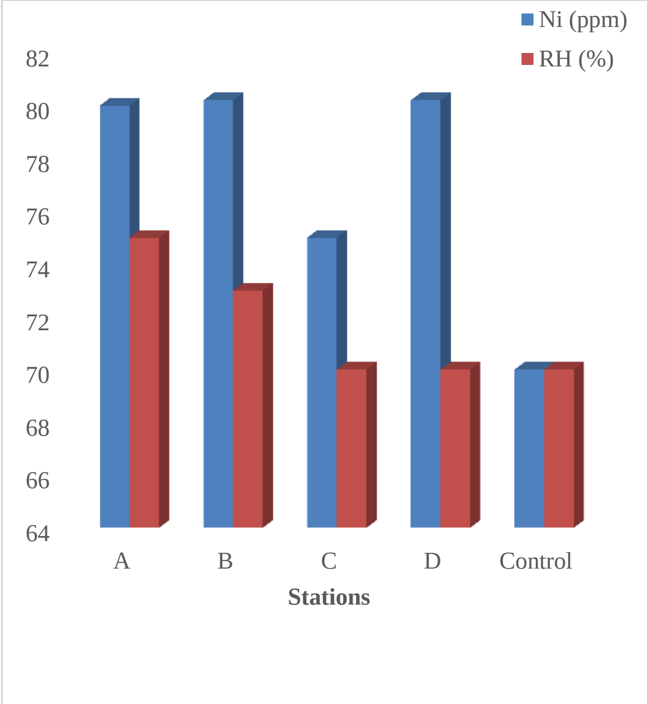


Fig. 6: Distribution of Ni (ppm) and RH (%) in the five sampling stations.

Table 1: Mean ambient air parameters and level of heavy metals in study area compared with Department of Petroleum Resource (DPR) Limit

Parameters (ppm)	Mean ± SE	Department of Petroleum Resource (DPR) Limit
SO_2	0.005 ± 0.001	10
VOC	0.002 ± 0.001	NA
Ozone	0.01 ± 0.005	0.1
H_2S	0.001 ± 0.0004	0.008
CO	1.80 ± 0.13	10
SPM	36.10 ± 1.75	250
Co	0.08 ± 0.02	0.2
Zn	0.01 ± 0.001	140
Cd	0.05 ± 0.022	0.8
Cu	2.00 ± 0.16	36.0
Pb	0.38 ± 0.07	85.0
Fe	0.10 ± 0.04	5000
Ni	75.41 ± 3.68	35.0

Table 2: Meteorological variables of the study area

Sampling stations	Wind speed (m/s)	Ambient temperature (°C)	Pressure (PSI)	Wind turbulence	Sun radiation	Precipitation
SS A	0.2	36.4	1090	Low	Sunny	Low
SS B	0.3	33.2	1060	Low	Sunny	Low
SS C	0.3	32.5	1120	Low	Sunny	Low
SS D	0.2	30.0	1003	Low	Sunny	Low
Control	0.3	28.6	1004	Low	Sunny	Low

IV. CONCLUSION

The contributions of heavy metals and other pollutants in ambient air from the Agbada II oil flow station was minimal with spatial variations in their levels. The mean values of all except Co and Ni were within the DPR permissible limit. It is thus recommended that the gases should be liquified and bottled for domestic and industrial purposes, and residential areas should be located at least 5 km from the gas flare stack to reduce the detrimental effects of the pollutants on Igwuruta community.

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