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Assessment of Air Quality Around Gbaran – Ubie Gas Processing Plant, yenagoa, Bayelsa State, Southern Nigeria

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Abstract
This study determined the air quality status around Gbaran and its environs as a result of gas processing taking place in the area. The study characterized and quantified air pollutants emitted into the surrounding at two different seasons and also determined the seasonal variations in the concentration levels of gases in the air sample with a view to evaluating the air quality implication of the gas processing plant. Digital hand - held gas Analyzers were used to monitor air pollutants including; Total Suspended Particulate Matter (TSPM), Sulphur dioxide (SO_2), carbon monoxide (CO) and Volatile Organic Compounds (VOCs), while Kestrel Model NO. 4500 pocket weather tracker was used to monitor the meteorological parameters such as: ambient temperature, relative humidity, wind speed. The direction of wind was also detected using wind vane. The results of the study showed dominant wind direction during the wet season within the SE and the NE direction while during the dry season it was NW and NE. The maximum wind speed during the wet and dry seasons was 3.75m/s and 2.80m/s respectively. The Relative humidity values in wet season ranged between 82.40% - 98.80% while in the dry were between 37.15% - 74.95%. Temperature in the wet season ranged between 24.80^{o}C – 30.40^{o}C while during the dry season it was between 31.05^{o}C– 43.20^{o}C. The mean concentration of TSPM during the wet season ranged between 16.00µg/m^3 – 2,423.50µg/m^3 while in the dry, it was between 508.00 µg/m^3– 3,800.00 µg/m^3. That of SO_2 during the wet season ranged between 0 ppm – 1 ppm while in the dry season it was between 0.50 ppm – 1.50 ppm. CO was emitted in the range of 0 .50ppm – 6.00 ppm in the wet season and 0.87 ppm – 2.00 ppm in the dry season. For VOCs, its mean concentration during the wet season ranged between 0.65 ppm – 3.25 ppm and 3.15 ppm – 10.00 ppm during the dry season. The study observed that the mean concentrations of gaseous pollutants in the dry season were higher than the wet season and were also found to exceed the limits recommended by Federal Ministry of Environment, except CO that was lower and below the set limit. The study therefore concluded that the Gbaran - Ubie gas processing plant is a source of air pollution in the area.
Keywords: Assessment, Air quality, Gas processing plant, Gbaran – Ubie, Obunagha, Yenagoa
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1. Introduction

Associated natural gas is a by - product of petroleum production reaching the earth surface through connected piping system and burns in a controlled process called gas flaring (Buzcu- Guven *et al.* 2012; Kearns *et al.* 2000; Onyekachi, 2016). The process of Gas flaring is carried out by the use of flare stack that is elevated in a vertical or horizontal direction to burn off unwanted associated gases from oil well, refineries or chemical plants, (Abdukadir *et al*. 2013; Atuma and Ojeh, 2013; Banerjee, 1995; Evoh, 2002).

Since the discovery of oil in commercial quantity by Shell - BP in 1956 at Oloibiri in the Niger Delta region of Nigeria, gas flaring has been on the increase and these has reduced the atmospheric quality through the release of pollutants like Carbon monoxide (CO), Nitrogen dioxide (NO_2), Sulphur dioxide (SO_2) Methane (CH_4), Hydrogen Sulphide (H_2S) and Particulate matters, among others into the atmosphere (Okoh, 2000; Obi, 2001; Enete and Ijioma 2011; Nkwocha *et al*. 2017).

As a result of the environmental pollution caused by the constant and increasing gas flaring in Nigeria, Nigeria it has been ranked the second highest gas flaring nation in the world after Russia and Iraq in 2006. However, the Nigeria National Petroleum Corporation (NNPC) in its quest to reduce gas flaring in the country, succeeded in pushing Nigeria down to the seventh position in 2016 to 2017 (NNPC, 2017). Despite this effort made by NNPC to reduce gas flaring in the country, by 26 percent point in the last Eleven years from 36% to 10% point, gas flaring still remains a menace that brings about multiple effects to the nation.

Some consequences of gas flaring include greenhouse effect, increase in temperature or thermal gradient, human health problems, poor agricultural yields, acid rain, acidification of aquatic environment and change in ecosystem (Oyekan, 2000; Nduka *et al.,* 2008; Bhatia and Wernham, 2009; Dung, 2008; Ekpoh and Obia, 2010; Efe, 2010; Gobo and Unbong, 2010; Ejelonu, *et al*., 2011; Julius, 2011; Anomohanran, 2012).

2. Study Area Description and Geology

The study area is easily accessible, bounded by two major roads; one along Agbia-Poluku road and the other Tombia - Amassoma Road all in Yenagoa local Government Area, Southern Nigeria. The study area is geographically located within latitudes 4°59'N and 5°28'N and longitudes 6°15' E and 6°21'E (Table 1). Majority

of the communities within the study area are completely surrounded by wetlands with elevation of 5 meters above sea level (Figure 1).

The area is part of Benin Formation it has lithologies comprises of sands, silts, gravel and clayey intercalations. it is situated within the lower floodplain of the Niger Delta, it is endowed with the sedimentary rocks and the area is made up of continental deposit of Miocene to recent sediments. Litho stratigraphically, the rocks are divided into the oldest Akata Formation (Paleoceone), the Agbada Formation (Eocene) and the youngest Benin Formation (Miocene to Recent). The wells and boreholes tap water from the overlaying Benin Formation (Coastal plain sands) (short and Stauble, 1967).

The Benin Formation is the water bearing zone of the area. It is overlain by Quaternary deposits (40-150m) thick, and generally consists of rapidly alternating sequences of sand, Silty and clay which latter become increasingly prominent seawards (Etu-Efeotor and Akpokodje, 1990). The study area is drained by Taylor creek, Epie creek and River Nun, these creeks flow into River Nun.

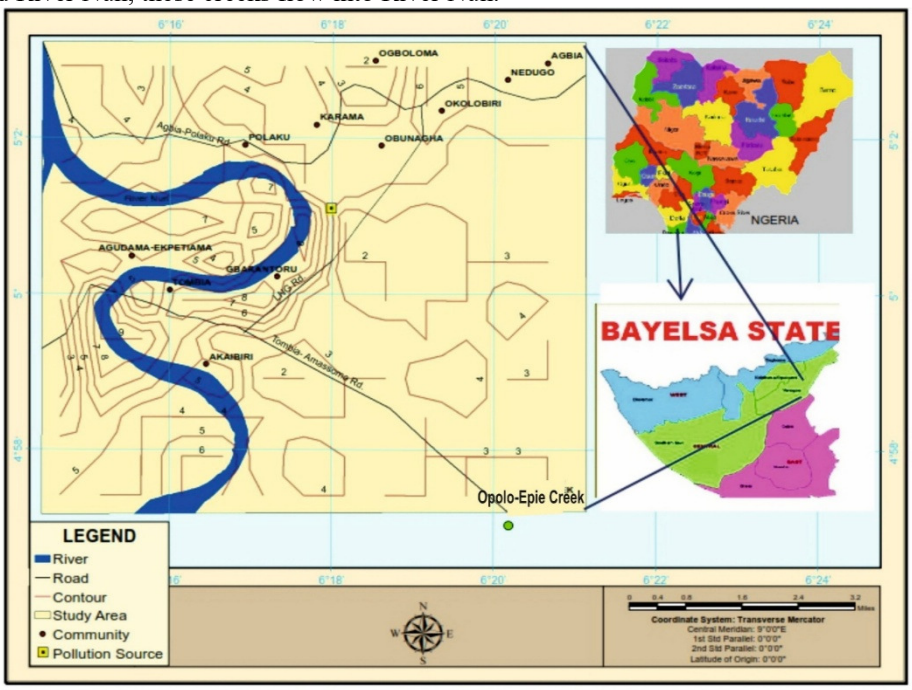

Figure 1. Location Map of the Study Area

3. Materials and Methods

Potable digital hand held gas Analyzers were used to monitor air quality *in-situ* around Gbaran – Ubie gas processing plant at different locations including; Gbarantoru, Polaku, Tombia, Koroama, Obunagha, Nedugo, Okolobiri, Ogboloma, Agudama-Ekpetiama, Akabiri, Agbia and the control station (Opolo- Epie) (Figure 1).The sampling equipment used in this study include Geographical Positioning system (GPS) used in the measurement of elevation and coordinate (longitudes and latitudes) of the sample locations. Wind Vane was used to determine the prevalent wind direction. Kestrel Model No. 4500 pocket weather tracker was used for the measurement of meteorological parameters; wind speed (m/s), ambient temperature (^oC) and Relative Humidity (%). GA-21 plus flue gas analyzer with electronic- chemical sensors was used for the detection of gas concentrations such as SO_2 and CO, Air Tester Model CH-HAT 200 with sensors was used for the detection of TSPM and Aeroqual series 200 gas monitor with VOCs sensor head was used for the detection of VOCs. The air quality implication of the project was determined by comparing the detected and quantified air pollutants from the study with the Nigerian Ambient Air Quality Standard set by the Federal Ministry of Environment (FMEnv), (1991); hydrocarbon - 160 $\mu g/m^3$ or 0.16ppm, SO_2 - 0.1ppm, CO – 10 ppm and PM – 250 $\mu g/m^3$.

4. Results and Discussion

Table 1. Coordinates of the study area

Location	**Longitude**	**Latitude**
	N	E
Nedugo	$6^0$20'48.066"	$5^0$3'5.856"
Agbia	$6^0$21'14.694"	$5^0$3'18.204"
Ogboloma	$6^0$20'26.670"	$5^0$2'52.236"
Okolobiri	$6^0$19'20.406"	$5^0$2'21.486"
Obunagha	$6^0$18'36.354"	$5^0$1'54.480"
Gbarantoru	$6^0$16'54.054"	$4^0$59'58.110"
Tombia	$6^0$16'0.732"	$5^0$0'2.478"
Agudama	$6^0$15'31.980"	$5^0$0'28.662"
Akaibiri	$6^0$16'27.738"	$4^0$59'5.760"
Opolo-Epie (Control)	$6^0$20'11.538"	$4^0$57'2.130"
Koroama	$6^0$17'48.018"	$5^0$2'9.660"
Polaku	$6^0$16'56.363"	$5^0$1'54.546"

Table 2. Wet and Dry Seasons Average Meteorological parameters

S/N	Sampling Locations	Ambient Temperature (°c)		Relative Humidity (%)		Wind Speed m/s		Wind Direction	
		Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry
1	Nedugo	26.70	34.05	94.20	72.00	0.80	1.69	NE	SW
2	Agbia	26.30	32.45	96.60	70.75	1.25	0.90	NE	SW
3	Ogboloma	25.90	35.15	98.80	62.85	1.25	1.20	SE	NW
4	Okolobiri	25.40	34.40	95.05	67.20	1.10	0.70	NE	NW
5	Ogbunagha	27.50	37.65	92.35	53.90	1.05	2.80	NE	NE
6	Gbarantoru	27.50	35.95	91.35	60.75	3.50	1.75	SE	NW
7	Tombia	28.65	31.05	82.40	74.95	0.45	0.95	SE	NW
8	Agudama	27.95	32.60	88.90	67.34	0.55	1.40	SE	NE
9	Akaibiri	30.40	33.85	82.35	63.62	0.40	1.15	SE	SE
10	Control (Opolo-Epie)	28.35	33.00	88.95	66.00	1.22	1.50	SE	NW
11	Korama	27.35	41.50	98.15	42.05	0.45	0.55	SW	NE
12	Polaku	24.80	43.20	98.5	37.15	3.75	1.00	SE	NE

Table 3. Wet and Dry Seasons Mean Concentration of Air pollutants

Locations	**TSPM (µg/m^3)**		**SO_2 (ppm)**		**CO (ppm)**		**VOCs (ppm)**	
	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry
Nedugo	24.00	281.50	0	1.00	4.50	0	1.40	3.95
Agbia	55.50	508.00	0	0.50	6.00	0	1.80	6.15
Ogboloma	16.00	558.50	0	0.50	0	0	1.10	3.15
Okolobiri	297.50	752.00	0	1.00	3.00	0	1.40	3.45
Obunagha	421.50	1024.50	0	0.50	4.00	2.00	0.65	3.55
Gbarantoru	286.00	789.00	0	1.50	0.50	1.00	3.25	10.00
Tombia	841.00	843.00	0	0.50	3.00	1.00	2.05	6.80
Agudama-Ekpetiama	919.50	932.00	0	0.58	3.50	0.87	1.40	6.86
Akabiri	151.50	901.00	0	0.88	0	0.94	1.10	7.52
Control (Opolo-Epie)	46.00	187.00	0	0	1.00	0	0.05	0.12
Korama	2423.50	3800.00	0	1.50	1.00	1.50	1.80	5.6
Polaku	525.00	957.50	1.00	0	2.00	0	2.05	6.7

4.1 Meteorological parameters determined

Table 2 indicates the mean values of the measured ambient temperature, relative humidity, wind speed and direction.

(a) **Wind direction**

The dominant wind direction in the wet season was within the SE and NE direction, with a few occasional drift to the SW direction, while in the dry season the dominant wind direction is NW and NE, with an occasional drift to the SE and SW direction (Table 2)

(b) **Wind Speed**

The wind speed ranged between 0.40 – 3.75m/s during the wet season, maximum wind speed stood at 3.75m/s, the lowest wind speed recorded at the dry season was 0.90 m/s, while the maximum wind speed stood at 2.80m/s (Table 2).

(c) Relative Humidity

Relative humidity during the wet season ranged between 82.40% - 98.80%. In the wet season, both Tombia and Akaibiri locations have the lowest humidity of 82.40% respectively while Ogboloma location has the highest relative humidity of 98.80%. During the dry season the relative humidity ranged between 37.15 – 74.95% with the lowest relative humidity at Polaku (37.15%) location while the highest humidity of 74.95% was recorded at Tombia location (Table 2).

(d) **Temperature**

During the wet season the temperature ranged between 24.80^{o}C - 30.40^{o}C, In the wet season Akaibiri location has the highest temperatures of 30.40^{o}C followed by Tombia that recorded 28.65, while lowest temperatures were observed at Polaku (24.80^{o}C) and Okolobiri (25.40^{o}C) locations, during the wet season the average temperature drops to about (26.30^{o}C to 27.95^{o}C). During the dry season, the temperature ranged between 31.05^{o}C to 43.20^{o}C, Polaku and Koroama recorded the highest temperature of 41.50^{o}C and 43.20^{o}C respectively (Table 2). The high temperature observed was due to an accumulation of the atmospheric temperature and the heat generated from the gas plant.

4.2 Gaseous Air Pollutants Distribution

The average gaseous emissions measured from the study locations are reported in table 3. The gaseous emissions characterized in this study are volatile organic compounds (VOCs), Carbon Monoxide (CO), Total Suspended Particulate Matter (TSPM) and Sulphur dioxide (SO_2) which are the most common air pollutants mostly affecting human health and the environment.

(a) Total Suspended Particulate Matter (TSPM)

The recorded mean concentration of Total Suspended Particulate Matter during the wet season ranged between 16.00 µg/m^3 – 2,423.50 µg/m,^{3} with the maximum mean concentration of 2,423.50 µg/m^3 recorded at Koroama that is worst affected by the TSPM emission from the gas plant during the wet season. While the lowest mean concentration of 16.00µg/m^3 was recorded at Ogboloma. During the dry season mean concentration of TSPM ranged between 508.00 µg/m^3- 3800.00 µg/m^3, highest concentration of 3800µg/m^3 was also observed at Koroama while its lowest concentration was reported at Agbia location. The mean concentrations of pollutants during dry season are found higher than that of the Control value (187.00 µg/m^3). The same situation applies to the wet season where all concentrations are also higher than the Control value (46.00 µg/m^3), except Nedugo and Ogboloma locations. The dry season mean concentrations of TSPM were generally found to be higher than those of the wet season values (Figure 2). While the concentration of TSPM within the study area in both wet and dry seasons are shown to be higher than the stipulated standard of 250µg/m^3 set by the Federal Ministry of Environment Nigeria, Except Nedugo, Agbia and Ogboloma locations during the wet season only. Therefore, exposure to this high level of TSPM is capable of causing respiratory diseases and cardiovascular disorder to the inhabitants of the area.

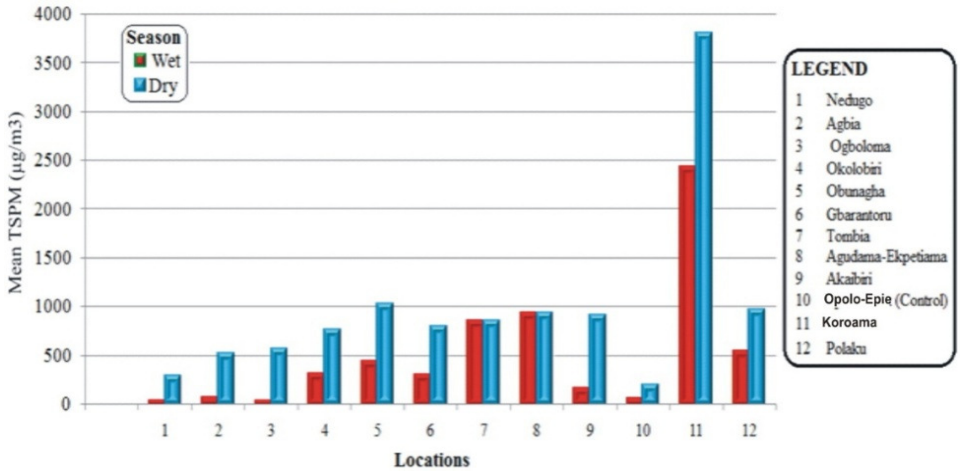

Figure 2. Seasonal variation of Total Suspended Particulate Matter (TSPM) Concentration during the Wet and Dry Seasons.

(a) **Sulphur dioxide (SO_2) Distribution**

During the wet season, all measured concentrations of Sulphur dioxide (SO_2) were below detection limit (less than 0.001 ppm) including the control location, except at Polaku location with 1.00 ppm. However, the dry season concentration of SO_2 ranged between 0.50 ppm - 1.50 ppm, Koroama and Gbarantoru communities recorded the highest concentration of 1.50 ppm respectively while the lowest concentration of 0.50 ppm was recorded at Agbia, Ogboloma, Obunagha and Tombia locations respectively. At the dry season Polaku and the Control were below detection limit. During the dry season all measured concentrations of SO_2 exceeded the Federal Ministry of Environment set limit of 0.10ppm except Polaku and the Control locations that were below detection limit. Therefore, these concentrations are capable of posing health challenges such as nose irritation, throat and shortness of breath when constantly inhaled; especially the elderly, children and the asthmatics are more at risk. Comparison of the dry and wet season concentrations indicate that the dry season values were higher than the wet season values (Figure 3).

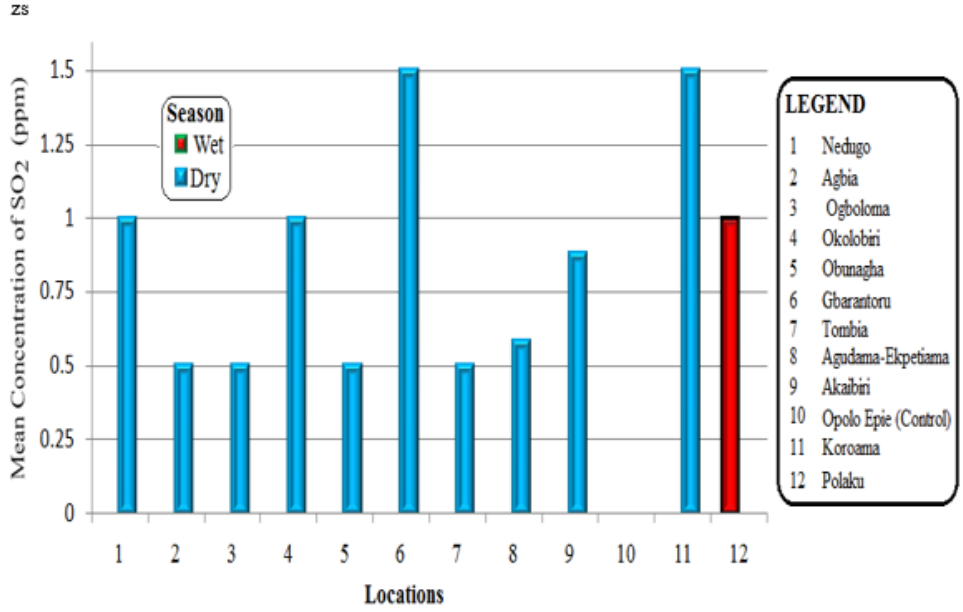

Figure 3: Seasonal variation of Sulphur dioxide (SO2) Concentration during the Wet and Dry Season

(b) **Carbon Monoxide (CO) Distribution:**

The measured concentration of Carbon monoxide during the wet season ranged between 0.50 ppm – 6ppm, in the wet season. Agbia location recorded the highest concentration of 6.00ppm and Gbarantoru location recorded the lowest concentration of 0.50 ppm. While the concentration of the Control location is 1.00 ppm. Concentrations of gaseous pollutants from all the locations during the wet season show higher values than the control value except Gbarantoru location. This erratic values of CO concentration suggest that not all concentrations recorded emanate from the singular source of the gas plant other sources also account for these undefined concentration pattern. During the dry season the values of CO

ranged between 0.87 ppm – 2.00 ppm. Obunagha location emitted the highest concentration of 2.00 ppm and the lowest concentration of 0.87 ppm was emitted at Agudama-Ekpetiama location. The concentration of the control location was below detection limit. The concentrations of carbon monoxide (CO) in the wet seasons were generally found to be higher than the dry season values (Figure 4), however, both season concentrations are below 10 ppm set by the Federal Ministry of Environment, therefore CO does not pose environmental and health problems.

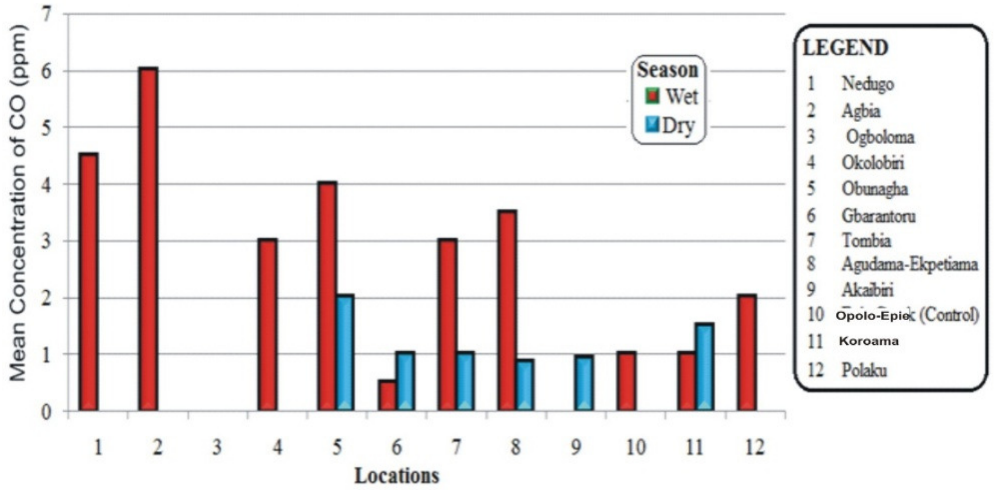

Figure 4. Seasonal variation of Carbon Monoxide (CO) Concentration during the Wet and Dry Season

(c) Volatile organic Compounds (VOCs) Distribution

The measured concentration of VOCs during the wet season ranged between 0.65 ppm – 3.25 ppm. The maximum values of 3.25 ppm for VOCs was recorded at Gbarantoru location and minimum value of 0.65 ppm was recorded at Obunagha location, while the Control location recorded the concentration of 0.05 ppm. It is indicated that the wet season concentrations were generally higher than that of the control location.

The concentrations values recorded in the dry season for VOCs ranged between 3.15 ppm to 10.00 ppm, the lowest value of 3.15ppm was recorded at the Ogboloma location and highest concentration of 10.00 ppm was recorded at Gbarantoru location, while the control location recorded 0.12 ppm during the season under consideration. It is observed that the dry season concentrations were generally higher than the control values. The VOCs concentrations values in the dry season were higher than those of the wet season (Figure 5). Concentration values of VOCs in all the locations in both seasons exceeded the permissible limit set by the FMEnv. (160µg/m^3) or (0.16ppm). Therefore, when breathed it can cause health problems such as liver damage, kidney and central nervous system, irritation of the eye, nose and loss of coordination.

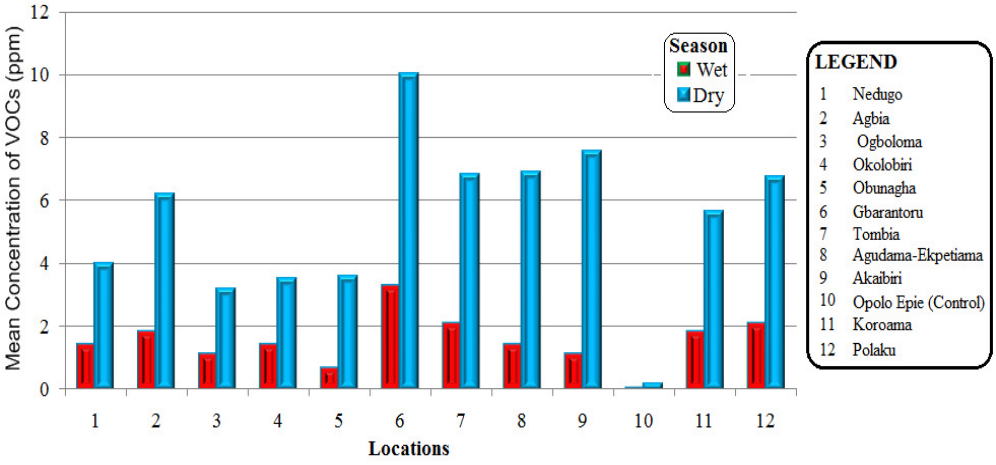

Figure 5. Seasonal Variation of Volatile Organic Compounds (VOCs) Concentration during the Wet and Dry Season

5. Conclussion

The study therefore concluded that the air quality status of Gbaran and its environs is poor and that Gbaran – Ubie

gas flaring plant is a source of air pollution. The measured concentrations of TSPM, SO_2 and VOCs exceeded the permissible limit of the Federal Ministry of Environment, 1991 Nigeria. This situation therefore could pose great health challenges, even death to human lives in the area, exception of CO that the concentrations were within the tolerable limit of FMEnv. The concentration level of gaseous pollutants in the area were found to varies with season, with the dry season values generally higher than those of the wet season, exception of CO in which the reverse is the case.

Suggestions/Recommendations

I suggest that gas scrubbers (absorption) should be installed and use in the gas plant to curb the issue of air pollution. Also Weighty sanctions should be promulgated and enforced by National Environmental Standards and Regulations Enforcement Agency (NESREA) and other regulatory Agencies against oil companies that default.

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