IOSR Journal of Environmental Science, Toxicology and Food Technology (IOSR-JESTFT)
e-ISSN: 2319-2402,p- ISSN: 2319-2399.Volume 17, Issue 10 Ser. 2 (October 2023), PP 21-27
www.iosrjournals.org

Analysis Of Atmospheric Pollutants Across Gas Flaring Sites In Rivers State, Nigeria

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Abstract
The study analyzed atmospheric pollutants as influenced by gas flaring sites in Rivers state, Nigeria. The air quality measurements around gas flaring sites. A total of 25 gas flaring sites from 25 communities were utilized for the study. The primary data investigation involved direct field survey measuring air quality around gas flaring sites with the use of AEROQUAL measurement instruments for gaseous pollutants and weather trackers for meteorological parameters. The field activities were caried out in wet and dry seasons across gas flaring sites. The results revealed mean concentration values of CO (10.7ppm), NO_2 (0.6ppm), VOC (321.8ppm), CH_4 (90ppm) with average temperature of 30.1 (^0C) during the wet season; and CO (13.1ppm), NO_2 (0.7ppm), VOC (338.2ppm), CH_4 (97.9ppm) with average temperature of 31.2 (^0C) during the dry season. High mean concentration values for CO, CH_4 and VOC were observed around gas flaring sites in Rivers state. Thus, gas flaring activities have significantly affected air quality in the study area. The study recommended amongst others that the government should enact laws that will checkmate gas flaring activities in the study area.

Keywords: *Atmospheric pollutant concentrations, Gas flare sites, Wet and Dry seasons, Rivers state*

Date of Submission: 14-10-2023 Date of Acceptance: 24-10-2023

I. Introduction

Gas flaring is the unscientific burning of excess hydrocarbons gathered in an oil/gas production flow station (Ogidiolu, 2003; Odjugo 2004). The reason while flaring is done is to act as a safety device to protect vessels or pipes from over-pressuring due to unplanned upsets. Obi and Osang (2015) stated that flaring is a means of safely disposing of waste gases using combustion. They noted that with an elevated flare, the combustion is carried out through the top of a pipe or stack where the burner and igniters are located. The size and brightness of the resulting flame depends on the amount of released flammable material (World Bank, 2011). In the Delta of the Niger, there are still more than one-hundred flares of gas combusting offshore as well as onshore. The region is a 70,000km^2area that has been producing the oil in Nigeria, and now experiencing this menace of flaring since 1956 when the production of oil started at Oloibiri in Bayelsa State in 1956 (Nigerian Environmental Study/Action Team, 1991).

The ecosystem of the Niger Delta region of Nigeria has greatly been endangered by ongoing oil and gas exploration, which commenced in 1958. Among the various activities associated with oil and gas exploration that directly affects the environment are oil spillage and fire, deforestation, dredging and associated waste, gas flaring has been indicted as a prominent agent of pollution in the region. With the absence or inadequacies of an efficient regulatory framework, inaccessibility to domestic and international markets and limited finances to undertake gas flaring reduction projects are major reasons for the continuous flaring of gas (World Bank, 2010). Gas flaring activities coupled with the surrounding activities have contributed to forest loss and deforestation in the Niger Delta. The flaring of gas has become most worrisome to communities as it is a trademark among host communities in the region.

Globally, high amount of gas is flared into the environment by oil and gas producing countries. Nigeria being among the world producing nations, flares a significant amount of its natural gases into the environment through vertical and horizontal flaring stack. Nigeria is ranked second country in the world after Russia (World Bank, 2011) and about 75 percent of natural acquired via oil production are flared by burning therefore releasing carbon dioxide (CO_2) this process introduce pollutants into the environment and also altered the climate (temperature) of the environment. On the other hand, the release of gas or flaring gives a higher potential of global warming and increases the amount of gas released into the atmosphere. Gas flaring is one of the processes (alongside venting and reinjection) used to dispose natural gases associated with crude oil. This process has commonly been adopted by all the oil companies operating in the region due to its cost effectiveness compared to the logical alternative of conversion of the gas to commercial natural gas. This practice of burning off the associated gas when crude oil is processed has continued unabated since the discovery of oil in Nigeria.

Report has it that about 75 percent of the gas produced in Nigeria is flared (Ibaba and Olumati, 2009). It is estimated that about two billion standard cubic feet of gas is currently being flared in Nigeria, the highest in any member nation of the Organization of Petroleum Exporting Countries (OPEC). Going by this fact, Nigeria accounts for about 19 percent of the total amount of gas flared globally.

Generally, gas flare sites constitute areas of high temperatures (Osuji and Avwiri, 2005; Oseji, 2007; Odjugo and Osemiwenkhae, 2010). High temperatures create physical, chemical, and biological conditions, which are harmful to human health, plant and soil micro-organisms. Air, which constitutes about 80% of man's daily intake by weight, if polluted may cause profound undesirable effects on human health and other equally negative consequences. Air is said to be polluted when its natural uses are impaired (Khayan *et al*., 2014). Consequently, a number of studies have implicated air pollution to having grave social and economic implications for Nigeria and the world in general, due to its negative environmental impacts and its contribution to climate change (Abdulkareem, 2005; Oseji 2007; World Bank, 2007; Omokaro, 2009; Edino *et al.,* 2010). In particular, it has been said to affect the physiochemical properties of soil in flaring vicinity (Abdulkareem, 2005) and a serious contributor to acid-rain, the impacts of which are already being felt in the Niger Delta region in terms of vegetation damage, corrosion and caving-in of roofing sheets and death of aquatic lives. The impact of gas flaring on the environment and health of host communities in Niger Delta, Nigeria is of great concern. Thus, governments need to help reduce this practice in developing countries by developing an appropriate legal, regulatory and financial environment that promotes the utilization of gas (World Bank, 2011) in view of the economic activities domiciled especially in the study area. This study was therefore borne out of the need to spatially assess the status of air quality around gas flare locations in Rivers state. Findings will therefore be useful for its effective management especially as it is now a public concern with several health implications on the people.

II. Materials and Methods

Description of the Study Area

Rivers State is one of the thirty-six (36) states of Nigeria (Figure 1). The state lies within the global positioning system (GPS) coordinates 4°45'N 6°50'E. Port Harcourt is the Capital City of the state. Rivers State occupies a total area of 11,077km^2 (4,277mi^2) consisting mainly of tropical rainforests in the inland part and mangrove swamps (typical of the Niger delta environment) towards the coastal part. Rivers State is one of the six (6) states in the South-South geopolitical zone and one of the nine (9) states in the Niger delta ecological region of Nigeria. .

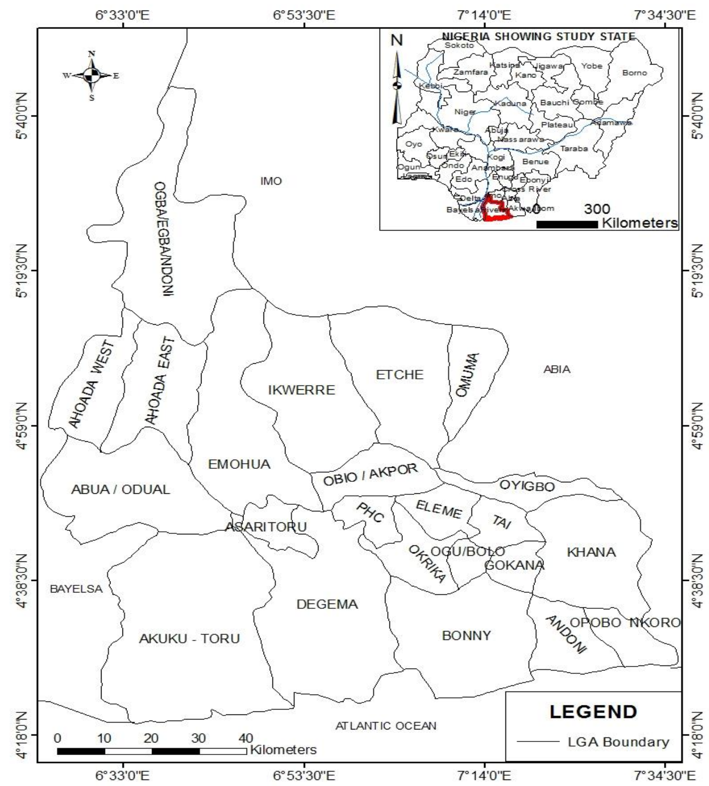

Figure 1: Rivers state and its LGAs (Inset- Rivers state location in Nigeria)

Rivers state lies on the recent coastal plain of the eastern Niger Delta. Its surface geology consists of fluvial sediments. This includes the recent sediments transported by Niger River distributaries and other rivers, such as Andoni, Bonny, and New Calabar. These materials deposited as regoliths overburden of 30m thickness are clays, peats, silts and gravels. Fourteen of the twenty-three LGAs of the State are located on the upland with varying heights between thirteen to 45m above sea level. These include Ogoni, Ikwerre LGAs, Ahoada, Abua/Odual, Ogba/Egbema, Ndoni LGAs and Port Harcourt LGAs (Figure 1). The entire topography of the state is characterized by a maze of effluents, rivers, lakes, creeks, lagoons and swamps crisscrossing the low-lying plains in varying dimensions. Rainfall in River state is seasonal, variable, and heavy. Generally, south of latitude 05N, rain occurs, on the average, every month of the year, but with varying duration. The state is characterized by high rainfall, which decreases from south to north. Total annual rainfall decreases from about 4,700 mm on the coast to about 1,700 mm in extreme north of the state. Deforestation is among the ecological problems confronting the state, as mass deforestation of both mangrove and rain forest is extensive. In fact, in some parts of the state, derived savannah exists. Rivers State is a state of physical difficulties, such as low-lying terrain riddled with an intricate system of natural water channels; much surface water and a high rainfall; and uninhabitable mangrove swamps and some part of the state suffer from inaccessibility. Rivers State and its capital city Port Harcourt has long been an important merchant port and it is today, the center of Nigeria’s oil industry. The area is the chief oil refining centers in Nigeria, oil being one of Nigeria’s most important commodities and the main foreign exchange earner. Agriculture is the main occupation of the people of Rivers State and the agricultural policy of the state government is anchored on food production (Adeomo, 2013).

Data Acquisition

A series of hand held air quality monitoring equipment (AEROQUAL) were used for monitoring air quality around gas flare sites. The direct field survey involved measuring air quality around gas flaring sites with the use of AEROQUAL measurement instruments for gaseous pollutants and weather trackers for meteorological parameters. Sampling in each case was for a period of eight hours per day with readings of all the parameters determined for four (4) hours in the morning period (8am -12 pm) and evening periods (2pm – 6pm). The daily means of measured air quality values were utilized for this study. A total of 25 gas flare sites (Table 1 and Figure 2) were identified and these were locations where air quality instruments were established during the wet and dry season periods.

Table 1: Gas Flaring Sites in Rivers State

S/N	Location/Communities	Y_axis	X_Axis
1	Obrikom	5.3954	6.667821
2	Obite	5.263023	6.651785
3	Rumuji	4.939548	6.77881
4	Rumuekpe	4.973843	6.695931
5	Ebubu	4.75402	7.156128
6	Idu	5.103892	6.548716
7	Igwurita	4.956412	7.023799
8	Ibocha	5.462091	6.699237
9	Idama Ekulama	4.627791	6.805899
10	Soku	4.678336	6.68248
11	Ekulama	4.54778	6.6651
12	Elemsagama	4.671622	6.583313
13	Oshia	5.097178	6.487315
14	Obagi	5.247847	6.614385
15	Bela	4.66537	7.30173
16	Krakama	4.752914	6.785609
17	Bonny	4.428669	7.186613
18	Kalabiama	4.527279	7.512541
19	Finima	4.391391	7.176332
20	Okolomatobe	4.850437	6.489315
21	Umubele	4.886795	7.125137
22	Ogbele,_Ibaa	4.896506	6.659823
23	Okpulor	4.889123	7.137118
24	Elelenwo	4.839769	7.072702
25	Afam	4.853569	7.049476

Source: Researcher’s Computation, 2023

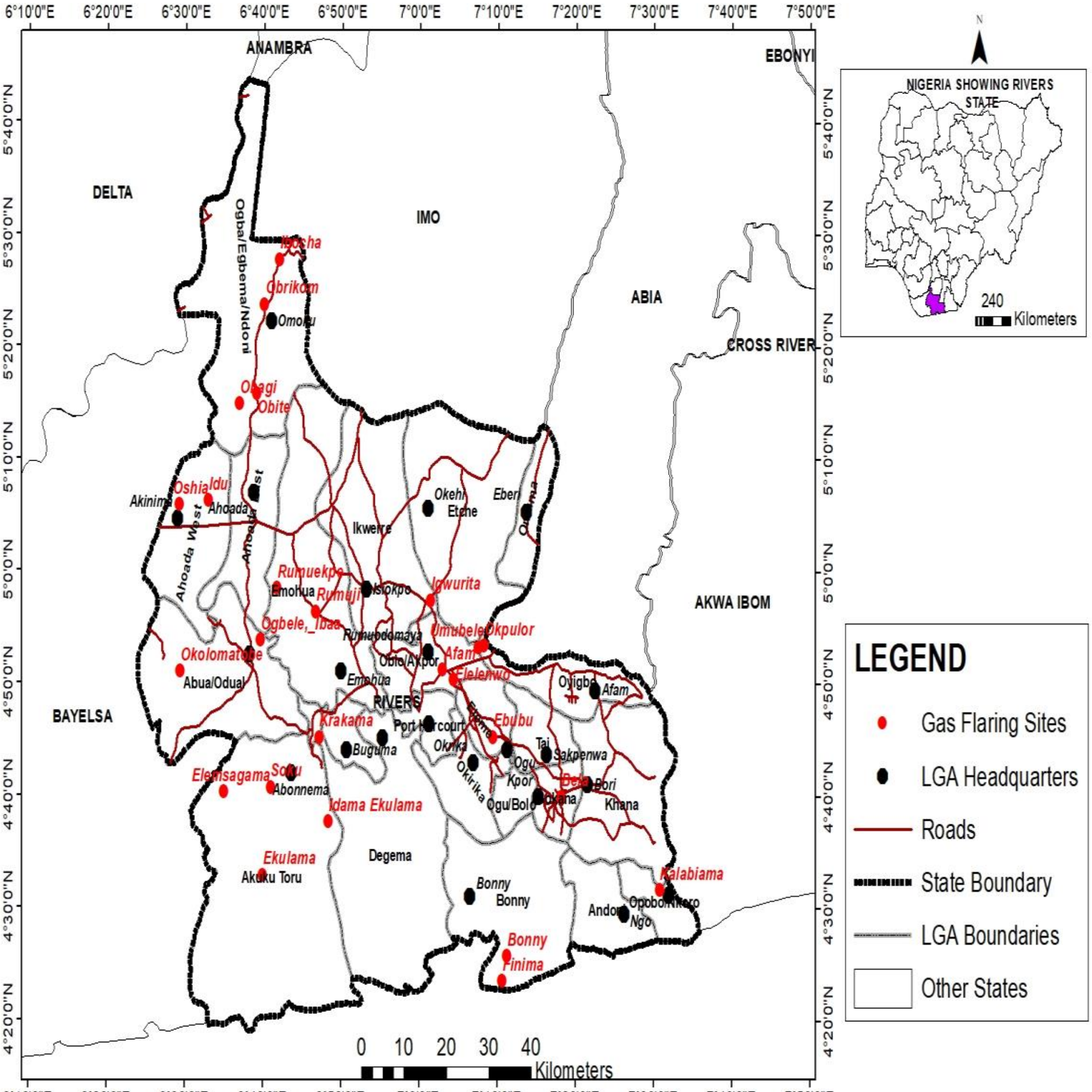

Figure 2: Distribution of Gas Flaring Sites in Rivers State
Source: Researcher's Analysis (2023)

Atmospheric pollutants as influenced by gas flare sites

The spatial distribution of the overall mean atmospheric pollutant concentrations and weather parameters as influenced by gas flaring sites during the wet season is displayed on Table 2. The results revealed that the highest mean values of temperature was 33.1 ^{0}C around Obite gas flaring site while the lowest of 29 ^{0}C was recorded around the Idu gas flaring station. Relative humidity (%) in the study area among sampled gas flaring stations ranged between the lowest of 77.3% in Ebubu gas flaring site and the highest of 89.0% in Oshie gas flaring sampling station. The most common wind speed mean value experienced during air quality sampling in the study area was 2.3 m/s. However, wind speed is one of the major factors determining the dispersion of pollutants and the results revealed that wind speed was generally stable across the gas flaring sampling stations. The concentration of CO (ppm) among gas flaring stations also varied showing higher mean concentration values of 15.0 ppm, 14.0 ppm, 13.0 ppm and 13.0 ppm in Elelenwo, Oshia, Obagi, Kalibiama respectively; and the lowest mean concentration values of 7.7 ppm, 8.0 ppm, 8.3 ppm, 8.7 ppm, 8.7 ppm and 8.7 ppm in Ogbele, Obrikom, Elemsagama, Okolomatobe, Idu and Okpulo gas flaring stations respectively. The concentration values of NO_2 ranged between 0.3 ppm and 1.1 ppm and for SO_2 the mean concentration values ranged between 0.4 ppm and 0.7 ppm. Generally, the mean concentration values of VOC (ppm) was between the lowest mean concentration value of 207.3 ppm in Krakama gas flaring station and highest mean concentration value of 504 ppm at the Igwurita gas flaring station. The mean concentration values of Methane (CH_4) (ppm) ranged between 32.7 ppm at the Okpulo gas flaring station and 358 ppm at the Elelenwo gas flaring station. Thus, mean concentration value recorded for CH_4 of 358.3 ppm at the Elelenwo gas flaring station was the highest in the study area.

The spatial distribution of the overall mean atmospheric pollutant concentrations and weather parameters as influenced by gas flaring sites during the dry season is displayed on Table 3. The results revealed that the highest mean values of temperature was 33.1 ^{0}C around Rumuji gas flaring site while the lowest of 29.5 ^{0}C was recorded around the Idu gas flaring station. Relative humidity (%) in the study area among sampled gas flaring stations ranged between the lowest of 69.3% in Obite gas flaring site and the highest of 78.6% at the Kalibiama gas flaring sampling station. The mean value of wind speed ranged between the lowest of 0.5 m/s and highest of 2.6 m/s. However, wind speed is one of the major factors determining the dispersion of pollutants and the results revealed that wind speed was generally stable across the gas flaring sampling stations during the dry season. The concentration of CO (ppm) among gas flaring stations also varied showing the highest mean concentration value of 20.0 ppm at the Elelenwo gas flaring station and the lowest mean concentration value of 8.0 ppm at the Okolomatobe gas flaring stations. The concentration values of NO_2 ranged between 0.5 ppm and 1.1 ppm and for SO_2 the mean concentration values ranged between 0.4 ppm and 0.9 ppm. The mean concentration values of NO_2 and SO_2 was slightly higher during the dry season when compared with the wet season. The mean concentration values of VOC (ppm) was between the lowest mean concentration value of 233.3 ppm in Ekniama gas flaring station and highest mean concentration value of 433.3 ppm at the Rumuekpe gas flaring station. The mean concentration values of Methane (CH_4) (ppm) ranged between 43.3 ppm at the Ogbele gas flaring station and 274 ppm at the Elelenwo gas flaring station. Thus, mean concentration value recorded for CH_4 of 274 ppm at the Elelenwo gas flaring station was the highest in the study area during the dry season.

Table 2: Mean Concentrations of Air Quality Parameters as Influenced by Gas Flare Sites (Wet Season)

S/N	Communities	CO (ppm)	NO_2(ppm)	SO_2(ppm)	VOC(ppm)	CH_4(ppm)	Temp	RH (%)	WS (m/s)
1	Obrikom	8.0	0.6	0.5	340.3	69.7	32.0	78.9	1.2
2	Obite	11.3	0.5	0.5	373.3	94.0	33.1	82.5	1.5
3	Rumuji	11.3	0.9	0.6	429.3	153.3	32.0	80.7	1.4
4	Rumuekpe	12.0	0.5	0.5	374.3	59.3	29.1	82.9	1.3
5	Ebubu	10.3	1.1	0.5	317.0	52.7	31.2	77.3	1.9
6	Idu	8.7	0.7	0.6	294.7	55.0	29.0	81.0	1.6
7	Igwurita	12.3	0.9	0.8	504.0	135.3	30.0	81.7	1.8
8	Ibocha	13.3	1.1	0.6	356.0	104.7	30.5	81.6	0.9
9	Idama Ekulama	10.0	0.7	0.5	271.7	37.7	29.2	85.2	2.1
10	Soku	9.3	0.6	0.6	283.0	62.7	30.7	84.4	1.4
11	Eknlama	9.0	0.5	0.5	291.3	37.3	29.6	84.9	1.1
12	Elemsagama	8.3	0.5	0.4	236.7	44.3	29.9	84.3	2.1
13	Oshia	14.0	0.4	0.5	340.7	76.7	31.3	89.0	1.9
14	Obagi	13.0	0.5	0.6	267.7	64.7	29.3	88.0	1.5
15	Bela	11.3	0.5	0.5	212.0	37.7	30.0	83.2	1.7
16	Krakama	10	0.6	0.5	207.3	46.7	30.5	83.9	2.3
17	Bonny	12.3	1.1	0.7	447.3	244.0	29.2	87.8	1.8
18	Kalibiama	13.0	0.5	0.4	279.7	147.3	31.9	83.6	1.7
19	Finima	10.0	0.5	0.6	347.7	71.7	29.9	82.1	2.3
20	Okolomatobe	8.7	0.4	0.4	239.7	58.0	30.2	85.7	2.3
21	Umubele	9.0	0.3	0.5	262.0	44.7	30.7	87.0	1.7
22	Ogbele	7.7	0.5	0.5	284.0	37.7	31.6	86.3	2.3
23	Okpulo	8.7	0.6	0.5	218.0	32.7	29.9	80.4	1.9
24	Elelenwo	15.0	0.9	0.7	477.0	358.3	29.8	79.0	2.7
25	Afam	11.0	0.7	0.5	391.0	123.7	29.8	82.8	2.0

Table 3: Mean Concentrations of Air Quality Parameters as Influenced by Gas Flare Sites (Dry Season)

S/N	Communities	CO (ppm)	NO_2(ppm)	SO_2(ppm)	VOC(ppm)	CH_4(ppm)	Temp	RH (%)	WS (m/s)
1	Obrikom	11.3	0.7	0.5	410.7	44.3	32.3	74.7	1.8
2	Obite	8.7	0.7	0.5	359.7	126.3	31.4	69.3	1.5
3	Rumuji	15.0	1.0	0.7	430.3	167.0	33.1	77.2	1.6
4	Rumuekpe	19.3	0.6	0.6	433.3	61.7	29.9	76.4	1.7
5	Ebubu	12.7	1.1	0.4	372.3	66.7	31.9	72.6	1.4
6	Idu	16.7	0.9	0.6	407.0	58.3	29.5	77.4	2.1
7	Igwurita	12.0	0.7	0.6	314.3	239.3	30.7	77.8	1.4
8	Ibocha	12.0	0.8	0.6	374.0	72.7	32.0	75.1	2.1
9	Idama Ekulama	15.7	0.7	0.8	346.0	92.3	31.1	77.1	1.9
10	Soku	16.3	0.9	0.8	325.7	81.3	32.0	76.7	2.6
11	Ekulama	11.3	0.5	0.5	233.3	44.3	31.8	74.9	1.1
12	Elemsagama	10.3	0.5	0.6	294.3	79.7	30.6	73.2	0.5
13	Oshia	12.7	0.5	0.4	392.0	123.3	32.4	76.1	1.3
14	Obagi	14.0	0.9	0.4	360.0	120.0	30.4	77.5	1.0
15	Bela	14.3	0.6	0.6	302.0	49.3	30.2	70.8	0.9
16	Krakama	13.3	0.7	0.4	252.3	49.7	30.6	75.3	1.3
17	Bonny	18.0	1.1	0.9	403.3	226.0	29.9	75.6	1.0
18	Kalibiama	13.3	0.5	0.4	313.0	72.3	32.9	78.6	0.7
19	Finima	10.7	0.5	0.6	305.2	60.7	31.2	75.2	0.9
20	Okolomatobe	8.0	0.6	0.3	254.7	56.7	30.4	72.4	1.1
21	Umubele	8.7	0.5	0.6	266.7	52.3	31.3	76.1	0.8
22	Ogbele	9.0	0.7	0.5	264.7	43.3	31.1	77.2	0.7
23	Okpulo	9.3	0.7	0.8	234.3	57.7	30.3	77.9	1.1
24	Elelenwo	20.0	1.3	0.8	418.0	274.0	31.3	79.4	0.8
25	Afam	15.3	0.7	0.6	389.0	127.7	31.6	73.1	1.2

III. Discussion

Findings of the study revealed that mean concentrations of CO, CH_4 and VOC were relatively high across gas flaring sites. However, higher readings were observed during the dry season period. Thus, gas flaring sites have influenced air quality in the communities; and these observed concentrations are further influenced by the activities surrounding the gas flare sites. For instance, Elelenwo is an area that is surrounded by several socio-economic activities which may have influenced the higher concentration of CO, VOC and CH_4 when compared with other gas flaring sites. This finding corroborates with the findings of United Nations Environmental Protection (UNEP) (2020) which is an initiative for Climate and Clean Air Coalition 2020 discovered that flaring emits black carbon, methane, and volatile organic compounds. Black carbon and methane are both powerful climate forcers and black carbon and VOCs are dangerous air pollutants. This was why according to the United States Environmental Protection Agency (USEPA) (2019) it was stated that flaring is a high-temperature oxidation process used to burn waste gases containing combustible components such as volatile organic compounds (VOCs), natural gas (or methane), carbon monoxide (CO), and hydrogen (H_2). The waste gases are piped to a remote, usually elevated location, and burned in an open flame in ambient air using a specially designed burner tip, auxiliary fuel, and, in some cases, assist gases like steam or air to promote mixing for nearly complete (e.g., $\geq$ 98%) destruction of the combustible components in the waste gas.

IV. Conclusion and Recommendation

The study concludes that gas flaring has impacted on air quality in the study area. The results showed high mean concentration values for CO, CH_4, and VOCs which have several health implications especially on residents in close proximity. The study therefore recommended that: that the government should enact laws that will checkmate gas flaring activities in the study area; the government can aid residents in terms of creating awareness as it concerns the pollutants distribution and the dry season which propels much of the pollutants in order to have adequate preparedness physically, economically and socially; stricter laws should be directed towards oil multinationals and their oil explorative activities in order to reduce its environmental pollution.

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