ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/25apr327

Spatio-Temporal Analysis of Air Quality within the Circumference of Flared Pollutant Areas in Rivers and Bayelsa States, Nigeria

Imiete, Godspower[1]; Kpang, MeeluBari Barinua Tsaro[2]

[1]Department of Environmental Management, Faculty of Environmental Sciences, Rivers State University, Nkpolu-Oroworukwo, Port Harcourt, Nigeria
[2] Department of Geography and Environmental Management, Faculty of Social Sciences, University of Port Harcourt, Port Harcourt, Nigeria
*Corresponding Author: Kpang, MeeluBari Barinua Tsaro

Publication Date: 2025/05/28

Abstract: Oil and gas exploration is characterized with release of gases, particulates and other wastes in the form of gas flaring which have significant consequences on both humans and the environment. Gas flaring contributes to contamination and deterioration of the air quality of surrounding areas. Therefore, this study focuses on examining the spatial variation of air quality in the vicinity of gas flared areas in Rivers and Bayelsa States. The experimental research design was adopted while the data for this study was sourced principally from primary source particularly air quality parameters recorded at various sampled locations The data were analyzed using Analysis of Variance (ANOVA); and one sample t- test. The volume of pollutants at different times of the day shows significant reduction in its concentration with respect to distance from the flare sites at P<0.05. ANOVA also revealed that the spatial variation for gases in the two states under investigation was significant at the P<0.05 (CO- F=08.1310, sig = 0.00; NO_x- F=09.0114, sig = 0.02; O_3-F=06.0114, sig = 0.05; SO_2-F=1.0211, sig = 0.21; CH_4- F=06.1321, sig = 0.23; VOC- F= 17.2131, sig = 0.03; H_2S -F=09.3112, sig = 0.01; $PM_{2.5}$- F=12.8230, sig = 0.00).The one sample t test showed that there is a significant difference between pollutants measured and WHO standards at p<0.05 in both states. Consequently, periodic air quality monitoring and reporting, strict adherence to air quality standards, enforcement of regulatory thresholds and adoption of environmentally friendly technologies were recommended.

Keywords*: Air Quality, Monitoring, Variation, Pollutants, Standards.*

How to Cite: Imiete, Godspower; Kpang, MeeluBari Barinua Tsaro (2025) Spatio-Temporal Analysis of Air Quality within the Circumference of Flared Pollutant Areas in Rivers and Bayelsa States, Nigeria. *International Journal of Innovative Science and Research Technology*, 10(4), 4322-4330. https://doi.org/10.38124/ijisrt/25apr327

I. INTRODUCTION

Gas flaring can be defined as the steady discharge of gaseous fuel into the atmosphere during petroleum exploration activities (Ansa & Akinrotimi, 2018). It is also said to be the process of burning-off the gas found in, or mixed with crude oil. Gas flaring occurs because it is costly to separate associated gas from the oil and some oil companies burn the gas directly from pits while others construct flare stacks. The flares often contain as many as 250 different toxins, and emit particulate matter. Exploration of oil and gas has been steadily increasing for more than four decades within the Niger Delta and has contributed immensely to the continuous production and release of wastes in the form of liquid, solid and gas into the environment. Burning of natural gas associated with oil extraction takes place because of technical, regulatory, and/or economic constraints. This causes more than 350 million tons of CO_2 emissions every year, with serious harmful impacts from methane that has not been combusted and black carbon emissions (World Bank, 2018). Flaring of gases associated with exploration and production processes contributes to the waste generated. Meanwhile, satellite data projections from the World Bank show that global gas flaring have risen to 150 billion cubic metres compared to the levels seen in 2009. Furthermore, gas flaring in the Niger Delta has resulted in thermal radiation, flue gas dispersion and emissions producing considerable amounts of air pollutants over the past 50 years. Flaring and venting of associated gas in the area contributes

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/25apr327

approximately 35 million metric tons of CO_2 per year, CH_4, a large number of hydrocarbons and other forms of GHGs into the atmosphere and because of the low burning efficiency of the flares, a significant percentage of the associated gas released is CH_4 that has a high global warming potential (Ite & Ibok, 2013b).

Gas flaring has made communities poor and there is increased mortality rate, with attendant environmental, economic and health difficulties, which are sufficient justifications for ending gas flaring (Ajugwo, 2013). Gas flaring contaminates water and food and causes ill-health, environmental degradation and displacement of people from their ancestral homes (Okotie, 2018). Furthermore, gas flaring impacts negatively on terrestrial ecosystems with particular emphasis on plant growth and development as it emits air pollutants such as oxides of nitrogen, carbon and sulphur. These pollutants are responsible for increase in soil acidity leading to mangrove swamps and salt marshes destruction, reduction in growth of some plants as well as soil degradation and declining agricultural productivity ((Ajugwo, 2013). Gas flaring is often characterized with the release of gases, particulates, noise and heat, which have adversely affected both the humans and the environment. This leads to substantial contamination and deterioration of the air quality, water and land and the flora inhabiting these biomes (Egwurugwu, Nwafor, & Ezekwe, 2013). It is against this background that this study intends to comparatively assess the air quality in the vicinity of gas flared pollutants in Rivers and Bayelsa states.

II. MATERIALS AND METHODS

The study was carried out in Rivers and Bayelsa States, Niger Delta region. Rivers State has a population of 5,185,420 with a landmass of 10,378 km^2 while Bayelsa State has a population of 1, 703, 358 with a landmass of 11,007 km^2 (NPC, 2006). Rivers State boarders Imo and Abia State to the north, Akwa-Ibom State to the East and Bayelsa and Delta States to the West whereas Bayelsa State shares boundary with Rivers State to the East and Delta State to the West, with the waters of the Atlantic Ocean dominating its southern boarders. Rivers and Bayelsa states in the Niger Delta falls within the tropical rainforest climate or the equatorial monsoon, designated by the Koppen climate classification as "Af" which is influenced by the monsoon running from the South Atlantic Ocean, (maritime tropical) air mass, a warm moist sea to land seasonal wind. It also has warm and high humidity characteristics which gives it a strong propensity to rise and produce abundant rainfall as an evidence of the condensation of water vapour in the swiftly rising air (Ayoade, 2004). The data used in this study were sourced from both primary and secondary sources. Two gas flare points were purposively selected and pollutants measured during the climatological hours of 00:00hrs, 06:00hrs, 12:00hrs and 18:00hrs using the multi gas detector to assess the level of spatial spread across the areas. The concentrations of the pollutants were obtained at 200m, 400m, 600m, 800m, 1000m and 2000m away from the gas flaring sites in the study areas to ensure spatial coverage and avoid point specific measurement in consonance with WHO (2005) cited in Weli, Kpang & Adegoke (2016) as shown in Figure 1and 2. The gases were measured in parts per million (ppm) while SPM was measured directly in microgram per cubic meters (ug/m^3).

The ANOVA and one sample t- test statistical techniques were employed for the analyses. The mathematical formula for ANOVA is given by the formula below (Akuezuilo & Agu, 2002):

$$\text{TES} = \sum x^2 - \frac{(\sum x)^2}{N} \quad \text{---- ---- ----} \quad 1$$

$$\text{ESS} = \frac{(\sum x_1)^2}{n_1} + \frac{(\sum x_2)^2}{n_2} + \frac{(\sum x_3)^2}{n_3} + \frac{(\sum x_4)^2}{n_4} - \frac{(\sum x)^2}{N} \ldots\ldots \quad 2$$

$$\text{WSS} = \text{TSS} - \text{BSS} \quad \text{---- ----} \quad 3$$

Where:

- TSS = Total Sum of Squares
- BSS = Between Sample Sum of Squares
- WSS = Within Sample Sum of Squares
- $n_1 \ldots n_3$ = Number of Samples means being compared
- N = Total items of all groups

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/25apr327

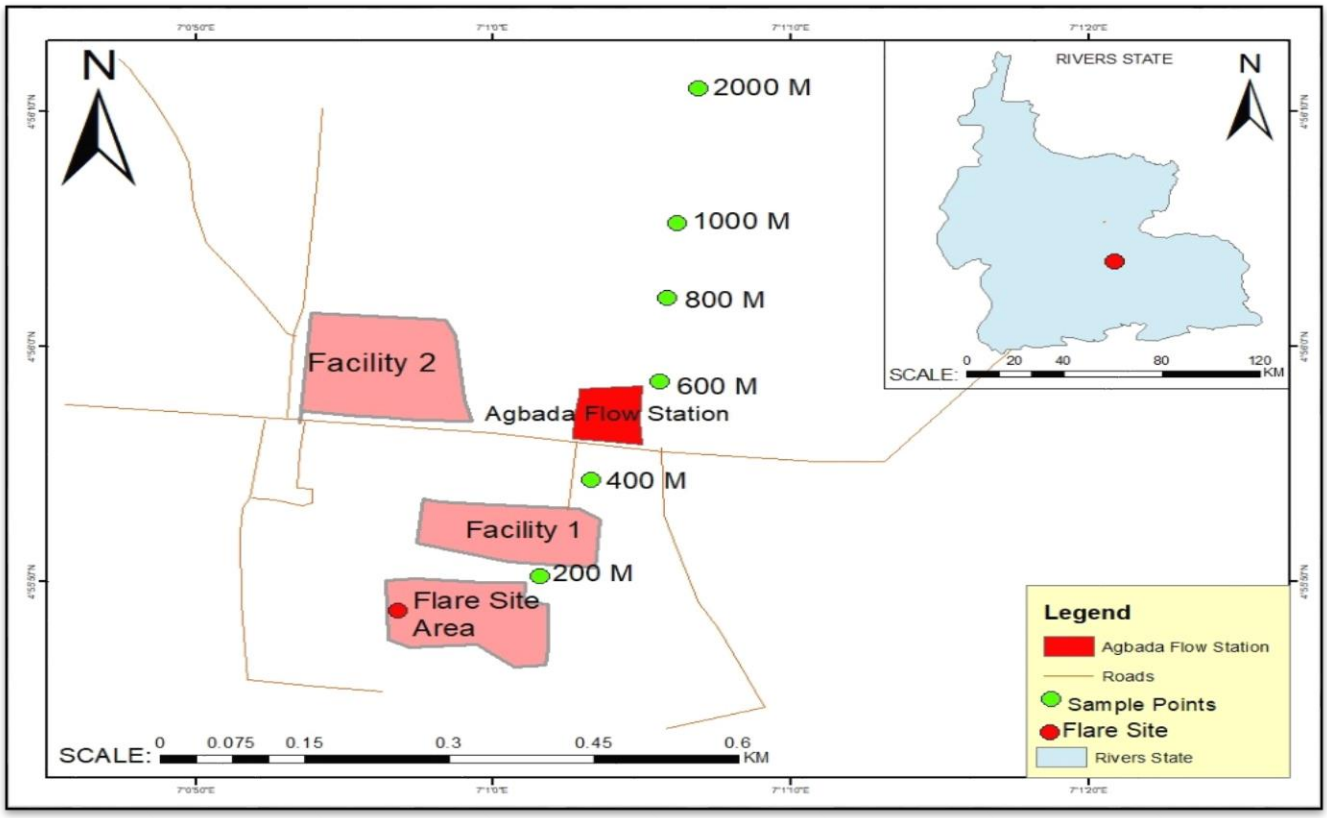

Fig 1: Sampling Points around Study area in Rivers State

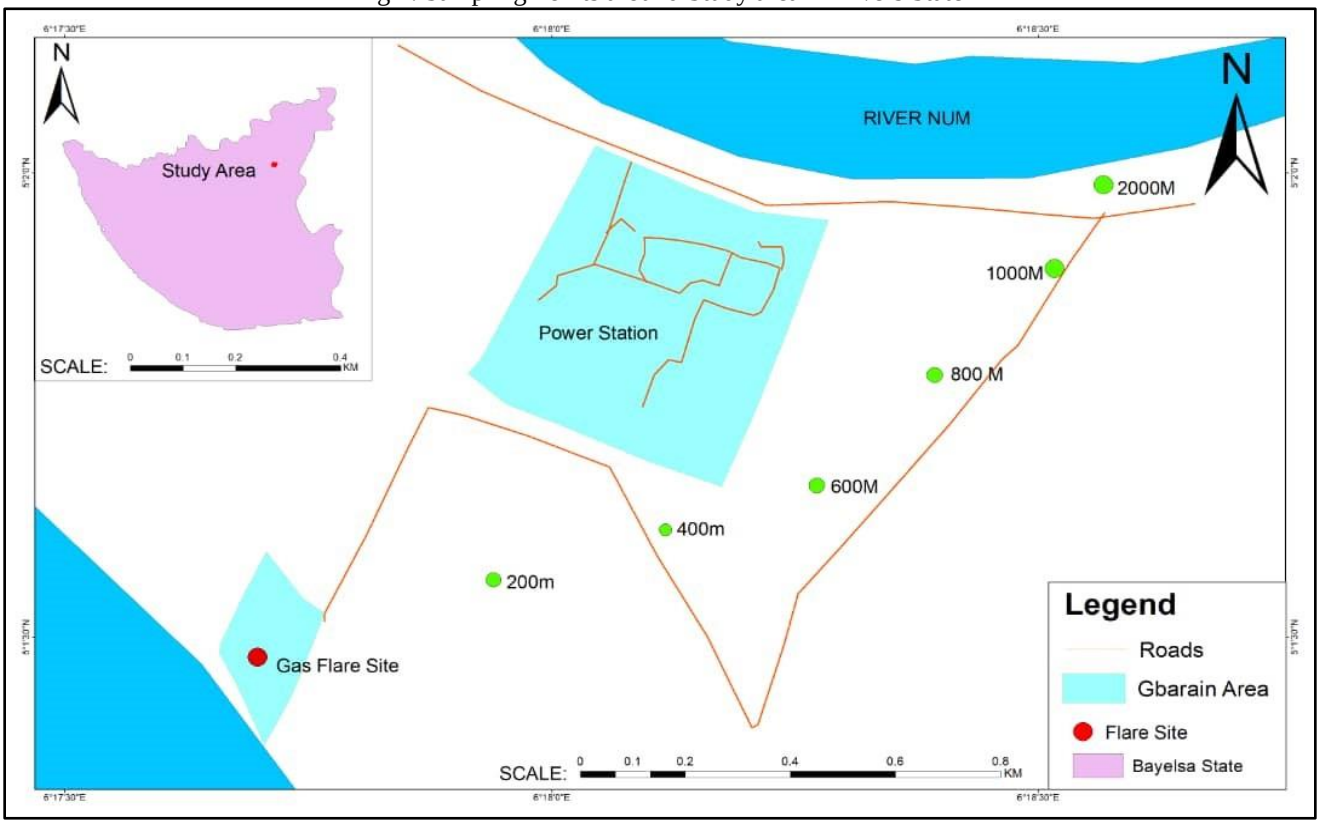

Fig 2: Sampling Points around Study area in Bayelsa State

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/25apr327

Table 1: Pollutant Volumes at Different Times of the Day in Rivers and Bayelsa States

Location	Time of day	CO (PPM)	NO_2 (PPM)	O_3 (PPM)	SO_2 (PPM)	$PM_{2.5}$ (µg/m3)	CH_4 (PPM)	VOC (PPM)	H_2S (PPM)
Rivers	Morning	205.17	199.63	172.73	0.10	107.18	156.13	18.67	3.63
	Afternoon	274.43	228.50	185.83	0.40	131.68	168.77	21.70	5.01
	Evening	253.50	196.40	163.70	0.10	106.00	170.66	20.24	4.40
Bayelsa	**Time of day**	**CO (PPM)**	**NO_2 (PPM)**	**O_3 (PPM)**	**SO_2 (PPM)**	**$PM_{2.5}$ (µg/m^3)**	**CH_4 (PPM)**	**VOC (PPM)**	**H_2S (PPM)**
	Morning	205.17	196.13	177.73	0.10	99.18	161.13	20.67	3.63
	Afternoon	266.13	219.70	189.53	0.10	114.38	176.47	21.90	4.41
	Evening	251.50	194.90	168.70	0.10	102.00	175.66	21.24	4.30

The data presented in Table 1 show the concentration of atmospheric pollutant at different time of the day from gas flaring stations in both Rivers state and Bayelsa states. The Table shows that there is variation in the volume of pollutants in the morning, afternoon and evening. The volume of carbon monoxide in the morning is 205.17ppm, afternoon 274.43ppm and evening is 253.50ppm. It is evident that there is a significant increase in the volume of carbon monoxide in the afternoon which can be adduced to the influence of weather characteristics. The case of ozone show that the volume in the morning is 172.73ppm, afternoon is 185.83ppm and evening is 163.70ppm which is also a replication of the pattern of concentration of other pollutants except methane that show higher concentration in the evening, with only slight variation between the morning, afternoon and evening concentration in the Rivers state. On the other hand, the Table also clearly revealed that there is a significant variation in the volume of $PM_{2.5}$ between the morning hours (99.19ppm), the afternoon hours (114.38) and evening hours (102.00ppm). Evidently, the volume of $PM_{2.5}$ is higher in the afternoon than what is experienced in the morning and in the evening in Bayelsa state. The concentration of Sulphur oxide did not show significant variation across different time of the day with 0.10ppm in the morning, afternoon and evening hours. There is a slight difference between the volume of hydrogen sulphide in the morning (3.63ppm) and in the afternoon (4.41ppm) and evening (4.31), but the volume of hydrogen sulphide in the afternoon is also higher than other time in the day. The case of nitrogen oxide also shows that the volume in the afternoon is higher with 196.33ppm in the morning, 219.70ppm in the afternoon and 194.90ppm in the evening.

Table 2: Analysis of Pollutants Variation at Different Times of the Day in Rivers State

Gas	T	Df	sig	Test value	Decision
	Morning				
CO	205.17	29	.000	4 (ppm)	Accept H_1
O_3	172.73	29	.000	60 (PPM)	Accept H_1
NO_2	199.63	29	.000	10 (PPM)	Accept H_1
SO_2	0.1	29	.000	40 (PPM)	Accept H_1
VOC	18.67	29	.000	0.5 (PPM)	Accept H_1
$PM_{2.5}$	107.18	29	.000	15 (µg/m^3)	Accept H_1

Methane and H_2S are not captured in the WHO AQG (2021)

The outcome of student t-test presented in Table 2 show the difference between the concentrations of pollutants in Port-Harcourt in the morning hours. The table shows variation in the volume of CO, O_3, NO_2, SO_2, VOC and $PM_{2.5}$ with the sig of 0.000 for all the pollutants. The implication is that the alternate hypothesis which states that there is significant variation between the concentration of pollutants from gas flaring sites and the World Health Organization standards is accepted for all the pollutants.

Table 3: Analysis of Pollutants Variation at Different Times of the Day in Rivers State

Gas	T	Df	sig	Test value	Decision
	Afternoon				
CO	274.43	29	.000	4 (ppm)	Accept H_1
O_3	185.83	29	.000	60 (PPM)	Accept H_1
NO_2	228.5	29	.000	10 (PPM)	Accept H_1
SO_2	0.4	29	.000	40 (PPM)	Accept H_1
VOC	21.7	29	.000	0.5 (PPM)	Accept H_1
$PM_{2.5}$	131.68	29	.000	15 (µg/m^3)	Accept H_1

Methane and H_2S are not captured in the WHO AQG (2021)

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/25apr327

The outcome of student t-test presented in Table 3 show the difference between the concentrations of pollutants in Port-Harcourt in the afternoon hours. The table shows variation in the volume of CO, O_3, NO_2, SO_2, VOC and $PM_{2.5}$ with the sig of 0.000 for all the pollutants. The implication is that the alternate hypothesis which states that there is significant variation between the concentration of pollutants from gas flaring sites and the World Health Organization standard is accepted for all the pollutants.

Table 4: Analysis of Pollutants Variation at Different Times of the Day in Rivers State

Gas	T	Df	Sig	Test value	Decision
	Evening				
CO	253.5	29	.000	4 (ppm)	Accept H_1
O_3	163.7	29	.000	60 (PPM)	Accept H_1
NO_2	196.4	29	.000	10 (PPM)	Accept H_1
SO_2	0.1	29	.000	40 (PPM)	Accept H_1
VOC	20.24	29	.000	0.5 (PPM)	Accept H_1
$PM_{2.5}$	106	29	.000	15 ($\mu g/m^3$)	Accept H_1

Methane and H_2S are not captured in the WHO AQG (2021)

The outcome of student t-test presented in Table 4 show the difference between the concentrations of pollutants in Port-Harcourt in the evening hours. The table shows variation in the volume of CO, 0_3, NO_2, SO_2, VOC and $PM_{2.5}$ with the sig of 0.000 for all the pollutants. The implication is that the alternate hypothesis which states that there is significant variation between the concentration of pollutants from gas flaring sites and the World Health Organization standards is accepted for all the pollutants.

Table 5: Analysis of Pollutants Variation at Different Times of the Day in Bayelsa State

Gas	T	Df	Sig	Test value	Decision
	Morning				
CO	205.17	29	.000	4 (ppm)	Accept H_1
O_3	177.73	29	.000	60 (PPM)	Accept H_1
NO_2	196.13	29	.000	10 (PPM)	Accept H_1
SO_2	0.1	29	.000	40 (PPM)	Accept H_1
VOC	20.67	29	.000	0.5 (PPM)	Accept H_1
$PM_{2.5}$	99.18	29	.000	15 ($\mu g/m^3$)	Accept H_1

Methane and H_2S are not captured in the WHO AQG (2021)

The outcome of student t-test presented in table 5 show the difference between the concentrations of pollutants in Bayelsa state in the morning hours. The table shows variation in the volume of C0, 0_3, NO_2, SO_2, VOC and $PM_{2.5}$ with the sig of 0.000 for all the pollutants. The implication is that the alternate hypothesis which states that there is significant variation between the concentration of pollutants from gas flaring sites and the World Health Organization standards is accepted for all the pollutants.

Table 6: Analysis of Pollutants Variation at Different Times of the Day in Bayelsa State

Gas	T	Df	Sig	Test value	Decision
	Afternoon				
CO	266.13	29	.000	4 (ppm)	Accept H_1
O_3	189.53	29	.000	60 (PPM)	Accept H_1
NO_2	219.7	29	.000	10 (PPM)	Accept H_1
SO_2	0.1	29	.000	40 (PPM)	Accept H_1
VOC	21.9	29	.000	0.5 (PPM)	Accept H_1
$PM_{2.5}$	114.38	29	.000	15 ($\mu g/m^3$)	Accept H_1

Methane and H_2S are not captured in the WHO AQG (2021)

The outcome of student t-test presented in Table 6 show the difference between the concentrations of pollutants in Bayelsa State in the afternoon hours. The table shows variation in the volume of C0, 0_3, NO_2, SO_2, VOC and $PM_{2.5}$ with the sig of 0.000 for all the pollutants. The implication is that the alternate hypothesis which states that there is significant variation between the concentration of pollutants from gas flaring sites and the World Health Organization standards is accepted for all the pollutants.

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/25apr327

Table 7: Analysis of Pollutants Variation at Different Times of the Day in Bayelsa State

Gas	T	Df	Sig	Test value	Decision
	Evening				
CO	251.5	29	.000	4 (ppm)	Accept H_1
O_3	168.7	29	.000	60 (PPM)	Accept H_1
NO_2	194.9	29	.000	10 (PPM)	Accept H_1
SO_2	0.1	29	.000	40 (PPM)	Accept H_1
VOC	21.24	29	.000	0.5 (PPM)	Accept H_1
$PM_{2.5}$	102	29	.000	15 ($\mu g/m^3$)	Accept H_1

Methane and H_2S are not captured in the WHO AQG (2021)

The outcome of student t-test presented in table 7 show the difference between the concentrations of pollutants in Bayelsa state in the evening hours. The table shows variation in the volume of CO, O_3, NO_2, SO_2, VOC and $PM_{2.5}$ with the sig of 0.000 for all the pollutants. The implication is that the alternate hypothesis which states that there is significant variation between the concentration of pollutants from gas flaring sites and the World Health Organization standards is accepted for all the pollutants.

Table 8: Spatial Distribution of Pollutants at Various Distances from the Flared Sites in Rivers and Bayelsa States

Location	Distance	CO (PPM)	NO_2 (PPM)	O_3 (PPM)	SO_2 (PPM)	$PM_{2.5}$ ($\mu g/m^3$)	CH_4 (PPM)	VOC (PPM)	H_2S (PPM)
Rivers	200	273.93	218.97	188.43	0.10	125.47	184.59	34.03	4.71
	400	259.60	213.63	181.77	0.10	120.17	175.25	25.33	4.51
	600	246.27	208.97	175.43	0.10	114.50	166.92	17.55	4.38
	800	235.60	205.63	170.77	0.10	110.50	160.25	14.91	4.25
	1000	228.60	202.30	166.10	0.10	109.67	154.59	13.72	3.81
	2000	221.60	198.97	161.43	0.10	108.83	148.92	15.07	3.81
Bayelsa	Distance	CO (PPM)	NO_2 (PPM)	O_3 (PPM)	SO_2 (PPM)	$PM_{2.5}$ ($\mu g/m^3$)	CH_4 (PPM)	VOC (PPM)	H_2S (PPM)
	200	272.60	216.47	195.10	0.10	117.80	192.59	37.20	4.58
	400	258.27	211.13	188.43	0.10	112.50	183.25	28.50	4.38
	600	244.93	206.47	182.10	0.10	106.83	174.92	20.71	4.25
	800	234.27	203.13	177.43	0.10	102.83	168.25	18.07	4.11
	1000	227.27	199.80	172.77	0.10	102.00	162.59	16.89	3.68
	2000	220.27	196.47	168.10	0.10	101.17	156.92	18.23	3.68

The data presented in Table 8 show the variation in the volume of pollutant across different proximate intervals from gas flaring sites in Rivers and Bayelsa States. The data show that there is a significant reduction with distance from the flare sites. That is the volume of pollutant reduces as you move away from the bund wall of the flare sites. The case of carbon monoxide in Rivers state shows 273.93ppm at 200m, 259.60 at 400m, 246.27ppm at 600m, 235.60ppm at 800m, 228.60ppm at 1000 and 221.60ppm at 2000m. The margin between the volume of carbon monoxide at point 200m and point 2000m is 52.33ppm reduction in volume which is substantial. The case of Sulphur oxide showed uniform concentration across different intervals from the flare point with 0.10ppm in River state. But evidently, the table show that the concentrations of all the other pollutants (NO_2, O_3, $PM_{2.5}$, CH_4, VOC and H_2S) show gradual reduction in concentration as the distance from the flare point increases. The pattern of concentration in Rivers State is slightly different in Bayelsa State where the concentration of volatile organic compound show 37.20ppm at 200m, 28.50ppm at 400m, 20.71ppm at 600m, 18.07ppm at 800mm, a slight reduction to 16.89ppm at 1000m, and increase to 18.23ppm at 2000m.

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/25apr327

Table 9: ANOVA Summary of the Spatial Variation in Atmospheric Pollutants Across the Study Area

Pollutants	Mean values		F-values	Sig
	Rivers	Bayelsa		
CO (PPM)	244.2667	242.9333	08.1310	*0.00
NO_2 (PPM)	208.0778	205.5778	09.0114	*0.02
O_3 (PPM)	173.9889	180.6556	06.2114	*0.05
SO_2 (PPM)	0.1000	0.1000	1.0211	0.21
CH_4 (PPM)	114.8556	107.1889	06.1321	0.23
VOC (PPM)	165.0867	173.0867	17.2131	*0.03
H_2S	20.1011	23.2678	09.3112	*0.01
$PM_{2.5}$ ($\mu g/m^3$)	4.2467	4.1133	12.8230	*0.00
**significant at 5% alpha level, n=30				

The data presented in Table 9 show the outcome of analysis of variance on the variation in the concentration of pollutants between Bayelsa and Rivers state. ANOVA show that the mean difference for carbon monoxide is between the two sampled states is significant at the $P<0.05$level. F=08.1310, sig = 0.00. Since the significant value is 0.00 which is below 0.05 (*p* value), it indicates that there is a statistically significant difference in the spatial variation in carbon monoxide in the two states under investigation at different gas flaring locations. The concentration of nitrogen oxide show statistical significant variation F=09.0114, sig = 0.02, ozone F=06.0114, sig = 0.05, Sulphur oxide did not show variation across the sampled locations in the two states (F=1.0211, sig = 0.21), this is because the outcome of the ANOVA analysis which is 0.21 is above the p value of 0.05. The concentration of methane show that there is no variation F=06.1321, sig = 0.23 which is also above the p value of 0.05, the concentration of volatile organic compound show that there is a significant variation F= 17.2131, sig = 0.03 which is below the p value thus reflect statistically significant variation. Hydrogen sulphide show F=09.3112, sig = 0.01 shows that a statistically significant variation exist since the outcome 0.01 is less than the p value. The concentration of $PM_{2.5}$ also show there is a significant variation F=12.8230, sig = 0.00.

III. DISCUSSION OF RESULTS

This study found that there is a significant variation in the concentration of pollutants around gas flaring communities in the morning, afternoon and evening. The data collected and analyzed in Bayelsa and Rivers state show that the amount of carbon monoxide, ozone, sulphur oxide, nitrogen oxide, $PM_{2.5}$, and hydrogen sulphide is higher in the afternoon hours and lower in the morning and in the evening hours. However, the concentrations of pollutant at all time of the day show severe consequences for the environment with attendant public health effects. Previous studies have adduced the variation of air pollutants in different time of the day to the influences of meteorological parameters such as temperature and relative humidity (Odjugo, 2008). While the flaring of gases in the oil and gas producing states have remained constant for decades since the commercial exploitation and processing of crude oil, this study reported disparity in air quality at different time of the day. Obi et al. (2021) contend that levels of air pollution from different sources reduce in the morning because of lower temperature, and the air temperature is cooler, denser with oxygen. They also argue that people feel less discomfort in the morning around gas flaring communities than in the evening. Other reports have added that the reduced industrial activities in the night also manifest in cleaner air in communities close to the source of the pollution, but this theory on lower level of temperature as a result of reduced industrial activities does not fully agree with the pattern of gas flaring that is nonstop. Perception studies in vulnerable communities carried out in the Niger Delta region have reported that the rate of flaring gas does not reduce in the night, and the light is seen from different locations which are also very disturbing. Gobo, Richard & Ubong (2009), added that relative humidity is also very critical in the differences seen in the quality of air in the morning, afternoon and evening hours, they argue that in many regions of the world, relative humidity tend to be higher in the morning due to cooler temperature and dew formation which can contribute to the feeling of cleaner air and lesser vulnerability in close communities. The natural process where plants releases oxygen through photosynthesis during the day and respire but consume oxygen while releasing carbon dioxide has been adduced to the variation in air quality in different hours. In the morning, plants begin photosynthesis again, contributing to a fresher atmosphere. The calmness of the wind in the morning reduces the volatility of atmospheric mixing which makes the air less polluted. When atmospheric mixing becomes more sporadic in the afternoon hours, and pollutants from different sources such as gas flaring, transportation, industrial activities and pollution from agriculture and construction are mixed, air pollution becomes more threatening and problematic. The outcome of this study is also consistent with Odu et al. (2019) when they assert that flared gases trapped in the upper atmosphere may cause radiation to take place within the immediate environment of the flare site, thereby increasing the mean daily temperature beyond tolerance range. The outcome of this study on the variation in air quality in different hours of the day is consistent with Nwachukwu, et al. (2022) in their report that the quality of air in gas flaring locations in river state during the rainy and the wet seasons. They measured ambient air quality in the morning, afternoon and evening in each of the

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/25apr327

four stations investigated for three months. They reported six potential air pollutants in the study area such as suspended particles such as particulate matter ($PM_{2.5}$, PM10) Carbon (II) Oxide (CO), Nitrogen (iv) Oxide (NO_2), Sulphur (IV) oxide (SO_2), methane (CH_4), volatile organic compound (VOC) with reference to meteorological parameters like relative humidity, ambient temperature, and wind speed and direction. The results of the study showed that the mean concentration of the air pollutants in the dry season and rainy season exceeded the limits of the World Health Organization (WHO). The study concluded that air quality in Ebocha is polluted with various pollutants particularly during the dry season.

The study found that the volume of pollutants from gas flare sites at different time of the day in Rivers and Bayelsa States exceeded the air quality guidelines (AQG) of the World Health organization (WHO). The implication is that public health within the circumference of the gas flaring sites is compromised. Increasing human activities and building of residential housing around the gas flaring catchment presents severe health implications. The AQG of the world health organization viz; Pm2.5 (10ppm), O_3 (100ppm), NO_2 (25ppm), SO_2 (40ppm), and CO (4ppm), VOC 100ppm are below the data recorded from rivers and Bayelsa state. this study also agree with the outcome of the study conducted by Nwagbara & Onwudiwe, (2020), the outcome of T-test and mean concentrations of air components were high compared with World Health Organization (WHO) and Federal Environmental Protection Agency (FEPA) standards. Results obtained from the t-test analysis showed that there was a significant difference between air quality around the flaring site, and air quality at the control point with mean concentrations of 3.10 ppm and 0.57 ppm respectively at 0.05 significant levels. Also, the mean concentrations of air components, 2.94, 0.99, 1.92, 0.85, 1.60, and 6.52 ppm for Carbon monoxide (CO), Hydrogen sulphide (H_2S), Sulphur dioxide (SO2), Nitrogen dioxide (NO_2), Volatile Organic Compounds (VOCs), and Suspended particulate matter (SPM) were above the AQG of the WHO. The outcome of this study on the spatial differences in the concentration of pollutants and the vulnerability of communities is consistent with the reports of Nwagbara & Onwudiwe, (2020) reported that there is a significant variation in air quality around gas flaring locations, and this is manifesting in the extent to which residential communities are vulnerable to different types of diseases. They reported air quality readings at intervals of 100 m, 200 m, 300 m and 4 km (as control point (K)) away from flare site. The outcome of t-test analysis show that that there was a significant difference between air quality around the flaring site, and air quality at the control point. This significant difference portends the variation in the extent that residents are exposed to diseases. They also reported that the concentration of pollutants around the gas flaring points at different intervals are above the WHO and FEPA standards, except for H_2S (1.10 ppm) in FEPA standard. Based on these results, it is concluded here that horizontal gas flaring in Izombe community has lowered the air quality around the flaring site. This portends great danger to residents, homes, farmlands and rivers/streams around it. This study also agree with Gobo, Richard & Ubong (2009) when they reported the nexus between health challenges and the rising spate of gas emissions by oil and gas companies in the Niger Delta region.

IV. CONCLUSION

It is an unarguable fact that oil and gas exploration and production activities in the Niger Delta has been on steady increase for more than four decades and these have contributed to the continuous production and release of wastes associated with exploratory activities in the form of liquid, solid and gas into the environment. It has been reported that gas flaring is dangerous and an abuse of human rights because the gas pollutants contain over 250 different toxins that are harmful, poisonous and unfriendly to human health and the physical environment within the gas flaring radius. Consequently, this study found that there is significant variation in the concentration of pollutants in the area close to the flaring sites during the morning, afternoon and evening hours in Rivers state and Bayelsa states. It is also revealed that the concentration of pollutant is higher in the afternoon around the gas flaring sites in the areas and the variations are adduced to the influences of meteorological parameters such as temperature, wind speed and relative humidity.

RECOMMENDATIONS

Arising from the findings of this study, industrial air quality monitoring agency are required for timely data collection and reporting of the trend in the concentration of the pollutant around the gas flaring sites and the implications for public health, stringent enforcement of punitive measures on defaulting companies, government enforcement of adoption of environmentally friendly technologies by oil and gas companies in their operations were topmost among the recommendations made.

REFERENCES

[1]. Ajugwo, A.O. (2013) Negative Effects of Gas Flaring: The Nigerian Experience. Journal of Environment Pollution and Human Health, 1, 6-8.
[2]. Akuezuilo, E. O., & Agu A. (2002). *Research and Statistics in Education and Social Sciences. Method and Applications*. Awka: Newl Centi Publishers and Academic Press Ltd, pp. 131-132.
[3]. Ansa, E. J. and Akinrotimi O. A. (2018). Reactions to Petroleum Exploration From Oil-Bearing
[4]. Communities: What Have We Learned? In: The Political Ecology of Oil and Gas Activities in the Nigerian Aquatic Ecosystem. Ed. Ndimele P. E. Elsevier Inc. Chapter 20:307–322.

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/25apr327

[5]. Ayoade, J.F. (2004). Introduction to climatology for the tropics. Ibadan: Spectrum Books Ltd.
[6]. Egwurugwu, J.N., Nwafor, A and Ezekwe, S.(2013): Impacts of prolonged exposure to gas flares on some blood indices in humans in the Niger Delta Region, Nigeria .Archives of Applied Science Research, 5(1):98-104.
[7]. Gobo, A.E., Richard, G., and Ubong, I.U. (2009) Health Impact of Gas Flares on Igwuruta/Umuechem Communities in Rivers State," *Applied Science & Environmental Management*, 13(3), 27-33.
[8]. Ite, A.E. and Ibok, U.J. (2013) Gas flaring and Venting Associated with Petroleum Exploration and Production in the Nigeria's Niger Delta, American Journal of Environmental Protection, 1(4): 70-77
[9]. Odjugo, P.O.A (2008). Quantifying the Cost of Climate Change Impact in Nigeria. Emphasis on Wind and Rainstorms. Journal of Human Ecology, 28, 93-101.
[10]. Nwachukwu, C. S. Anyanwu, J.C.; Njoku, P.C. and Nwachukwu J. I. (2022). Impact of gas flaring on air quality in Ebeocha community rivers state. International Journal of Advanced Academic Research, 8 (9).
[11]. Nwagbara M. O and Onwudiwe, H. T (2020). Air quality assessment around horizontal gas flaring sites in Izombe, south east. *Nigeria. Journal of Geography and Earth Sciences* . 8, (1). 16-23
[12]. Obi, N. I., Bwititi, P. T., & Nwose, E. U. (2021). Evaluation of government's efforts to mitigate the adverse effects of gas flaring in host communities. *Journal of Complementary and Alternative Medical Research*, *16*(2), 42-50.
[13]. Odu, C. T. I., Enyoh, C.E., Eke, A. C., Afuikwa, J. N. and Adie, G. U (2019). Impact of gas flaring on soil microbial community structure and function in the Niger Delta region, Nigeria. *Environmental monitoring assessment* 4, 206
[14]. Okotie, S. (2018). The Nigerian Economy Before the Discovery of Crude oil In: The Political Ecology of Oil and Gas Activities in the Nigerian Aquatic Ecosystem, Academic Press, 71-81
[15]. Weli, V., Adegoke, J., and Kpang, M. (2016) The Epidemiology of Cardio-Vascular Diseases in Relation to the Air Quality of Abattoirs in Port Harcourt, Nigeria. *World Journal of Cardiovascular Diseases*, 6, 94-106.
[16]. World Bank Development Report, 2018