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Air Quality Implications of Gas Flaring in Communities Prone to Oil and Gas Activities in Rivers State

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Abstract:
This study was carried out to assess the air quality implications of gas flaring in selected communities prone to oil and gas activities in Rivers State. The study made use of both primary and secondary data. Primary data were collected from field measurements of nitrogen dioxide (NO_2), sulphur dioxide (SO_2), hydrogen sulphide (H_2S), carbon monoxide (CO), suspended particulate matter (SPM), noise levels, wind speed, relative humidity and temperature while secondary data were retrieved from online journals and published articles. The results revealed that the mean concentration of NO_2, SO_2, H_2S and CO ranged from 0.03ppm-0.4ppm, 0.01ppm-0.59ppm, 0.01ppm-0.3ppm and 0.83ppm-11.12ppm respectively. SPM concentration ranged from 2.06mg/m^3-9.76mg/m^3 while noise levels ranged from 67.3dBA-71.2dBA. Analysis of meteorological variables revealed that wind speed, relative humidity and temperature ranged from 0.48m/s - l.38m/s, 62.4% - 69.7% and 32.6^{0}C - 38.0^{0}C, respectively. ANOVA analysis on the variation in air quality parameters and noise levels between the flare site and control site showed a value of 0.00., implying a statistically significant variation in air quality parameters and noise levels between the flare site and control site. Pearson Product Moment Correlation computed for hypothesis 2 revealed that there is no statistically significant relationship between micro-climatic parameters (Temperature, relative humidity, wind speed) and the concentration levels of carbon monoxide (CO), sulphur dioxide (SO_2), and nitrogen oxide (NO_2).

Keywords: *Air quality, implications, gas flaring, oil and gas activities*

1. Introduction

Air Pollution refers to the introduction of one or more toxic contaminants, such as mist, dust and smoke, into the atmosphere in quantities and duration that are detrimental to human health, plants, animals and properties (Inumidun *et al*., 2021).

Gas flaring is often deployed during petroleum refining and chemical processing for secured disposal of waste gases during process upsets, plant start-up or shutdown and process emergencies. Flaring is an oxidation process undertaken under extreme temperatures and is often used to combust volatile components, mostly hydrocarbons, of waste gases during industrial operations. Gas flaring is the combustion of associated gas produced with crude oil or from gas fields (Udok & Akpan, 2017).).

Oil and gas companies deploy the option to release gas to the atmosphere by flaring and venting, basically because of safety concerns. Flaring is the controlled burning of natural gas produced in association with oil during routine oil and gas production operations. Venting is the controlled release of gases into the atmosphere during oil and gas production operations. In order to ensure safe operation and minimize undesirable venting, gas flaring was introduced into oil and gas operations. Gas flares are the choice disposal option for handling waste hydrocarbon gases because of their ability to burn efficiently (Ite & Ibok, 2013).

In oil-rich regions of the world, gas flaring has become a familiar sight in oil fields, most especially in developing countries that lack the necessary infrastructure to trap and maximize the use of the gases and/or in circumstances where the market for these gases are non-existent (Inumidun *et al*., 2021).

Gas flaring has generated numerous concerns considering its deleterious impacts, and this has facilitated renewed calls to reduce the volume of gas flaring. However, despite calls by environmental agencies and international bodies such as the World Bank's initiative, Global Gas Flaring Reduction (GGFR), the volume of gas flared globally seems to have continued to increase and has been reported to be 130 billion cubic meters (bcm) since 2008. According to GGFR (2012), there was a steady rise of 2 bcm in the volume of gas flared in 2011 compared to 2010. On a yearly basis, 140 billion cubic meters of gas flare across oil-producing countries globally (McGreevey & Whitaker, 2020).

In Nigeria, despite the declaration of gas flaring as an illegal enterprise since 1984, it is surprising that Nigeria is still listed among the top 10 gas-flare countries, with about 7.4 billion cubic meters of gas flared in 2018 and about 425.9 billion standard cubic feet of gas flared in 2019 (Eboh, 2019).

Gas flaring has had negative effects on the environment. Its contribution to global warming and climate change need not be overemphasized. Gas flaring releases excessive amounts of carbon dioxide and methane into the atmosphere. Another major consequence of gas flaring is the emission of hydrogen sulphide and sulphur oxides. When these compounds combine with atmospheric oxygen and water, they produce acid rain (Akhionbare *et al*., 2020).

The attendant consequences of gas flaring have generated concern on a local, regional and global level. In Nigeria, gas flaring has had harmful impacts on the local environment. Agricultural productivity has been directly hit by gas flaring. The burning process increases the soil temperature, destroying soil microorganisms that need a certain temperature for optimal effect. This results in a reduction in crop yield. Moreover, acid rain destroys vegetation and corrodes roofing sheets. Acid rain also destroys aquatic life and wildlife, while the smoke that flows out from the flare stacks is harmful to both flora and fauna within the flare locations (Nwaogu & Onyeze, 2010).

The release of soot and other toxic gases emanating from the flare site reduces air quality. Gas flares contain dangerous toxins, such as benzene, benzopyrene, toluene, mercury, and arsenic, that are carcinogenic. Examples of these are. Flare sites have been associated with high concentrations of nitrogen dioxide, sulfur dioxide, carbon monoxide and suspended particulate matter. The reduction in air quality poses serious health risks to humans living within the flare locations, including cancer and lung damage, as well as deformities in children, asthma, bronchitis, pneumonia, and neurological and reproductive problems (Allison *et al.,* 2018).

In local Nigerian communities in Rivers State, flare sites still exist, and associated gases have been flared for over 20 years while the vagaries of gas flaring have been neglected. This has further exacerbated the impact of gas flaring on the air quality of communities, which has also had negative health implications for the residents of those communities close to flare sites. This study is, therefore, necessitated on the premise that it is necessary to evaluate the concentration of these toxic air pollutants in the selected flare locations compared to a control site and NAAQS air quality standards. Moreover, it is also necessary to ascertain the relationship between atmospheric pollutants and the meteorological variables in the study area.

2. Materials and Methods

The study area, Rivers State, is located between latitude $4^{0}30^{I}$-$5^{0}40^{I}$N and Longitude $6^{0}40^{I}$-$7^{0}20^{I}$E (Figure 1).

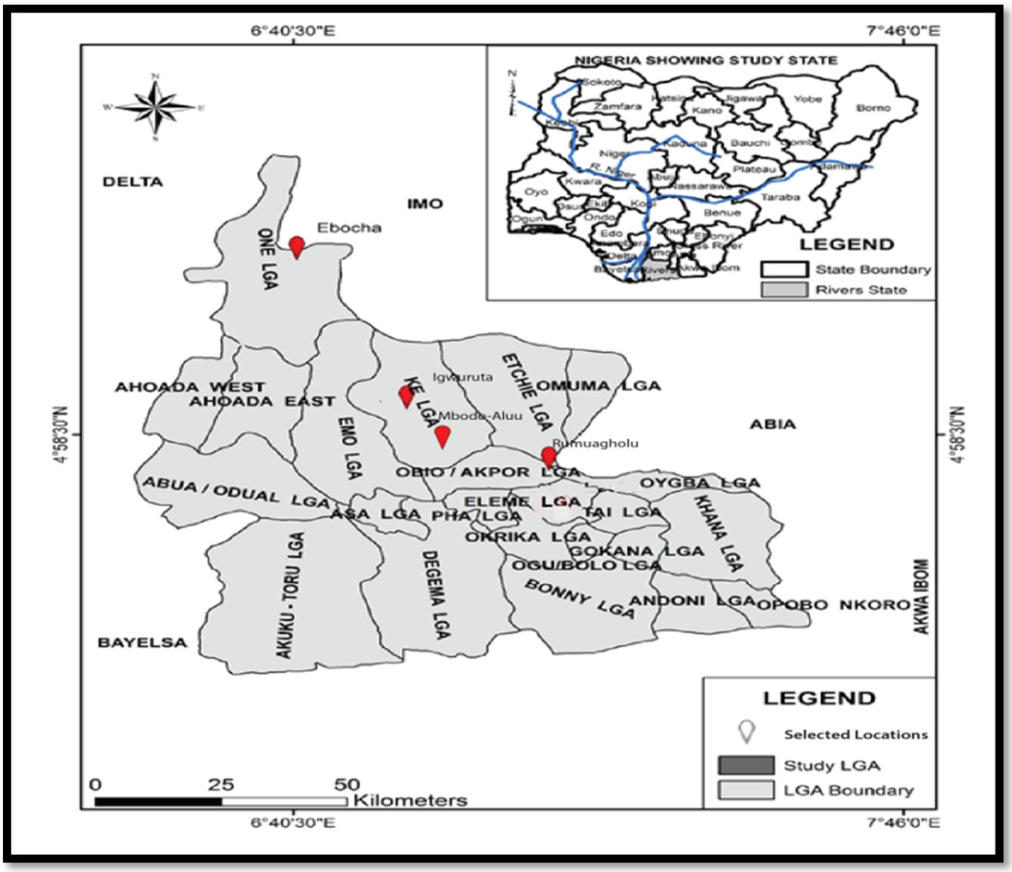

Figure 1: Map of Rivers State Showing the Selected Sampling Locations
Source: Cartography/GIS Laboratory, Department of Geography and Environmental Management, University of Port Harcourt, Choba

Table 1 below briefly describes the selected location and their coordinates.

S/No	Sample Location	Latitude (^{0}N)	Longitude (^{0}E)
1.	Ebocha	N5^{0}31.298’	E006^{0}45.058”
2.	Iguruta (Agbada II)	N4^{0}55’57.72”	E7^{0}0’53.68”
3.	Mbodo-Aluu (Agbada I)	N4^{0}55’55.30”	E6^{0}58’28.58”
4.	Rumuagholu (Control)	N4^{0}53’26.43”	E6^{0}58’30.72”

Table 1: Locational Characteristics of Selected Sampling Points
Source: Researcher’s Analysis (2024)

The state is located in the Niger Delta region of Nigeria and occupies an area of approximately 11,077 km^2 of the delta. Rivers State is bounded on the South by the Atlantic Ocean, to the North by Imo, Abia and Anambra States, to the East by Akwa Ibom State and to the West by Bayelsa and Delta States (Ofomata, 1979). The mean annual temperature of the area is 28^{o}C. It is predominantly under the influence of the monsoon wind and also records heavy rainfall of 2370.5 mm. The soil type of Port Harcourt is a mix of silty clays and sand and can be classified geologically under the Benin formation (Wizor, 2012).

The parameters measured include air temperature, relative humidity, wind speed, nitrogen dioxide (NO2), sulphur dioxide (SO2), carbon monoxide (CO), Hydrogen Sulphide (H_2S) and suspended particulate matter (SPM).

Table 2 shows the parameters measured and the equipment used.

S/No	Parameters Measured	Equipment Used
1	Sulphur Dioxide (SO_2)	Multi–RAE PLUS (PGM-50), a programmable Multi-Gas Monitor
2	Nitrogen Dioxide (NO_2)	Multi–RAE PLUS (PGM-50), a programmable Multi-Gas Monitor
3	Carbon Monoxide (CO)	ELE Analox Sensor Gas Monitor Model GC 401
4	Windspeed	Digital Anemometer (Taylor wind scope)
5	Air Temperature	Hand-held Digital Thermometer.
6	Relative Humidity	A logger (Testo 450)
7	Suspended Particulate Matter	A Met One Instrument, Inc Aerosol Mass Monitor
8	Noise levels	Noise Meter

Table 2: Parameters Measured and Equipment Used

3. Results

3.1. Micro Climatic Parameters

3.1.1. Wind Speed

The result showed that wind speed ranged from the lowest of 0.48m/s at the control site (Rumuagholu) to the highest of 1.38m/s at Agbada I (Mbodo-Aluu). Agbada II (Iguruta) recorded a windspeed of 0.58m/s, while Ebocha recorded a windspeed of 1.10 m/s, as shown in figure 2 below.

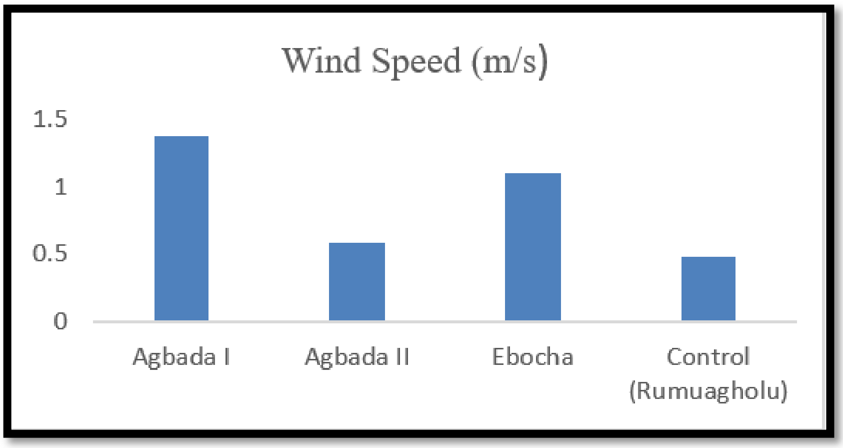

Figure 2: Mean Wind Speed of Selected Locations

3.1.2. Relative Humidity

The result showed that relative humidity ranged from the lowest of 62.4% at Ebocha to the highest of 69.7% at the control site (Rumuagholu). Agbada I (Mbodo-Aluu) recorded a relative humidity of 68.8%, while Agbada II (Iguruta) recorded a relative humidity of 67.4%, as shown in figure 3 below.

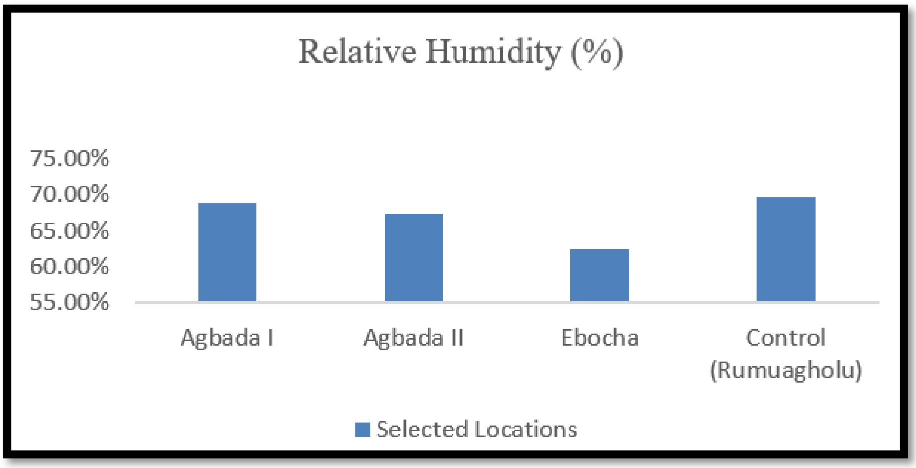

Figure 3: Mean Relative Humidity in Selected Locations

<u>3.1.3. Temperature</u>

The result showed that temperature ranged from a lowest of 32.6^{0}C at the control site (Rumuagholu) to a highest of 38.0^{0}C at Ebocha. Agbada I (Mbodo-Aluu) recorded a temperature of 36.8^{0}C, while Agbada II (Iguruta) recorded a temperature of 36.4^{0}C, as shown in figure 4 below.

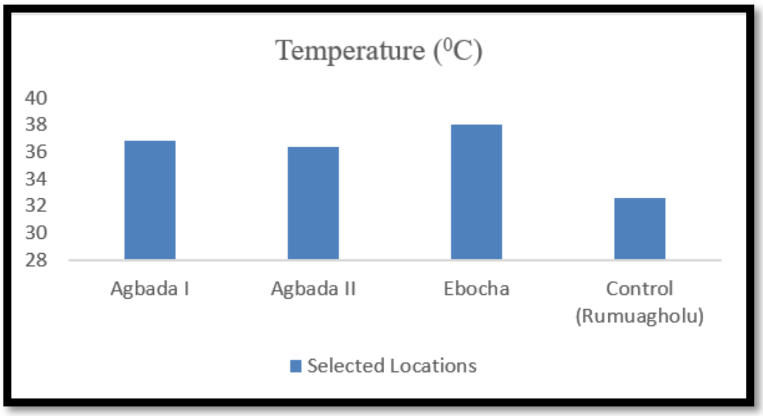

Figure 4: Mean Temperature in Selected Locations

3.2. Spatial Distribution of Air Quality Parameters

<u>3.2.1. Nitrogen Dioxide (NO_2)</u>

The results of the mean concentrations of NO_2, as measured in all the selected locations, showed that NO_2 concentration ranged from a lowest of 0.03ppm at the control site (Rumuagholu) to a highest of 0.4ppm at Ebocha. Agbada I (Mbodo-Aluu) recorded 0.3 ppm, while Agbada II (Iguruta) recorded 0.1 ppm, as shown in figure 5 below.

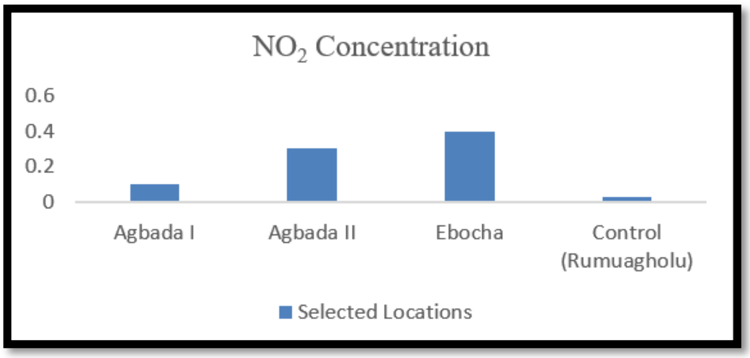

Figure 5: Mean Nitrogen Dioxide in the Selected Locations

<u>3.2.2. Sulphur Dioxide (SO_2)</u>

The mean SO2 concentrations measured in all the selected locations showed that SO_2 concentration ranged from 0.01 ppm at the control site (Rumuagholu) to 0.59 ppm at Agbada II (Iguruta). Agbada I (Mbodo-Aluu) recorded 0.2 ppm, while Ebocha recorded 0.12 ppm, as shown in figure 6 below.

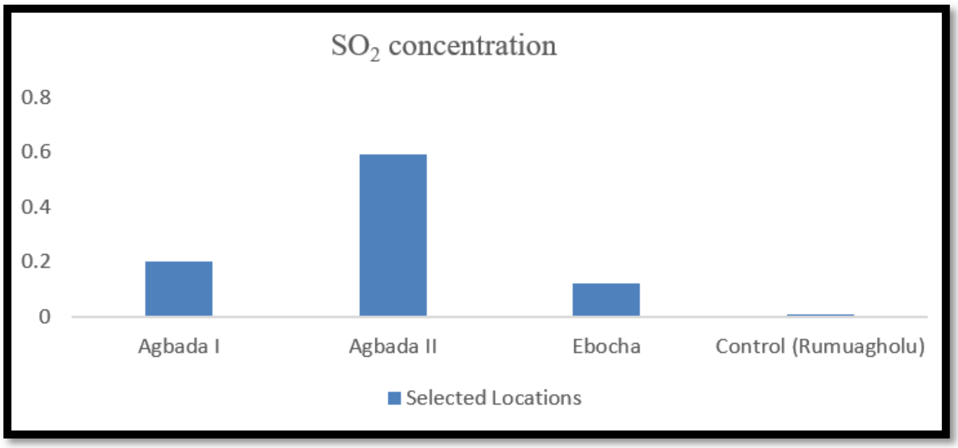

Figure 6: Mean Sulphur Dioxide in the Selected Locations

3.2.3. Hydrogen Sulphide (H_2S)

The results of the mean concentrations of H_2S, as measured in all the selected locations, showed that H_2S concentration ranged from a lowest of 0.01 ppm at the control site (Rumuagholu) to a highest of 0.3 ppm at Ebocha. Agbada I (Mbodo-Aluu) recorded 0.2 ppm, while Agbada II (Iguruta) recorded 0.1 ppm, as shown in figure 7 below.

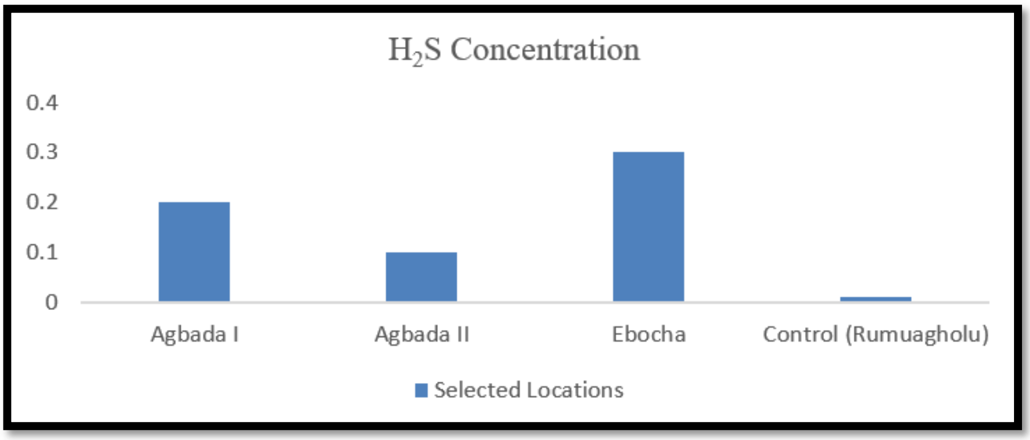

Figure 7: Mean Hydrogen Sulphide in the Selected Locations

3.2.4. Carbon Monoxide (CO)

The results of the mean concentrations of CO as measured in all the selected locations showed that CO concentration ranged from a lowest of 0.83 ppm at the control site (Rumuagholu) to a highest of 11.12 ppm at Ebocha. Agbada I (Mbodo-Aluu) recorded 9.30 ppm, while Agbada II (Iguruta) recorded 2.40 ppm, as shown in figure 8 below.

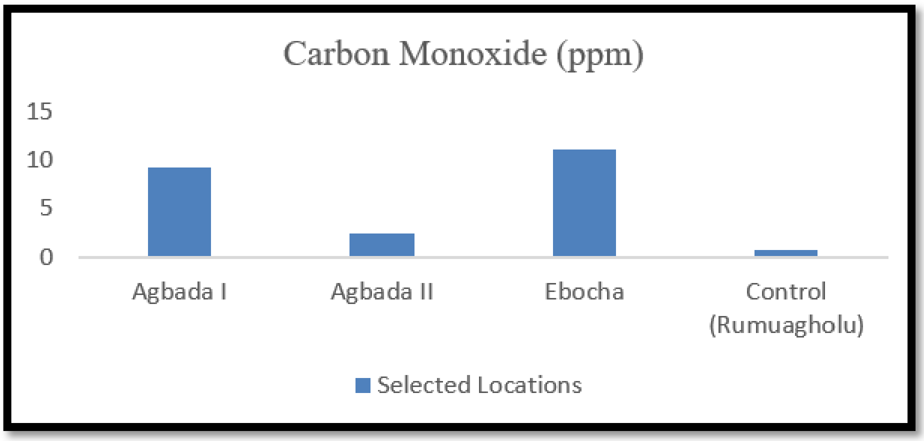

Figure 8: Mean Carbon Monoxide in the Selected Locations

3.2.5. Suspended Particulate Matter (SPM)

The mean concentrations of SPM, as measured at all the selected locations, show that the control site recorded the lowest concentration of 2.06mg/m^3, while Ebocha recorded the highest concentration of 9.76mg/m^3. Agbada I (Mbodo-Aluu) recorded 8.41mg/m^3, while Agbada II (Iguruta) recorded 7.24mg/m^3, as shown in figure 9 below.

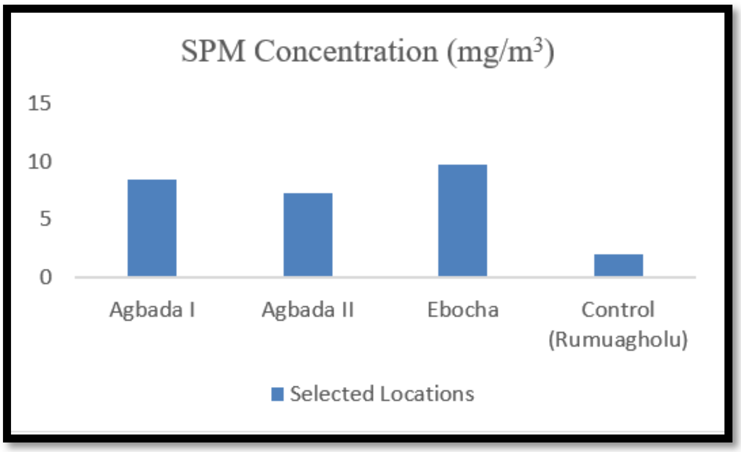

Figure 9: Mean Suspended Particulate Matter in the Selected Locations

3.2.6. Noise Levels

The noise levels, as measured at all the selected locations, show that the control site recorded the lowest noise level, 67.3 dBA, while Agbada I (Mbodo-Aluu) recorded the highest mean, 71.2 dBA. Ebocha recorded 70.3 dBA, while Agbada II (Iguruta) recorded 70.1 dBA, as shown in figure 10 below.

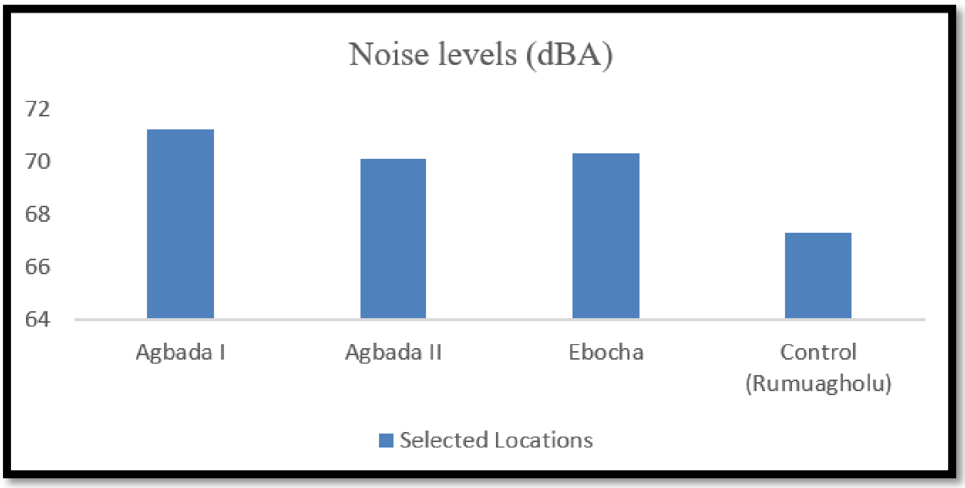

Figure 10: Noise Levels in the Selected Locations

3.3. Hypotheses Testing

- H_{01}: There is no statistically significant variation in air quality parameters and noise levels between the flare sites and the control site.

As shown in table 3, the ANOVA analysis of the variation in air quality parameters and noise levels between the flare site and control site showed a value of 0.00. Since this value is less than 0.05, the alternate hypothesis (H1), which states that there is a statistically significant variation in air quality parameters and noise levels between the flare site and control site, is accepted.

	Sum of Squares	**Mean Square**	**F**	**Sig.**
Between Groups	196.994	39.399	11.973	0
Within Groups	59.233	3.291		
Total	256.227			

Table 3: Analysis of Variance for Air Quality Parameters

- H_{02}: There is no statistically significant relationship between meteorological parameters and the concentration levels of air pollutants in the selected sampling locations.

Table 4 below reveals the Pearson Product Moment Correlation computed for hypothesis 2. The correlation table revealed that there is no statistically significant relationship between micro-climatic parameters (Temperature, relative humidity, wind speed) and the concentration levels of carbon monoxide (CO), sulphur dioxide (SO_2), and nitrogen oxide (NO_2) as their p-values were greater than the critical value of α=0.05.

S/No	Atmospheric Pollutants	Temperature	Relative Humidity	Wind Speed
1.	Carbon Monoxide	0.742	0.832	0.812
2.	Sulphur Dioxide	0.872	0.917	0.697
3.	Nitrogen dioxide	0.640	0.843	0.749

Table 4: Pearson Product Moment Correlation Computed for Hypothesis 2

4. Discussion

The findings of this research revealed variations in the mean concentration levels of air pollutants and noise levels between the flare locations and the control site. This implies that gas flaring had a significant impact on air quality. The finding of this research is in tandem with the findings of Nwachukwu *et al*. (2022), who, in their separate study, revealed that gas flaring had negative impacts on air quality in the Ebocha community. This could be attributed to the uncontrolled release of toxic air pollutants during flaring.

Furthermore, the research also revealed no statistically significant relationship between micro-climatic parameters (Temperature, relative humidity, windspeed) and the concentration levels of carbon monoxide (CO), sulphur dioxide (SO_2), and nitrogen oxide (NO_2). The findings of this research are in sharp contrast to the findings of Chukwu (2022), who revealed in his research that a statistically significant relationship exists between the concentration of atmospheric pollutants and the prevailing meteorological factors.

The findings of this research revealed that the concentration levels of Nitrogen dioxide at the selected gas flare locations were above the FEPA limit of 0.04ppm-0.06ppm. If these concentrations were to be consistent on a daily basis, it could result in respiratory diseases, cardiovascular illnesses and chronic nephritis in the exposed population. However, the concentration level of Nitrogen dioxide at the control site was within the FEPA limit. On the contrary, the mean concentration of carbon monoxide at the flare locations did not exceed the National Ambient Air Quality Standards (NAAQS) stipulated limit of 20 ppm.

Research findings revealed that the mean concentration of sulphur dioxide at the flare locations exceeded the National Ambient Air Quality Standards (NAAQS) stipulated limit of 0.1 ppm except at the control site, which was below the FEPA limit. If these concentrations were to be consistent on an hourly and daily basis, it could result in breathing problems and aggravation of respiratory diseases in people who are susceptible. The finding of this research is in tandem with the findings of Amadi et al. (2022) in their separate study on gas flaring and its environmental impact in the Epkan community. Delta State revealed exceedances in NO_2 and SO_2.

The findings of this research revealed that the H_2S concentration in all the locations was within the stipulated limit of 5.76 ppm, which is the National Ambient Air Quality Standard. The concentration levels at the flare and control sites are within permissible limits and are not likely to cause any adverse health and environmental consequences.

5. Conclusion

This study has shown that gas flaring contributes to air pollution. It has also shown that nitrogen and sulphur dioxide at the selected locations exceeded the limits stipulated by the National Ambient Air Quality Standards (NAAQS). Therefore, this poses a great health hazard to residents who reside close to these flare sites.

6. References

i. Akhionbare, S. M. O., Okweri-Eric, O. G., & Ihejirika, C. E. (2020). Comparative assessment of air quality in Igwuruta and Aluu, Rivers State, Nigeria. *Journal of Applied Sciences and Environmental Management*, 24(4), 607–614.

ii. Allison, C., Oriabure, G., Ndimele, P., & Shittu, J. (2018). Dealing with oil spill scenarios in the Niger Delta: Lessons from the past. In *The political ecology of oil and gas activities in the Nigerian aquatic ecosystem* (pp. 351–368). Elsevier.

iii. Amadi, A. H., Usiabulu, G. I., Adebisi, O., Ifedili, U. D., & Ajayi, K. E. (2022). Gas flaring, and its environmental impact in Epkan community, Delta State, Nigeria. Available at SSRN: https://ssrn.com/abstract=4214256 or http://dx.doi.org/10.2139/ssrn.4214256.

iv. Chukwu, M. N. (2022). Gas flaring effects around Agbada II flow station in Igwuruta, Rivers State, Nigeria. *University of Thi-Qar Journal of Science*, 9(2), 84–89. https://doi.org/10.32792/utq/utjsci/v9i2.909.

v. Eboh, M. (2019). Nigeria: Despite paucity of funds, Nigeria flares N461bn gas in 2019. Retrieved from: https://allafrica.com/stories/201912310199.html.

vi. GGFR. (2012). GGFR partners mark 10th anniversary by scaling up flaring reduction efforts. *The News Flare, World Bank-Global Gas Flaring Reduction*, Washington DC, 2012.

vii. Inumidun, F. V., Aderemi, A. F., & Nnamdi, C. V. (2021). Air pollution: Causes, effects and remediation in Nigeria. *International Journal of Advanced Academic Research*, 7(1), 13–30.

viii. Ite, A., & Ibok, U. (2013). Gas flaring and venting associated with petroleum exploration and production in Nigeria's Niger Delta. *American Journal of Environmental Protection*, 1(4), 70–77.

ix. McGreevey, C. M., & Whitaker, G. (2020). Zero routine flaring by 2030. Retrieved from: https://www.worldbank.org/en/programs/zero-routine-flaring-by-2030.

x. Nwachukwu, C. S., Anyanwu, J. C., Njoku, P. C., & Nwachukwu, J. I. (2022). Impact of gas flaring on air quality in Ebeocha Community, Rivers State. *International Journal of Advanced Academic Research*, 8(2), 98–109.

xi. Nwaogu, L., & Onyeze, G. (2010). Environmental impact of gas flaring on Ebocha-Egbema, Niger Delta. *Nigerian Journal of Biochemistry and Molecular Biology*, 25(1), 25–30.

xii. Ofomata, G. E. K. (1975). *Nigeria in maps: Eastern States*. Ethiope Publishers.

xiii. Udok, U., & Akpan, E. (2017). Gas flaring in Nigeria: Problems and prospects. *Global Journal of Politics and Law Research*, 5(1), 16–28.

xiv. Wizor, C. H. (2012). Analysis of the developmental trends of single-family housing estates in Port Harcourt metropolitan fringe areas (Ph.D. dissertation). Department of Geography and Environmental Management, University of Port Harcourt, Choba, Rivers State.