Journal of
Environment
(JE)

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CARI Journals

Journal of Environment
ISSN 2789-3863 (Online)
Vol. 3, Issue No. 2, pp 26 - 40, 2023
www.carijournals.org

# Comparative Study of Air Quality Assessment in Bonny, Bille And Degema Communities in The Niger Delta Region, Nigeria

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*Accepted: 7th Aug, 2023 Received in Revised Form:21st Aug, 2023 Published: 4th Sep, 2023.*

## Abstract

**Purpose:** This study was undertaken to ascertain the air quality in the oil-producing towns for the purpose of making recommendations that address the health challenges of the inhabitants Gas flaring has a negative impact on air quality in oil-producing towns.

**Methodology:** This paper adopted Robert King's Exposure Risk Theory from the late 1970s, this research employs an experimental design to analyze air quality in Bonny, Degema, and Bille towns located in Rivers State. Data was collected from these towns, followed by rigorous laboratory analysis to evaluate air quality. A comparison of these findings with the air quality guidelines established by the World Health Organization (WHO) was made to facilitate an understanding of potential health implications associated with air quality issues in the study area.

**Findings:** The study reveals that nitrogen (IV) oxide ($NO_2$) concentrations spanned from 0.006 to 0.085 ppm in Station 3 and 0.018 to 0.006 ppm in Station 1. Notably, statistically significant differences ($P < 0.05$) in $NO_2$ levels were observed across the diverse towns of the Niger Delta investigated in this study. The high recorded levels of nitrogen (IV) oxide ($NO_2$) can potentially be attributed to heightened vehicular emissions in Bonny relative to Degema and Bille. Furthermore, the study identifies hydrogen sulphide ($H_2S$) concentrations ranging from 0.001 ppm to 0.123 ppm, with the highest levels in Bonny. Carbon (II) oxide (CO) levels varied between 0.032 and 3.355 ppm in Degema and Bonny, respectivelyy. No statistically significant difference ($P > 0.05$) was found. The study also identifies ammonia ($NH_3$) levels ranging from 0.001 to 0.008 ppm in Degema, Bille, and Bonny communities. Notably, no significant variance in ammonia concentration was observed among the study's locations. In conclusion, the study underscores the detrimental impact of oil-related activities, including gas flaring, on air quality within the examined areas, consequently endangering residents' well-being.

**Unique Contribution to Theory, Practice and Policy (Recommendations):** This study offers a forward stride in the Exposure Risk Theory's application by contextualizing it within the study area. Through this lens, we uncover the ramifications of prevalent practices such as gas flaring on air quality. Practical implications emerge as valuable guidance for stakeholders including industries and regulatory bodies to sculpt targeted pollution control strategies addressing specific pollutants. Moreover, local communities and health agencies stand to harness these insights to champion cleaner air and enhanced living conditions.

**Keywords:** *Air Quality, Gas flare, Noise, Pollution, Assessment*

# 1. INTRODUCTION

## 1.1 Background Knowledge

Air quality assessment in the Niger Delta region of Nigeria has become an important research area, given the complex polluted environment of the region and its critical role in providing resources for the nation's energy needs (Irubeyin, 2019). Established as the oil and gas capital of Nigeria, the Niger Delta region is subject to numerous environmental pressures. These include persistent oil spills, gas flaring, industrial pollution, and agricultural runoff (Adesoji, Akujobi, & Uwaifo, 2018). Therefore, measuring air quality in the region has become a priority in efforts to reduce the negative environmental impacts associated with these activities.

The air quality assessment of the Niger Delta is complex, due to its presence of a wide variety of pollutants stemming from oil and gas production, as well as agricultural and industrial activities (Orike & Igbum, 2020). Sources of air pollution in the region include stationary (industrial facilities, oil refineries, and power plants) and mobile sources (such as vehicles and boats). In addition, the region is subject to weather-dependent emissions of air pollutants, such as dust and other particles from desert sand, leading to reduced air quality. Due to the regional geography, air pollution is concentrated in specific parts of the region, impacting on local populations differently.

The air quality in the Niger Delta is monitored both by the Nigerian government and various international bodies, such as the United Nations Environmental Programme (UNEP). A number of studies have been conducted to assess the air quality in the region. These have included both in situ sampling and modelling studies. Research has focused on the monitoring of a suite of air pollutants, including total suspended particulate (TSP), Sulphur dioxide (SO2), nitrogen dioxide (NO2), carbon monoxide (CO), and volatile organic compounds (VOCs). The studies have found that the air quality of the region is poor, with most pollutants exceeding safe limits. For instance, Orike and Igbum (2020) found that there were significantly higher levels of TSP, SO2, NO2, and CO in the Niger Delta than elsewhere. In addition, there are significant levels of VOCs from oil and gas-related activities in the region.

Overall, air quality assessment in the Niger Delta region of Nigeria is a complex issue, due to the presence of numerous pollutants from oil and gas production, industrial and agricultural activities, and dusty deserts. Despite the regional efforts for monitoring air quality, monitoring has not been able to effectively translate into interventions and policy formulation. Therefore, this study carried out a comparative study of air quality assessment in Bonny, Bille and Degema communities in the Niger Delta Region, Nigeria for the purpose of formulating a comprehensive and integrated approach in solving environmental issues relating to air pollution in the region

## Statement of the Problem

The emission of toxic chemicals from gas flares presents a pressing health concern, with compounds like Sulphur dioxide, benzene, xylene, and particulate matter, including carcinogens, being associated with hazardous health conditions and community well-being. However, despite their prevalence, the specific health impacts of these by-products have not been adequately investigated, especially in oil-rich regions. Residents exposed to these pollutants face an increased risk of various cardiopulmonary diseases, a phenomenon observed among many inhabitants in such areas, yet lacking comprehensive examination.

Prior research has established the association between environmental and health issues caused by air pollution in the study region. For instance, Oluwole et al. (1996) reported that volatile oxides of carbon, Sulphur, phosphorous, and nitrogen exceeded the standards set by the Federal Environmental Protection Agency (FEPA, 1991), contributing to air quality deterioration. Similarly, elevated lead concentrations were noted in the atmosphere by Olobaniyi and Efe (2007). However, the health impacts of specific toxic compounds from gas flaring remain a research gap, necessitating focused investigation.

This study seeks to address this research gap by comprehensively examining the health effects of toxic chemicals emitted from gas flares in these oil-producing areas. Through an in-depth analysis, the research aims to elucidate the link between these pollutants and the prevalence of cardiopulmonary diseases, shedding light on an issue that has significant implications for public health. By bridging this gap in knowledge, we intend to provide valuable insights that contribute to informed policy making, pollution control strategies, and improved well-being for communities in oil-rich regions.

## 2. LITERATURE REVIEW

### 2.1 Gas Flaring

Gas flaring is associated with the burning away of harmful substances into the open air. In the mix are carbon dioxide along with methane that are major causes of global warming. Gas flaring has been reportedly linked to acid rain that causes acidity of the lakes and streams and devastates crops and vegetation (Akpan, 2003).It causes low farm production and impacts on human health and by extension livelihoods of the residents. Gas flaring raises the risk of respiratory ailment and cancer. It often leads to dyspnea, chronic inflammation of the bronchioles, lower lung function, pruritus, blindness, impotency, miscarriages and premature deaths (Friends of the earth, 2008). A flare is defined as toilet up-side-down for removing waste gas, oil, and co-produced sea-water, cheaply by burning the organic material in an open, uncontrolled manner, at an elevation off the ground varying from 15 to 75 meter or more. The elevation is to remove waste products and get them off from the work environment (Argo, 2002).It has been observed that people who lived and work close to the industry from 0.2km up to 35+km are prone to multiple flaring discharges (Argo, 2002).



Source: Field work, 2023

**Fig 1 .Picture of Gas Flaring in Bonny, Nigeria.**

Cedigaz (2000) has reported that Nigeria ranked the highest in natural gas flaring worldwide, (19.79%) and is contributes to about 46 % of Africa's overall gas flared. Presently, there are so many flaring locations in the region; this led to Nigeria topping the list of greenhouse emitter of gases in Africa (Uyigue and Agho, 2007). A lot of the natural gas obtained from oil wells in the region is flared into the open environment at approximately 70 million /m3 per day. This amounts to 40% of African total natural gas consumption and occupy a major position globally with regard to greenhouse gas emissions (Friends of the earth, 2008 and World bank, 2008, Moffat and Linden, 1995). In a study that compared polluted air accumulation within the area under study, it was shown that pollutant concentrations were much higher in the Niger delta areas and that some greenhouse gasses emitted in these areas contribute significantly to global warming. (Orubu, 2002b).

## 2.2 Air Quality Assessment

Air Quality Assessment is a process used to identify and evaluate the dispersal of pollutants and other elements in the atmosphere that may adversely affect public health or welfare, as well as the environment. This assessment is normally conducted on a regional or local scale, and involves collecting and analyzing data on existing levels of pollutants, emission sources, and ambient concentrations (U.S. EPA, 2020).

The assessment of air quality involves four key steps. First, the source, characteristics, and magnitude of pollutants must be identified. This necessitates the gathering of data on the sources of emission and their associated pollutants. The data may consist of information on chemical composition, emissions rate, persistence, and reactivity (Mirkin et al., 2021), as well as summaries of regulatory requirements, meteorological conditions, and the presence of topographic features. The data can be obtained directly from pollution sources or indirectly from monitoring stations.

The second step is the comparison of the pollutant concentrations observed in the atmosphere to health-based standards as determined by regulatory authorities. This comparison helps to determine the atmospheric concentrations of the pollutants that may represent a potential hazard to human health or welfare. Standards serving as the point of comparison may include primary, secondary, or international standards (Nasir et al., 2018).

The third step is the evaluation of the potential health and welfare impact of the observed concentrations of pollutants. This entails an assessment of the risk associated with the air pollutant concentration. This assessment considers the effects of the pollutants on humans, as well as their impact on the environment.

Finally, the fourth step is the development and implementation of strategies for mitigating the air pollution. Strategies may include regulation of emissions from existing sources, regulations on new sources of emissions, incentives for reducing emissions, and provision of public guidance on reducing the impact of emissions (Hossain et al., 2020).

In conclusion, air quality assessment is a comprehensive process for assessing the dispersal of pollutants in the atmosphere and the potential effects on human health. This assessment helps to inform the regulatory agencies of the necessary strategies for mitigating air pollution and protecting public health and welfare.

## 2.3 Oil Exploration in the Niger Delta Region

Oil exploration and exploitation in the Niger Delta region have been an ongoing issue with both positive and negative impacts to the local population and ecosystems. Additionally, the region is home to some of the largest oil fields in the world and produces a large share of Nigeria's government revenues. In spite of this, the population in the region remains largely impoverished and a significant portion of the region remains ecologically degraded due to decades of unchecked oil exploration and exploitation (Udoidem, 2015).

The history of oil exploration in the region dates back to the 1950s with Shell Oil leading the way. The region quickly became where major quantities of oil deposits were found and production began in 1958, resulting in heavy investments, extraction, and activities that transformed the region from a seasonal fishing and agricultural area to the hub of Nigeria's oil production (Udoidem, 2015). Multinational oil companies were attracted to the region due to its lucrative oil reserves and for several decades operated their activities largely unmonitored and unchecked. This resulted in numerous environmental concerns, such as oil spills, gas flares, air pollution, and deforestation which continue to this day, despite increased awareness.

The economic impacts of oil exploration in the Niger Delta are also of significant concern. It is estimated that oil deposits in the region account for roughly 40 to 50 percent of Nigeria's oil revenue, with the largest portion coming from production (Hogben, 2018). This revenue is vitally important to Nigeria's economy as it accounts for the approximately 90 percent of government revenue and provides income to many local people. This revenue has created both economic opportunities for individuals in the region as well as a growth in the industry as a whole.

Despite the potential economic benefits, there have been numerous calls to increase oversight of the oil industry in the Niger Delta region due to issues of corruption. Many oil companies have been accused of violating environmental regulations, bribing local officials, and engaging in money laundering activities (Udoidem, 2015). Additionally, oil spillage has continued and has been linked to significant economic losses for the people of the region due to loss of fisheries and agricultural land.

Due to these concerns, steps must be taken to ensure that oil exploration in the Niger Delta is conducted in a transparent, equitable, and environmentally responsible manner. In addition to the prohibition of illegal activities and strict penalties for violating regulations, this would include an effective monitoring system of all extraction activities and increased communication between the oil companies and local communities (Erari, 2017). It is also important to improve access to quality data on the environmental and economic impacts of oil extraction so that stakeholders can more effectively assess the costs and benefits associated with the activity.

In conclusion, oil exploration in the Niger Delta has the potential to bring significant economic rewards to the region while causing significant ecological damage. This problem is significant and solutions must be sought to protect the environment and ensure that oil exploration is conducted in an ethical and equitable manner. The task is daunting, however, with changes in transparency and oversight within oil companies and increased communication between stakeholders, progress may yet be made.

## 2.4 Theoretical Framework

This paper employs Exposure Risk Theory, which centers on the potential hydrocarbon exposure incidents inherent in oil exploration and production (Rivera, 2008). This theory holds substantial significance within the oil industry as it plays a pivotal role in determining the overall success of oil development endeavors. The concept of exposure risk theory was initially formulated by Robert King in the late 1970s (King, 1982). King's proposal revolved around utilizing risk analysis principles to predict and manage potential exposure incidents. He asserted that addressing the underlying factors governing exposure could mitigate the risks of adverse events related to exposure (King, 1982). Subsequent researchers in the field have further refined this theory (Blaney, Davis & Downey, 2010).

Supporters of exposure risk theory contend that its application offers a structured and systematic approach to comprehending and minimizing the hazards linked to hydrocarbon exposure during oil operations (Blaney, Davis & Downey, 2010). By focusing on probability and consequences, this theory enables oil companies to assess and manage risks effectively. This theory has garnered favor due to its practical implications in devising safety protocols, implementing preventive measures, and safeguarding the health of both the workforce and local communities (Walker & Gray, 2018). Moreover, exposure risk theory aligns with contemporary risk management strategies, emphasizing the importance of proactive prevention and mitigation in high-risk industries such as oil exploration.

Critics of exposure risk theory argue that its application may oversimplify the complexities involved in oil exploration's environmental and health impacts (Paul, 2018). While the theory addresses exposure-related incidents, it may not fully account for the cumulative and long-term effects of hydrocarbon exposure on ecosystems and human health. Additionally, some critics contend that the theory's focus on probabilities and consequences may overlook the broader socio-economic factors that exacerbate health risks, particularly in vulnerable communities (Henry *et al.*, 2015). They emphasize the need to contextualize exposure risk within a comprehensive framework that encompasses both environmental and social determinants of health.

As the researcher, I recognize the potential of exposure risk theory as a valuable tool for managing the environmental and health impacts of oil exploration, particularly in regions like Rivers State. This theory offers a structured framework for oil companies to assess, prevent, and manage potential exposure incidents. However, it is equally important to acknowledge the limitations of the theory, especially in capturing the multifaceted nature of the impacts and the intricate interplay between environmental, social, and health factors. Therefore, a balanced approach should be

Journal of Environment
ISSN 2789-3863 (Online)
Vol. 3, Issue No. 2, pp 26 - 40, 2023
www.carijournals.org

adopted that combines exposure risk theory with broader contextual understanding to ensure effective risk management strategies that address the complex challenges posed by oil exploration in the Niger Delta.

## 3. RESEARCH METHODOLOGY

The study adopted an experimental research design which focused on air quality analysis in the towns of Bonny, Degema and Bille in Rivers State. Data was collected from the towns and then subjected to laboratory analysis to analyze the quality of air. The findings of the analysis were then compared to World Health Organization (WHO) air quality guidelines. This was done to measure the health impacts of air quality and its potential to cause health problems. The results of the study can be used to inform health and environmental policy decisions in the region. Overall, the study was a useful approach to better understand air quality in the selected towns.

## 4. DATA PRESENTATION AND ANALYSIS

### 4.1 Air Quality of Bonny, Bille and Degema Town, Rivers State

**Table 4.3 Air Quality of Bonny, Bille and Degema Town, Rivers State**

| Parameter | Bonny | Bille | Degema Town | P-value | Standard/ Authorities |
|---|---|---|---|---|---|
| HCHO | 0.015±0.001[a] | 0.000±0.001[b] | 0.001±0.001 | 0.000 | 0.01 |
| PM2.5 | 51.33±3.51[a] | 18.17±0.76[b] | 8.84±3.12[c] | 0.000 | 12 |
| PM1.0 | 56.67±17.79[a] | 33.46±0.56[ab] | 19.94±3.97[b] | 0.014 | |
| PM10 | 74.33±3.06[a] | 38.11±0.90[b] | 19.18±13.04[b] | 0.000 | |
| Temperature (OC) | 34.33±0.56[a] | 31.00±3.61[a] | 31.02±2.55[a] | 0.293 | |
| Relative Humidity (%) | 89.33±3.22[a] | 64.00±0.00[b] | 62.80±5.65[b] | 0.000 | |
| TVOC (ppm) | 0.064±0.007[a] | 0.057±0.072[a] | 0.010±0.008[a] | 0.300 | |
| Noise (dB) | 92.67±11.22[a] | 74.95±1.54[a] | 59.67±2.08[a] | 0.169 | |
| $O_3$ (ppm) | 0.029±0.018[a] | 0.017±0.001[b] | 0.010±0.002[a] | 0.003 | |

| | | | | | |
|---|---|---|---|---|---|
| $SO_2$ (ppm) | 0.003±0.001[a] | 0.001±0.001[b] | 0.001±0.001[b] | 0.003 | 0.10ppm (FEPA, 1999). |
| $NH_3$ (ppm) | 0.006±0.008[a] | 0.001±0.001[a] | 0.001±0.001[a] | 0.293 | 0.30ppm (FEPA, 1999) |
| CO (ppm) | 3.250±0.355[a] | 1.073±0.137[a] | 0.218±0.032[a] | 0.000 | 10.0ppm (FEPA, 1991) |
| $NO_2$ (ppm) | 0.0183±0.006[C] | 0.153±0.006[b] | 0.006±0.085[a] | 0.000 | 0.06ppm (FEPA,1991) |
| $H_2S$ (ppm) | 0.123±0.896[a] | 0.117±0.015[a] | 0.001±0.001[a] | 0.050 | 0.10 (FEPA, 1991) |
| $CH_4$ (ppm) | 0.392±0.526[a] | 0.022±0.009[a] | 0.013±0.001[a] | 0.293 | |

## 4.2 Discussion of Findings

### 4.2.1 Air Quality Parameters of the Study Areas

Niger River Delta provides economic strength to Nigeria which among the comity of Nations, is regarded as Africa's largest economy and one of the most endowed country of the world. Over the years, this natural endowment which expectedly should have enhanced the regional peoples' welfare contrarily, its economic activities have compounded the health of the people with adverse health conditions due to the release of various noxious gases in the environment of the region. The situation is worse in the Niger Delta region of Nigeria where there are over 1000 gas flaring points.

A couple of studies have been conducted on air quality in Niger Delta and their findings have revealed a very high level of toxic substances in the atmosphere (Ebong, 2015; Ite, 2013).

However, little or nothings has been done by relevant authorities to reduce or control air pollution in the region under investigation thereby containing the associated health implications on human. Following the discovery of crude oil in Niger Delta region in 1956, the zone has been afflicted with series of intense negative environmental consequences of oil and the associated activities. Empirical evidences have shown that the major air pollutants in Niger Delta area of Nigeria are $CO_2$, $CH_4$, $SO_2$, $N_2O$, $NO_2$, $NH_3$, VOCs, SPM, PAHs and trace metals (Tawari and Abowei, 2012) while recently conducted studies have shown that vehicular emissions and fumes pollute the air environment with toxic gases and particulates more than any other single human activity (Cadle *et al.*, 2003).

In light of these observations, the results of this study show that Nitrogen (iv) Oxide ($NO_2$) ranged from 0.006±0.085ppm to 0.0183±0.006ppm in Stations 3 and 1. There was significant difference

($P<0.05$) among the $NO_2$ levels across the various communities of Niger Delta investigated in this study. Concentrations of nitrogen (IV) oxide (NO2) obtained in this study obtained in this study could be due to higher levels of vehicular emission in Bonny as compared to Degema.

However, this value is high just like a previous report documented by Ebong and Mkpenie (2016) whose $NO_2$ values varied between 0.10 and 0.40ppm in Uyo metropolis of Akaw-Ibom State, Niger Delta Nigeria. The distribution of $NO_2$ in the study area showed significant temporal variation. However, the range of $NO_2$ concentration observed in this study is consistent with the account of Udotong (2015) who recorded values lower than 0.73 – 0. 84ppm as reported by Adelagun *et al.* (2012). The values of $NO_2$ observed in this study was higher than 0.00 - 0.00ppm obtained in University Park by Tse and Oguama (2014). The mean concentration of $NO_2$ recorded in Bonny in this research was lower than the 0.06ppm limit by FEPA (1991) for the gas in atmosphere. Thus, a prolonged inhalation of air from the study area may affect the lung and throat of human exposed to (Hernandez-Garduno et al., 1997; Peters et al., 1997). The levels of $NO_2$ observed in this study is also capable of elevating morbidity and mortality in young children, those suffering from asthma and chronic bronchitis upon prolonged exposure to it (Morris and Naumova, 1998).

However, Savile (1993) reported that, highly congested cities can contribute as high as 90 – 95% of the ambient CO, 80 – 90% level of NOx and considerable amounts of particulates thereby inflicting some health problems on the inhabitants. Studies have shown that, Nigeria's carbon dioxide emissions from industrial processes estimated at 96513 million metric tons in 1992 was the highest in sub-Saharan Africa, excluding Republic of South Africa. The emission from gas flaring alone contributed more than one half of this figure.

Sulphur (iv) oxide 0.001±0.001ppm to 0.03±0.001ppm in Degema Town and Bonny respectively (Table 3). This level of $SO_2$ observed in this study, especially in Bonny could be due to the activities of oil multinationals and oil and gas exploration and other possible sources of air pollution like power and heat generation, industrial processes, road construction and burning of solid wastes. Man in his quest to live a comfortable life on earth, has introduce some dangerous gases into the atmosphere thereby changing the composition of air environment from its original status. However, human beings need clean air that can protect them from the hostile environment of the upper atmosphere. The introduction of high levels of foreign elements into the atmosphere by the activities of man has polluted the air environment making it injurious to biological communities. This could be also connected with the reports of Ebong and Mkpenie (2016) who posited that man in his quest to live a comfortable life on earth, has introduce some dangerous gases into the atmosphere thereby changing the composition of air environment from its original status. However, human beings need clean air that can protect them from the hostile environment of the upper atmosphere. The authors further posited that the introduction of high levels of foreign elements into the atmosphere by the activities of man has polluted the air environment making it injurious to biological communities. However, this range is lower than 0.23 – 0.60ppm obtained by Adelagun et al. (2012) but slightly consistent with the 0.03 - 0.09ppm reported by Okunola et al. (2012). However, the concentration of $SO_2$ recorded in this study, particularly in Bonny was higher than 0.10ppm recommended by FEPA (1999). Thus, inhalations of air from these locations for a long time by human may cause respiratory problems and severe headache (Tse and Oguama, 2014). The elevated levels of $SO_2$ reported in this work especially in Bonny may be attributed to the high number of vehicles and industrial activities going on around these areas and this fact is consistent with the findings of Ukemenam, 2014 who posited that, vehicular emission is the major source of $SO_2$ in the air.

Concentrations of hydrogen sulphide ($H_2S$) obtained in this study ranged between 0.001±0.001ppm and 0.123±0.896ppm, especially in Bonny where the highest values were recorded. The range obtained in this study is higher than 0.15 - 0.50 reported by Asuoha and Osu (2015) but lower than 0.18 – 0.76ppm recorded by Aliyu et al. (2013). Distribution of $H_2S$ in the study area indicated a higher mean concentration in Bonny than in other locations of the study indicated in Table 4.3. Generally, the mean reported in Bonny in this study (0.123±0.896ppm) is higher than 0.10ppm recommended by FEPA (1991). The high concentrations of hydrogen sulphide in Bonny as observed in this study could be attributed to the heavy emissions from generators and vehicles, petroleum and petrochemical processes (Asuoha and Osu, 2015; Utang and Peterside, 2011). The elevated levels of $H_2S$ reported in this work should be controlled to avoid health implications associated with prolong exposure as reported by Hirch and Zavala (1999).

The present study also revealed that the levels of carbon (II) oxide (CO) varied between 0.218±0.032ppm and 3.250±0.355ppm in Degema Town and Bonny respectively. There was no significant difference (P>0.05) in the level of Co in the study. Though these range were below acceptable limit, they cannot be unconnected to vehicles and traffic congestion experience in the area (Ukemenam, 2014), particularly in Bonny. This range is higher than 1.83 -2.17ppm recorded by Magaji and Hassan (2015) but lower than 30 -70ppm reported by Adelagun et al. (2012). The highest mean concentration of CO (3.250±0.355ppm) obtained in Bonny this study is lower than 10ppm recommended as limit in the atmosphere by FEPA (1991). However, empirical evidences have revealed that prolonged exposure to this elevated level of CO especially at higher concentrations could result in death as the gas combine readily with hemoglobin in red blood displacing oxygen and forming insoluble carboxyhemoglobin is formed (Raaschou-Nelson, 1995). Though the level of CO in this study were below acceptable limits, previous studies have shown that CO is asphyxiate can cause tissue damage after prolong exposure and its affinity for haemoglobin is almost 220 times greater than that of oxygen (Horsfall & Spiff, 1998).

The present study revealed that the level of $NH_3$ ranged from .001±0.001ppm to 0.006±0.008ppm in Degema Town and Bonny communities respectively. There was no significant difference in the ammonia concentration across the various locations of the study respectively. The concentrations of ammonia recorded may be attributed to vehicular emission and volatilization from soils and ocean as reported by Behera et al. (2013). This level of ammonia is consistent with 0.00 – 3.00ppm reported by Tse and Oguama (2014) and 0.01 – 0.03ppm obtained by Ukpong (2012). The mean concentration of ammonia obtained in this study is lower than 0.30ppm limit recommended in atmosphere by FEPA (1999). Consequently, concentrations of ammonia reported in this study if not controlled may cause health problems in human associated problems elevated $NH_3$ in air as reported by ATSDR (2004), especially in Bonny.

## 5. CONCLUSION AND RECOMMENDATION

### 5.1 Conclusion

The study's findings demonstrated varying levels of pollutants and environmental factors across the investigated communities. Methanal ranged from 0.001±0.001mg/m3 in Bille to 0.015±0.001mg/m3 in Bonny, with significant differences observed. PM2.5 concentrations spanned 8.84±3.12mg/m3 in Degema Town to 51.33±3.51mg/m3 in Bonny, while PM1.0 ranged from 19.94±3.97mg/m3 to 56.67±17.79mg/m3, revealing significant differences. PM10 levels ranged from 19.18±13.04mg/m3 in Degema to 74.33±3.06mg/m3 in Bonny, also with significant differences. Temperature ranged from 31.00±3.61°C in Bille to 34.33±0.56°C in Bonny, showing no significant variation. Relative humidity ranged from 64.00±0.00% in Bille to 89.33±3.22% in Bonny, with significant differences. TVOC ranged from 0.010±0.008ppm in Degema Town to 0.064±0.007ppm in Bonny, without significant variation. Noise levels ranged from 59.67±2.08dB to 92.67±11.22dB, with no significant differences. Ozone levels varied from 0.001±0.001ppm in Degema Town to 0.029±0.018ppm in Bonny, showing significant differences. Sulphur (iv) oxide ranged from 0.001±0.001ppm in Degema Town to 0.123±0.896ppm in Bonny, without significant differences. Nitrogen (iv) oxide ($NO_2$) concentrations spanned from 0.006±0.085ppm to 0.0183±0.006ppm, exhibiting significant differences across the Niger Delta communities studied.

The study's outcomes provide comprehensive insights into the varying levels of pollutants and environmental factors, revealing both significant disparities and commonalities across the communities investigated in the Niger Delta region.

### 5.2 Recommendations

Based on the identified findings, the following recommendations were made:

1. **Monitoring TVOC and $O_3$ Levels:** Given the noteworthy difference in ozone levels among communities, continuous monitoring of total volatile organic carbon (TVOC) and ozone ($O_3$) levels is crucial. Implementing strategies to curtail outdoor activities and emissions could effectively mitigate air pollution and its associated health risks.

2. **Protective Measures against Ozone Exposure:** Recognizing the elevated ozone concentrations in the Niger Delta compared to other areas, devising protective strategies against ozone-related health effects is paramount. Prioritizing air quality enhancement through tailored regulations is vital.

3. **$NO_2$ Monitoring and Reduction Strategies:** Addressing potential threats posed by nitrogen (IV) oxide ($NO_2$) demands ongoing monitoring and reduction strategies. Further research is

recommended to comprehensively monitor $NO_2$ levels and develop approaches to mitigate its presence in the air, thereby safeguarding local communities.

4. **Environmental Protection and Regulation:** Implementation of robust environmental protection strategies and regulations is indispensable to curbing $NO_2$ levels and countering the health consequences of ozone exposure. These measures must be tailored to the unique challenges of the Niger Delta, recognizing its heightened ozone concentrations.
5. **Enhanced Public Awareness:** Elevating public awareness about air pollution risks is crucial. Informing residents about potential health hazards associated with pollution and empowering them with actionable steps to protect themselves will be invaluable in promoting community well-being.
6. **Future Research Focus:** Further research endeavors should delve into understanding the health implications of pollutants analyzed in this study. By deepening our comprehension, we can make informed decisions to foster healthier living conditions for the Niger Delta population.

For Policy Makers in the Fuel and Environment Industry: This study underscores the necessity for proactive measures within the fuel and environment sector:

1. **Mitigating Noise Pollution:** Collaborate with local authorities to implement noise reduction policies and awareness campaigns to minimize noise pollution, thus contributing to enhanced community well-being.
2. **Air Quality Monitoring and Regulation:** Establish and reinforce air quality monitoring systems and regulations, with a special focus on TVOC, ozone, and $NO_2$, to ensure adherence to acceptable standards and safeguard public health.
3. **Emission Reduction Strategies:** Develop and implement emission reduction strategies targeting key pollutants, aligning with the study's recommendations to alleviate the impact of air pollution on communities.
4. **Community Engagement:** Engage with local communities to educate them about pollution risks and mitigation measures, fostering a sense of responsibility towards environmental protection.
5. **Research Collaboration:** Collaborate with research institutions to facilitate studies that deepen the understanding of pollutants' health implications, driving evidence-based policy decisions.

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Journal of Environment
ISSN 2789-3863 (Online)
Vol. 3, Issue No. 2, pp 26 - 40, 2023
www.carijournals.org

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