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Air Quality Assessment of Ubeji Community near Petroleum-Related Activities

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Abstract

The escalating global concern over air pollution requires rigorous investigations. This study assesses air quality near residential areas affected by petroleum-related activities in Ubeji Community, utilizing Aeroqual handheld mobile multi-gas monitors and air quality multi-meters. Air sampling occurred on three distinct days using multi-gas monitors and meters, covering parameters such as CO, NO_2, CH_4, NH_3, VOCs, Particulate Matter, Temperature, Relative Humidity, and Air Quality Index. Soil and plant samples were collected and analyzed for physicochemical and organic components. Air pollutant concentrations showed significant fluctuations. Carbon monoxide (CO) ranged from 0.00 to 3.22 ppm, NO_2 from 0.00 to 0.10 ppm, CH_4 from 4.00 to 2083 ppm, NH_3 from 371 to 5086 ppm, and VOCs from 414 to 6135 ppm. Soil analysis revealed low total nitrogen, and undetected BTEX levels. Plant samples displayed a pH range of 7.72 to 9.45. CO concentrations, although below WHO limits, indicated potential vehicular and industrial influences. Fluctuations in NO_2 and CH_4 were linked to traffic, industrial activities, and gas flaring. NH_3 levels suggested diverse pollution sources. The result in this study highlights the dynamic nature of air pollution in Ubeji community, emphasizing the urgent need for effective pollution control measures. Although CO concentrations were within limits, continuous monitoring is essential. Elevated NO_2 levels gave information on the impact of industrial activities, while high CH_4 concentrations may be associated with gas flaring and illegal refining. The study recommends comprehensive measures and collaborative efforts to address these complex issues, safeguarding both the environment and public health. This study shows the potential syn-

ergy between air quality sensors and plants for holistic environmental health assessments, offering valuable insights for environmental assessments and remediation endeavours. The findings call for stringent regulations and collaborative efforts to address air pollution in Ubeji community comprehensively.

Keywords

Air Quality Assessment, Bioindicators, Ubeji Community, Pollution Assessment

1. Introduction

Air pollution is a global public health crisis and an alarming environmental concern, causing an estimated 2 million deaths due to indoor pollution and 1.3 million deaths from outdoor pollution worldwide, with the most severe impacts observed in developing nations [1]. The surge in air pollution levels can be attributed to human activities, particularly the rapid urbanization, industrialization, and overpopulation trends [2]. These activities have dire consequences, resulting in the depletion of forest reserves, which serve as critical carbon sinks, and widespread environmental degradation, encompassing soil, plant, and air contamination [3].

Industrial expansion plays a pivotal role in exacerbating air pollution, as demonstrated by over 40% of China's mainland being affected by industrial pollution [4]. These industrial operations discharge hazardous chemicals, including volatile organics, heavy metals, and toxic organic micro-pollutants, thereby posing significant threats to biodiversity, public health, and structural integrity [5] [6]. The Niger Delta region in Nigeria, a significant industrial hub, features both upstream and downstream petroleum sectors, along with other activities like biomass combustion and traffic emissions, emitting volatile organics, carbon, nitrogen, Sulphur oxides, particulate matter, heavy metals, and other toxins into the atmosphere [7]. These emissions contribute to acid rain formation, water and soil pollution, and a decline in the quality of flora, fauna, and material resources.

Assessing air quality holds a pivotal role in identifying areas with deteriorating air quality and in monitoring pollution trends over time. While traditional methods such as stationary monitoring stations and satellite imagery remain common practices, recent research has shown the efficacy of using plants and handheld air quality devices for such assessments [8] [9] [10]. Plants have proven their worth as bioindicators, showcasing sensitivity to a wide array of pollutants and offering continuous, long-term records of air pollution dynamics, which is invaluable for tracking changes in air quality, especially in regions where conventional monitoring infrastructure is lacking or not available [11]. Nonetheless, interpreting physiological changes in plants can be intricate and

may not always straightforwardly correlate with alterations in air quality [12]. Moreover, certain pollutants, such as particulate matter (PM), which directly impact human health, may not be effectively measured using plant bioindicators [13]. Similarly, handheld air quality devices have gained prominence as portable tools for air quality assessment [14]. These compact devices can measure a range of pollutants, including PM, O_3, NO_x, and SO_x across various settings, providing real-time data that is invaluable for pinpointing areas with elevated pollution levels. Nonetheless, it is essential to recognize that the accuracy of these devices can vary widely, potentially compromising data reliability [15].

Both plant-based bioindicators and handheld devices hold promise for air quality assessment, with plants furnishing long-term records but posing interpretational challenges, while handheld devices deliver portability and real-time data but are subject to accuracy and cost considerations. Given the concerns surrounding air quality in the Ubeji community, heightened by industrial operations and human activities like increased petroleum tanker traffic, urbanization, and environmental deterioration, the importance of conducting a comprehensive air quality assessment in this area becomes abundantly clear. This study aims to assess air quality in Petroleum prone area of Ubeji community, utilizing air quality sensors and a plant.

2. Research Methodology

2.1. Study Area

The area of focus in this study is Ubeji community of Warri South Local government area, Delta State. Ubeji Community is an Itsekiri community located in the Warri South Local Government Area of Delta State, Nigeria. It is a suburb of the City of Warri and shares boundaries with Ifie Community, Aja-Etan Community, Ijala-Ikenren Community, and Ekpan Community. Ubeji Community is near the Warri Refinery and Petrochemical Company (WRPC) in Ekpan, and as such, suffers huge environmental pollution in the form of air pollution majorly and frequent spills around the community primarily due to pipeline leakage.

Samples were taken from three (3) locations around Ubeji community, and a control point as shown in **Figure 1** below. The sampling represented random sampling strategy that utilized a means to cover residential houses around the WRPC and farm tank areas around the community. The control sample was in the Department of Environmental Management and Toxicology, University of Petroleum Resources Effurun Delta state.

2.2. Air Quality Assessment

Air sampling was conducted on 26th of October 2021, November 22nd, 2021, and April 4th 2022, all tagged as Day 1, 2 and 3 respectively. Sampling was carried out using an Aeroqual handheld mobile multi-gas monitor fitted with different sensors of (Carbon Monoxide (CO), NH_3, CH_4, and NO_2, while air quality multi-meter was used for Particulate Matter (PM1.0, PM2.5 and PM10),

Figure 1. Sampling areas.

Volatile Organic (VOC), Temperature and Relative Humidity was used for the collection of air quality parameters. Data was collected in triplicates and the mean concentration recorded.

2.3. Plant and Soil Samples Analysis

The dried corn seeds were planted and placed in four designated locations of the study area and left to grow for a period of four months, and a control sample was placed in the Department of Environmental Management and Toxicology, FUPRE. During the period of the four months the plants were watered daily to aid proper growth (**Figure 2**, **Figure 3**).

Physico-Chemical Analysis of Soil and Plant

1) pH

A pH meter calibrated using buffer 7.0 and 4.0 was used for this study.

2) Total Nitrogen

The study utilized the Kjeldahl method for the assessment of total nitrogen in the soil samples.

3) Soil Moisture Content

The moisture content of the soil samples was determined using the gravimetric method of analysis.

4) Soil Electrical Conductivity

Electrical conductivity in the soil samples was determined using a calibrated conductivity meter following a standardized procedure, where 20 grams of air-dried soil was combined with 20 milliliters of distilled water in a 50-milliliter

beaker, allowing it to stand for 30 minutes with intermittent stirring using a glass rod; subsequently, the electrode of the conductivity meter was inserted into the settled solution to obtain the measurement.

5) Soil Phosphorus

The available phosphorus content in soil samples for this study was determined using a method that involved shaking 5.0 g of oven-dried soil with 100 ml of an extracting solution for 30 minutes. After filtration and subsequent chemical reactions, absorbance measurements were taken at 720 nm to calculate the available phosphorus content in milligrams per kilogram (mg/kg) of soil.

Figure 2. Soil samples used for plant cultivation in this study.

Figure 3. Plants (bioindicator) from the study location before harvesting.

6) Soil Organic Carbon

The study utilized the Kjeldahl method for the assessment of total nitrogen in the soil samples.

In this study, organic carbon in soil samples was determined using a method that involved weighing soil samples into 250 ml conical flasks, adding $K_2Cr_2O_7$, H_2SO_4, and o-phosphoric acid, and conducting titrations with 0.5N Ferrous ammonium to observe color changes for the end point. The % TOC was then calculated using the formula.

$$\%\ \mathrm{TOC} = \frac{\left(\mathrm{mLFe}^{2+}\ \text{for blank} - \mathrm{mLFe}^{2+}\ \text{for sample}\right)}{\left(\mathrm{Wfofsoiling}\right) \times \text{Normality of}\ \mathrm{Fe}^{2+} \times 0.390} \tag{1}$$

7) Total Petroleum Hydrocarbon (TPH)

In the analysis of total petroleum hydrocarbon (TPH), the method of [16], was utilized. A 50:50 solvent mix of acetone and methylene chloride was prepared, and 10 g of a well-mixed sample was combined with 50 ml of the solvent mix. After sonication for 15 minutes at 70˚C and the addition of anhydrous sodium sulphate to obtain a clear extract, the sample was fractionated into aliphatic and aromatic fractions using silica. The analysis was conducted using a Gas Chromatography system 6890 series and 6890 plus, with specific instrument settings.

8) Benzene, Toluene, Ethylbenzene, and Xylene (BTEX)

For the determination of BTEX (Benzene, Toluene, Ethylbenzene, and Xylene), the method utilized by [17] was used with slight modification. A 5 g of the soil sample was weighed and placed in a headspace sampling vial, and 5 ml of water was added before sealing. The vial was transferred to the headspace for sampling, and the analysis was carried out using Gas Chromatography system 5890 series, with instrument settings.

3. Results and Discussion

3.1. Concentration of Air Pollutants in Residential Areas around WRPC

The concentrations of air quality parameters namely, CO, NO_2, CH_4, NH_3, and VOCs are depicted in **Figure 4** below. The concentration of CO in Ubeji community showed significant fluctuations over these two days. On Day 1, Location B exhibited the highest CO level at 3.22 ppm, decreasing slightly to 3.16 ppm on Day 2, whereas Location A, initially registering 2.29 ppm on Day 1, experienced a complete absence of CO with a reading of 0.00 ppm on Day 2, indicating potential sources of fluctuation.

One significant factor contributing to such variations could be heavy vehicular traffic and emissions from the nearby Warri Refinery. This industrial complex is known for its significant CO emissions. The variations in CO levels may also be influenced by gas flaring, which is common in oil-producing regions. The results of the CO concentration in the study were found to be below the permissible limit set by the World Health Organization (WHO) of 5 ppm.

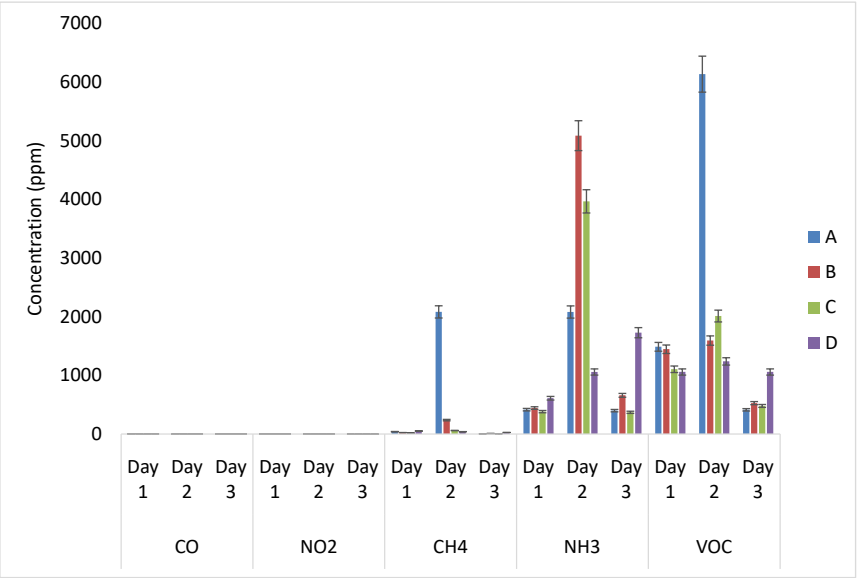

Figure 4. Air quality parameters in Ubeji Community.

For NO_2, fluctuations were observed as well. On Day 1, NO_2 concentrations varied between 0.015 ppm at Location A and 0.031 ppm at Location B, while on Day 2, the range expanded from 0.080 ppm at Location A to 0.099 ppm at Locations C and D. These fluctuations might be related to changes in traffic patterns, industrial activities, or even weather conditions. The concentrations of NO_2 in this study was below the permissible limit set by the WHO of 0.1ppm.

The CH_4 concentration exhibited fluctuations across the two days, with Location D registering 53 ppm and Location A recording 42 ppm on Day 1, while on Day 2, Location B showed a notable increase to 239 ppm. Such fluctuations could be linked to gas flaring or even the release of air pollutants due to illegal refining in the vicinity. CH_4 in this study was above the permissible limit set by WHO (100 ppm).

The concentrations of NH_3 exhibited significant variations over the three days of monitoring. On Day 1, levels ranged from 383 ppm at Location C to 611 ppm at Location D, while on Day 2, concentrations spanned from 1058 ppm at Location D to 5086 ppm at Location B. The significant increase in NH_3 levels observed in Location B on Day 2 suggests a potential influence from industrial or refining activities. NH_3 concentrations on Day 3 showed a range from 371 ppm (Location C) to 1728 ppm (Location D). The substantial rise in NH_3 levels, particularly in Location D, on Day 3 may indicate increased pollution sources or fluctuations in local industrial activities.

The concentrations of VOCs exhibited variations, with Location A registering the highest concentration at 2083 ppm on Day 1, while Location B recorded the peak level at 5086 ppm on Day 2. These fluctuations could result from factors such as industrial processes, emissions from refineries, and perhaps even illegal refining operations in the area. VOC concentrations on Day 3 ranged from 414 ppm (Location A) to 1059 ppm (Location D). Like previous days, fluctuations in

VOC levels may be attributed to industrial processes, gas flaring, and possible illegal refining operations. The concentration of VOC recorded in this study was higher than WHO permissible limit (75 ppm).

The fluctuations in air quality parameters across the three days could be influenced by a combination of factors, including heavy vehicular traffic, emissions from nearby industrial facilities, gas flaring activities, and the release of air pollutants due to illegal refining operations in the area. These findings highlight the complex and dynamic nature of air pollution in Ubeji Community and emphasize the urgent need for effective pollution control measures and regulations to safeguard the environment and public health in this region.

Figure 5 below provides a detailed overview of the Air Quality Index (AQI), particulate matter concentrations, relative humidity (RH), and temperature (Temp) recorded during each of these days.

On Day 1, the AQI ranged from 50$ to 68%, with Locations C and B recording the lowest at 50%, followed by Location D (60%) and A (68%). On Day 2, the AQI fluctuated between 17 and 25%, with Location C recording the lowest at 17%, followed by Locations D (19%), A (22%), and B (25%). On Day 3, the AQI varied between 5 and 8%, with Location D recording the lowest at 5%, followed by Locations B (6%), A (7%), and C (8%).

On Day 1, PM_{10} concentration ranged from 37 to 67 μg/m^3, with Location C recording the lowest at 37 μg/m^3, followed by Locations B and A (40 and 52 μg/m^3), and D recording the highest at 67 μg/m^3. On Day 2, PM_{10} concentration varied from 19 to 27 μg/m^3, with Location C recording the lowest at 19 μg/m^3, followed by Locations A and D (22 and 23 μg/m^3), and B recording the highest at 27 μg/m^3. On Day 3, PM_{10} concentration ranged from 6 to 9 μg/m^3, with Locations B and A recording the lowest at 6 and 8 μg/m^3, followed by Locations D and C (9 μg/m^3).

On Day 1, $PM_{2.5}$ levels fluctuated between 34 and 51 μg/m^3, with Location C recording the lowest at 34 μg/m^3, followed by Locations B and A (38 and 42 μg/m^3), and D recording the highest at 51 μg/m^3. On Day 2, $PM_{2.5}$ levels ranged from 17 to 26 μg/m^3, with Location C recording the lowest at 17 μg/m^3, followed by Locations A and D (20 and 22 μg/m^3), and B recording the highest at 26 μg/m^3. On Day 3, $PM_{2.5}$ levels spanned from 5 to 8 μg/m^3, with Location D recording the lowest at 5 μg/m^3, followed by Locations B (6 μg/m^3), A (7 μg/m^3), and C (8 μg/m^3).

On Day 1, the temperature ranged from 33˚C to 34˚C, with Locations C and B recording the lowest at 33˚C and 32.6˚C, followed by Locations A (34˚C) and D recording the highest at 34˚C. On Day 2, the temperature ranged from 26.1˚C to 28.7˚C, with Locations B and A recording the lowest at 26.1˚C and 27.3˚C, followed by Locations C (27.4˚C) and D recording the highest at 28.7˚C. On Day 3, the temperature ranged from 33.3˚C to 36.2˚C, with Location C recording the lowest at 33.3˚C, followed by Locations B (33.6˚C), A (35.4˚C), and D recording the highest at 36.2˚C.

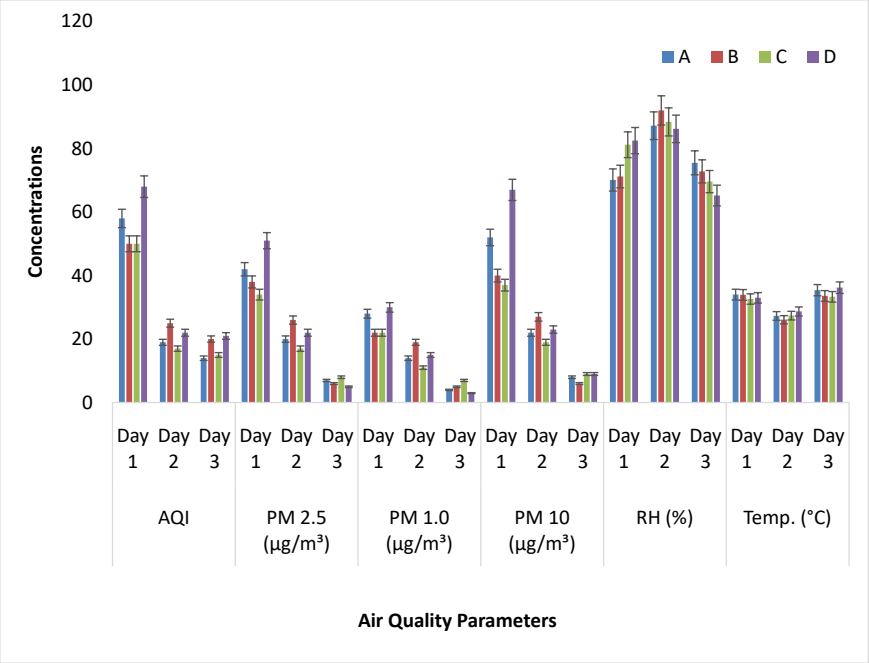

Figure 5. Concentrations of air quality parameters in Ubeji Community across three distinct sampling days.

On Day 1, $PM_{1.0}$ concentration ranged from 22 to 30 µg/m^3, with Locations B and C recording the lowest at 22 µg/m^3, followed by Locations A (28 µg/m^3) and D recording the highest at 30 µg/m^3. On Day 2, $PM_{1.0}$ concentration spanned from 11 to 19 µg/m^3, with Location C recording the lowest at 11 µg/m^3, followed by Locations A and D (14 and 15 µg/m^3), and B recording the highest at 19 µg/m^3. On Day 3, $PM_{1.0}$ concentration ranged from 3 to 7 µg/m^3, with Location D recording the lowest at 3 µg/m^3, followed by Locations B (5 µg/m^3), A (4 µg/m^3), and C recording the highest at 7 µg/m^3.

On Day 1, relative humidity varied between 70.1% and 82.5%, with Locations B and A recording the lowest at 70.1% and 71.2%, followed by Locations C (81.2%) and D recording the highest at 82.5%. On Day 2, relative humidity ranged from 26.1% to 92.0%, with Locations B and C recording the lowest at 26.1% and 27.4%, followed by Locations A (27.3%) and D recording the highest at 92.0%. On Day 3, relative humidity varied from 65.2% to 75.5%, with Location D recording the lowest at 65.2%, followed by Locations C (69.9%), A (72.8%), and B recording the highest at 75.5%.

The significant fluctuations observed in AQI and particulate matter levels across the three days of sampling may be attributed to various factors, including heavy vehicular traffic, industrial emissions from the nearby WRPC, gas flaring activities, and potentially the release of air pollutants due to illegal refining operations in the region.

These fluctuations reflect the dynamic and complex nature of air quality in Ubeji Community, where various industrial activities and environmental challenges interact. Effective pollution control measures, stringent regulations, and a

collaborative effort among local authorities, environmental agencies, and industries are vital to address these issues comprehensively and safeguard the environment and public health in this region.

Although the CO concentration was below the permissible limit, there is a need for continuous assessment and monitoring and implementing pollution containment and management systems. Additionally, regulating car internal combustion engines for better efficiency and reduced carbon emissions is necessary. In a study by [18], CO concentrations in residential buildings in Oleh community in the Isoko South Local Government Area of Delta State were found to be between 73,000 ppm to 125,000 ppm, which were higher than the results of this study. High concentrations of CO can cause various health effects such as headaches, dizziness, restlessness, tingling, difficulty breathing, sweating, tiredness, increased heart rate, elevated blood pressure, coma, asphyxia, and convulsions [19].

The elevated NO_2 levels were due to various activities in the community such as the frequent movement of tankers, caused by the presence of depots and tanker farms, leading to emissions from not just tankers but also cars, buses, and motorcycles. Additionally, past emissions from the WRPC refinery's burning of fossil fuels have altered the community's natural atmosphere. Long-term exposure to high levels of nitrogen dioxide can lead to chronic lung disease and increase a person's risk of respiratory infections and asthma [20]. NO_2 and other nitrogen oxides (NO_x) also contribute to acid rain, which can harm sensitive ecosystems such as lakes and forests [21].

In a study by [22], it was found that methane emission in mangroves is strongly affected by anthropogenic activities such as aquaculture and sewage. Mangroves with high human disturbance show significantly higher amounts of CH_4. Exposure to high levels of CH_4 can result in various health challenges such as reducing the amount of oxygen breathed from the air, causing mood changes, slurred speech, vision problems, memory loss, nausea, vomiting, facial flushing, headache, changes in breathing and heart rate, balance problems, numbness, and unconsciousness in severe cases.

A study in Uyo metropolis, a Niger Delta oil-producing state, categorized the potential causes of elevated ammonia and other pollutants into two factors: factor 1 represented the impact of fuel combustion and vehicular emissions, while factor 2 represented the influence of organic matter decomposition and petroleum processing [23]. The high concentration of ammonia observed during this study could have been caused by past activities of the WRPC refinery, as well as agricultural activities, decaying plants and animals, and high levels of vehicular emissions in the community.

Exposure to high concentrations of ammonia can result in severe health risks, such as immediate burning of the eyes, nose, throat, and respiratory tract. In severe cases, it can cause blindness, lung damage, or death. The severity of health effects depends on the route of exposure, the dose, and the duration of exposure [24].

VOCs pollution in Ubeji community may have resulted from the past industrial activities and vehicular emissions, VOCs are known to combine with oxides of nitrogen in the atmosphere to form tropospheric ozone, contributing to greenhouse gases and promoting climate change. VOCs are health hazard resulting in eye, nose, and throat irritation, headaches, loss of coordination, nausea, damage to liver, kidney, and central nervous system. Some organics can cause cancer in animals; some are suspected or known to cause cancer in humans. Key signs or symptoms associated with exposure to VOCs include conjunctival irritation, nose and throat discomfort, headache, allergic skin reaction, dyspnea, declines in serum cholinesterase levels, nausea, emesis, epistaxis, fatigue, and dizziness [25].

Particulate matter is mainly produced by combustion sources such as industrial facilities, diesel engine emissions, and the burning of wood and fossil fuels. Oxides of nitrogen are key precursors of particulate matter and were present in all four locations. Location D recorded the highest values of PM_{10}, $PM_{2.5}$, and $PM_{1.0}$ due to the catering activities that use firewood as an energy source for food production.

Exposure to particulate matter can have adverse health effects, especially in the short term. According to [26], hours to days of exposure can result in irritated eyes, nose, and throat, worsen asthma and lung diseases such as chronic bronchitis (COPD), and cause heart attacks and arrhythmias in people with heart disease.

The environmental impact of particulate pollution is significant as well. It contributes to acid rain and climate change, and can also change weather patterns, cause drought, contribute to global warming, and cause ocean acidification [27].

3.2. Concentration of Pollutants Found in Soil and Plant Samples in Study Area

The findings from the soil analysis, encompassing measurements of moisture content, Total Nitrogen, Total Organic Carbon, Total Petroleum Hydrocarbon (TPH), Benzene, Toluene, Ethylbenzene, and Xylene (BTEX), as well as Available Phosphorous are presented in Table 1 below.

Table 1. Concentrations of soil samples.

	Field Code	Moisture Content (%)	Total Nitrogen (%)	Total Organic Carbon (%)	TPH (mg/kg)	BTEX (mg/kg)	Available Phosphorous (mg/kg)
1	LOCATION A SOIL	0.39	0.014	1.72	9.069	<0.005	7.217
2	LOCATION B SOIL	0.24	0.012	2.34	0.840	<0.005	19.36
3	LOCATION C SOIL	0.31	0.013	2.22	19.723	<0.005	8.167
4	LOCATION D SOIL	0.21	0.011	1.89	20.904	<0.005	53.040
5	CONTROL SOIL	0.50	0.015	1.72	16.019	<0.005	36.403
6	INITIAL SOIL	0.45	0.015	1.72	0.006	<0.005	8.940

The moisture content of the soil exhibited a range from 0.50% to 0.21%, with the control sample displaying the highest moisture content, while the initial soil showed the lowest at 0.05%. Total Nitrogen concentration ranged from 0.15% to 0.11%, and Total Organic Carbon levels varied from 1.72% to 2.34%. Available Phosphorous content ranged from 53.040 mg/kg to 8.167 mg/kg, and Total Petroleum Hydrocarbon (TPH) levels were measured between 0.006 mg/kg and 20.904 mg/kg.

The concentration of Benzene, Toluene, Ethylbenzene, and Xylene (BTEX) in the soil samples was found to be below the detection limit of the instrument employed for analysis. These results provide critical insights into the composition of soil in the study area and offer valuable data for environmental assessments and remediation efforts.

The results of plant sample analysis, which encompass measurements of Total Organic Carbon, pH, Electrical Conductivity, Temperature, Total Petroleum Hydrocarbon (TPH), and Benzene, Toluene, Ethylbenzene, and Xylene (BTEX), are summarized in Table 2 below.

The pH levels in the plant samples ranged from 9.45 to 7.72, with location A and the control sample displaying the highest pH level of 9.45 each, while location D, B, and C had pH levels of 8.94, 8.09, and 7.72, respectively. Electrical conductivity measured in the plants exhibited a range from 571 to 6110 µS/cm, with the control plant and location C having the highest concentrations of 6110 and 1155 µS/cm, while location A, B, and D measured 906, 714, and 571 µS/cm, respectively. Total organic carbon content in the plant samples was not detected. The temperature levels varied from 26.5˚C to 26.3˚C, with location A and the control sample showing 26.5˚C, while location B, C, and D recorded 26.3˚C. The concentrations of Total petroleum hydrocarbon and Benzene, Toluene, Ethylbenzene, and Xylene (BTEX) in the plant samples were found to be below the detection limit of the instrument employed for analysis.

Total nitrogen is a major indicator for soil fertilty, Nitrogen is one of the major nutrients affecting soil fertility [28]. The soil levels of nitrogen form available to plants are generally low, and they range from 1% to 5% [29]. Although the concentration of TPH in the study area was below the permissible soil guideline value of 100 mg/kg. In a study conducted by [30] in oil impacted area in Abalagada-Aboh area in the Niger delta, the values of TPH concentrations varied significantly among various environmental matrices. The concentrations ranged

Table 2. Concentrations of total organic carbon, ph, electrical conductivity, temperature, BTEX, and TPH in plant samples.

S/N	Field Code	pH	Electrical Conductivity (uS/cm)	Total Organic Carbon (%)	Temperature (˚C)	BTEX (mg/kg)	TPH (mg/kg)
1	LOCATION A PLANT	9.45	906	ND	26.50	<0.005	<0.001
2	LOCATION B PLANT	8.09	714	ND	26.30	<0.005	<0.001
3	LOCATION C PLANT	7.72	1155	ND	26.30	<0.005	<0.001
4	LOCATION D PLANT	8.94	571	ND	26.30	<0.005	<0.001
5	CONTROL PLANT	9.45	6110	ND	26.50	<0.005	<0.001

widely between 2.80 - 786 mg/kg, 2.84 - 805 mg/kg, 0.30 - 865 mg/kg and 0.03 - 22.9 mg/kg for surface water, sediments, topsoil, and subsoil, respectively. Health disorders associated with exposure to TPH include skin and eye irritation, breathing and neurologic problems, and stress. TPH have a strong impact on mental health and induce physical/physiological effects, and they are potentially toxic to genetic, immune, and endocrine systems [31].

4. Conclusion

This research has revealed significant fluctuations in the concentrations of various air pollutants in residential areas surrounding the Warri Refinery and Petrochemical Company (WRPC). These fluctuations were observed in parameters such as CO, NO_2, CH_4, NH_3, VOCs, as well as the Air Quality Index (AQI) and particulate matter levels across three distinct sampling days. The variations in air quality parameters were found to be influenced by a combination of factors, including heavy vehicular traffic, emissions from nearby industrial facilities, gas flaring activities, and the release of air pollutants due to potential illegal refining operations in the area. These findings underscore the complex and dynamic nature of air pollution in Ubeji community. Furthermore, the assessment of soil and plant samples in the study area provided valuable insights into the composition of soil and plant samples. The absence of Benzene, Toluene, Ethylbenzene, and Xylene (BTEX) in both soil and plant samples was encouraging, as these compounds are known to be harmful to human health and the environment. The results indicated the urgent need for effective pollution control measures and stringent regulations to protect both the environment and public health in Ubeji community. Continuous monitoring and the implementation of pollution containment and management systems are essential. Additionally, measures such as regulating car internal combustion engines for better efficiency and reduced carbon emissions should be considered.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

References

[1] Manisalidis, I., Stavropoulou, E., Stavropoulos, A. and Bezirtzoglou, E. (2020) Environmental and Health Impacts of Air Pollution: A Review. *Frontiers in Public Health*, **8**, Article No. 14. https://doi.org/10.3389/fpubh.2020.00014

[2] Li, X., Yang, Y., Xu, X., Xu, C. and Hong, J. (2016) Air Pollution from Polycyclic Aromatic Hydrocarbons Generated by Human Activities and Their Health Effects in China. *Journal of Cleaner Production*, **112**, 1360-1367. https://doi.org/10.1016/j.jclepro.2015.05.077

[3] Etim, E.U. (2012) Estimation of Pollution Load from an Industrial Estate, South-Western Nigeria. *African Journal of Environmental Science and Technology*, **6**, 125-129. https://doi.org/10.5897/AJEST10.240

[4] Liu, Y., Zhou, Y. and Wu, W. (2015) Assessing the Impact of Population, Income and Technology on Energy Consumption and Industrial Pollutant Emissions in China. *Applied Energy*, **155**, 904-917. https://doi.org/10.1016/j.apenergy.2015.06.051

[5] Masindi, V. and Muedi, K.L. (2018) Environmental Contamination by Heavy Metals. *Heavy Metals*, **10**, 115-132. https://doi.org/10.5772/intechopen.76082

[6] Chavoshani, A., Hashemi, M., Mehdi Amin, M. and Ameta, S.C. (2020) Micropollutants and Challenges. In: *Emerging in the Aquatic Environments and Treatment Processes*, Elsevier, Amsterdam, 1-33. https://doi.org/10.1016/B978-0-12-818612-1.00001-5

[7] Echendu, A.J., Okafor, H.F. and Iyiola, O. (2022) Air Pollution, Climate Change and Ecosystem Health in the Niger Delta. *Social Sciences*, **11**, Article No. 525. https://doi.org/10.3390/socsci11110525

[8] Gadzała-Kopciuch, R., Berecka, B., Bartoszewicz, J. and Buszewski, B. (2004) Some Considerations about Bioindicators in Environmental Monitoring. *Polish Journal of Environmental Studies*, **13**, 453-462.

[9] Govindapyari, H., Leleeka, M., Nivedita, M. and Uniyal, P.L. (2010) Bryophytes: Indicators and Monitoring Agents of Pollution. *NeBIO*, **1**, 35-41.

[10] Suriano, D. (2021) A Portable Air Quality Monitoring Unit and a Modular, Flexible Tool for On-Field Evaluation and Calibration of Low-Cost Gas Sensors. *HardwareX*, **9**, e00198. https://doi.org/10.1016/j.ohx.2021.e00198

[11] Bayouli, I.T., Bayouli, H.T., Dell'Oca, A., Meers, E. and Sun, J. (2021) Ecological Indicators and Bioindicator Plant Species for Biomonitoring Industrial Pollution: Eco-Based Environmental Assessment. *Ecological Indicators*, **125**, Article ID: 107508. https://doi.org/10.1016/j.ecolind.2021.107508

[12] Darrall, N.M. (1989) The Effect of Air Pollutants on Physiological Processes in Plants. *Plant, Cell & Environment*, **12**, 1-30. https://doi.org/10.1111/j.1365-3040.1989.tb01913.x

[13] Anwar, M.N., Shabbir, M., Tahir, E., Iftikhar, M., Saif, H., Tahir, A. and Nizami, A.S. (2021) Emerging Challenges of Air Pollution and Particulate Matter in China, India, and Pakistan and Mitigating Solutions. *Journal of Hazardous Materials*, **416**, Article ID: 125851. https://doi.org/10.1016/j.jhazmat.2021.125851

[14] Shukla, D. and Dutta, V. (2022) Indoor Air Quality Monitoring of Urban and Rural Households of a North Indian City during Cooking Hours. *Aerosol Science and Engineering*, **6**, 86-98. https://doi.org/10.1007/s41810-021-00126-1

[15] Xie, X., Semanjski, I., Gautama, S., Tsiligianni, E., Deligiannis, N., Rajan, R.T. and Philips, W. (2017) A Review of Urban Air Pollution Monitoring and Exposure Assessment Methods. *ISPRS International Journal of Geo-Information*, **6**, Article No. 389. https://doi.org/10.3390/ijgi6120389

[16] Yang, Z., Wang, Z., Yang, C., Hollebone, B.P., Brown, C. and Landriault, M. (2013) Evaluation of Total Petroleum Hydrocarbons (TPH) Measurement Methods for Assessing Oil Contamination in Soil. *Environmental Forensics*, **14**, 193-203. https://doi.org/10.1080/15275922.2013.814180

[17] Orazbayeva, D., Kenessov, B., Koziel, J.A., Nassyrova, D. and Lyabukhova, N.V. (2017) Quantification of BTEX in Soil by Headspace SPME-GC-MS Using Combined Standard Addition and Internal Standard Calibration. *Chromatographia*, **80**, 1249-1256. https://doi.org/10.1007/s10337-017-3340-0

[18] Akpoghelie, J.O., Agbaire, P.O., Orisaremi, A. and Irerhievwie, G.O. (2016) An Assessment of Air Quality in Sub-Urban Cities in Isoko, Delta State Nigeria. *Journal of*

Emerging Trends in Engineering and Applied Sciences, **7**, 179-185.

[19] Jacobson, T.A., Kler, J.S., Hernke, M.T., Braun, R.K., Meyer, K.C. and Funk, W.E. (2019) Direct Human Health Risks of Increased Atmospheric Carbon Dioxide. *Nature Sustainability*, **2**, 691-701. https://doi.org/10.1038/s41893-019-0323-1

[20] Hesterberg, T.W., Bunn, W.B., McClellan, R.O., Hamade, A.K., Long, C.M. and Valberg, P.A. (2009) Critical Review of the Human Data on Short-Term Nitrogen Dioxide (NO_2) Exposures: Evidence for NO_2 No-Effect Levels. *Critical Reviews in Toxicology*, **39**, 743-781. https://doi.org/10.3109/10408440903294945

[21] Oesch, S. and Faller, M. (1997) Environmental Effects on Materials: The Effect of the Air Pollutants SO_2, NO_2, NO and O_3 on the Corrosion of Copper, Zinc and Aluminium. A Short Literature Survey and Results of Laboratory Exposures. *Corrosion Science*, **39**, 1505-1530. https://doi.org/10.1016/S0010-938X(97)00047-4

[22] Zhang, Y., Gautam, R., Pandey, S., Omara, M., Maasakkers, J.D., Sadavarte, P. and Jacob, D.J. (2020) Quantifying Methane Emissions from the Largest Oil-Producing Basin in the United States from Space. *Science Advances*, **6**, Eaaz5120. https://doi.org/10.1126/sciadv.aaz5120

[23] Ebong, G.A. and Mkpenie, V.N. (2016) Air Quality Monitoring in Uyo Metropolis, Akwa Ibom State, Niger Delta Region of Nigeria. *International Journal of Scientific Research in Environmental Sciences*, **4**, 55-62. https://doi.org/10.12983/ijsres-2016-p0055-0062

[24] Egwurugwu, J.N., Nwafor, A., Oluronfemi, O.J., Iwuji, S.C. and Alagwu, E.A. (2013) Impact of Prolonged Exposure to Oil and Gas Flares on Human Renal Functions. *International Research Journal of Medical Sciences*, **1**, 9-16.

[25] Rouf, Z., Dar, I.Y., Javaid, M., Dar, M.Y. and Jehangir, A. (2022) Volatile Organic Compounds Emission from Building Sector and Its Adverse Effects on Human Health. In: Malik, J.A. and Marathe, S., Eds., *Ecological and Health Effects of Building Materials*, Springer, Berlin, 67-86. https://doi.org/10.1007/978-3-030-76073-1_5

[26] Ogundele, L.T., Owoade, O.K., Hopke, P.K. and Olise, F.S. (2017) Heavy Metals in Industrially Emitted Particulate Matter in Ile-Ife, Nigeria. *Environmental Research*, **156**, 320-325. https://doi.org/10.1016/j.envres.2017.03.051

[27] Babayemi, J.O., Ogundiran, M.B. and Osibanjo, O. (2016) Overview of Environmental Hazards and Health Effects of Pollution in Developing Countries: A Case Study of Nigeria. *Environmental Quality Management*, **26**, 51-71. https://doi.org/10.1002/tqem.21480

[28] Heumann, S., Böttcher, J. and Springob, G. (2002) N Mineralization Parameters of Sandy Arable Soils. *Journal of Plant Nutrition and Soil Science*, **165**, 441-450. https://doi.org/10.1002/1522-2624(200208)165:4<441::AID-JPLN441>3.0.CO;2-F

[29] Bednarek, W. and Tkaczyk, P. (2002) The Influence of Mineral Fertilization on the Content of Some Nitrogen Forms in Soil. *Zeszyty Problemowe Postepow Nauk Rolniczych*, **484**, 55-60.

[30] Iwegbue, C.M. (2011) Assessment of Heavy Metal Speciation in Soils Impacted with Crude Oil in the Niger Delta, Nigeria. *Chemical Speciation & Bioavailability*, **23**, 7-15. https://doi.org/10.3184/095422911X12964002282100

[31] Kuppusamy, S., Maddela, N.R., Megharaj, M., Venkateswarlu, K., Kuppusamy, S., Maddela, N.R. and Venkateswarlu, K. (2020) Impact of Total Petroleum Hydrocarbons on Human Health. In: Kuppusamy, S., *et al.*, Eds., *Total Petroleum Hydrocarbons: Environmental Fate, Toxicity, and Remediation*, Springer, Berlin, 139-165. https://doi.org/10.1007/978-3-030-24035-6_6