Air Quality Assessment in Parts of Onne, Rivers State Southeastern Nigeria

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Air Quality Assessment in Parts of Onne, Rivers State Southeastern Nigeria

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Abstract

The quality of air, noise level, wind direction, wind speed, relative humidity, temperature and total suspended particulate (TSP) in parts of Onne in Eleme Local Government Area of Rivers State, south-south Nigeria, were determined using portable hand held air monitors and anemometer. The gaseous parameters measured were sulphur dioxide (SO_2), nitrogen dioxide (NO_2), hydrogen sulphide (H_2S), carbon monoxide (CO), hydrocarbon (C_XH_Y) and volatile organic carbon (VOCs). The peak values of SO_2, NO_2, H_2S, CO, C_XH_Y, VOCs, wind speed, temperature, noise and relative humidity obtained in the area were 50.94ug/m^3(TSP), 27.47ug/m^3 (SO_2), 124.78ug/m^3 (NO_2), 59.47ug/m^3(CO), 23.43ug/m^3(H_2S), 521.32ug/m^3(C_XH_Y), 890.22ug/m^3(VOCs), 4.53m/s (Wind Speed), 70.37Db(A)(Noise), 31.52^{0}C(Temperature), 70.37Db(A) Noise and 78.38%(Relative Humidity) respectively. The results reveal that there is a high concentration of CO, C_XH_Y, H_2S, NO_2, VOCs and noise level in location ON4. The concentration of CO in location ON4 surpasses the Federal Ministry of Environment (FMENV) and International Finance Corporation (IFC) / World Health Organization (WHO) limit/guidelines and therefore poses environmental health concern for the inhabitants of the area. The quality of air in the area is poor and need to be regularly monitored. The air pollutants can contribute considerably to global warming, acid rain deposition, respiratory and cardiovascular conditions. The air pollutants can be mitigated using scrubbers, enacting serious air quality policies and implementing same, employment of segmented operation by industries and constant air quality monitoring.

Keywords: Air, Pollutants, Anemometer, global warming, quality monitoring.

Introduction

Air pollution comes from nature and from human activities (exploration and exploitation of minerals and hydrocarbons, vehicular movements, etc.) that created pollution daily all over the world. In nature, air pollution occurs when volcanoes erupt, an enormous quantity of ash and sulfur dioxide into the atmosphere); forest fires burn and their smokes are blown by winds; and when winds whip up plant pollens and dust from deserts [1].

There are numerous human activities, which result in the release of potentially toxic substances into the atmosphere [1,2]. From human activities, the primary source of air pollutants nowadays is the waste products released into the air from the exhaust of internal combustion engine and boilers and furnaces of industries, plants, and homes [3].

Onne Oil & Gas Free Zone enjoys an unrivaled strategic position in West Africa and it is undoubtedly the ideal location from which to establish your 'Distribution Hub' to service Oil & Gas projects in not only Nigeria (onshore & offshore) but also provides easy entry to all the Sub Saharan Region. The ability to service the high-speed requirements and demands of the oil & gas industry has led Onne oil & gas Free Zone to the forefront of becoming the World's Premier Oil & Gas Free Zone, servicing major development projects in Nigeria such as the Niger Delta Basin region where the AGIP (Abo, Field), CHEVRON (Amenam), SHELL (Bonga & Ea Fields) as well as TEXACO (Agbami Field) are in operation.

Being an international center of the world trade, finance, business and telecommunication, there is high demand and pressure on development of housings and other infrastructures within the small flatland areas. Most of these areas are already developed and in order to meet its demand, these small available flatland areas and the nearby areas are required to be developed in high- density mode. In addition, energy consumption and traffic activities also increase with the growth of the economy and leading to increased amount of air pollutants being emitted. As a result, economic growth increases the degree of urbanization and thus the emission of air pollutants in Onne. Due to the high-density development mode of the urbanized area in Onne, densely tall buildings create a phenomenon called street canyons. This is an enclosure that hinders the dispersion of emitted air pollutants and as such contributing to the local ambient air pollution. Furthermore, rapid economic activities and development in the area also contribute to air quality deterioration in the past 20 years. The use of fossil fuel to meet the world's energy needs is a contributor to an increase in greenhouse gases mainly carbon dioxide (CO_2) and methane in the Earth's atmosphere which is leading to climate change with adverse effects on the environment. According to [4], the quality of air around a location may be impacted by activities such as the burning of fossil fuel, by waste gas flaring from oil production facilities, burning of fuel in the operation of high capacity power generators for long periods and emissions from vehicles. In the Onne area, the use of these generators for very long periods of hours and even days is a consequence of non-availability of power supply from the national grid which causes the long period of power outages running into hours, days or weeks. Emissions from these generators include sulfur dioxide, oxides of nitrogen and carbon monoxide in addition to unburnt fossil fuel that may be presented as suspended particulates and soot. The increasing building density and economic growth increases urbanization and emission of air pollutants. As a result, there is the likelihood of air quality degradation in Onne due to the rapid urbanization, and industrialization process.

Although rapid development and intensive economic activities have benefited the wealth of the society, such development and activities also, increase the air pollution in Onne and have high social costs. There is a direct relationship between ambient air pollution and various types of diseases and health problems, such as asthma, lung cancer, cardiovascular disease, respiratory diseases and symptoms, due to the long-term exposure to the pollutants [5]. According to a survey the cost of health problems created, including both direct and indirect, by air pollution in 2006 is at least US$1.1 billion at lower-end estimation [5].

Different studies exist in the literature on air quality. The effects of air pollution on vegetation and microclimate, surface and groundwater through acidification of rainwater could be profound as shown by [6] in a comprehensive air quality assessment of the Niger Delta. Results of the assessment show that the levels of concentration of volatile oxides of carbon, nitrogen, sulphur oxide and total particulates exceed existing Federal Environmental Protection Agency's [7] standards. The authors in [8] also show elevated levels of lead (0.56 mg/l) and low pH values ranging from 5.10 – 6.35 in rainwater collected in Warri and environs. The author in [9] also report low pH values from water obtained from shallow hand-dug wells in Ughelli, Warri, and Okurekpo all in Delta State.

The ambient air quality of industrial areas of Nigeria for criteria pollutants CO, NO_2, SO_2, O_3, Particulate Matter, Pb were monitored by [10] who found all of them to be very high as compared to World Health Organization Air Quality Guideline. The authors in [11] also produced data to show that the major air pollutants in Niger Delta area are CO_2, CH_4, SO_2, N_2O, NO_2, NH_3, VOCs and Particles (PM10, PM2.5), Primary aromatic Hydrocarbons, (PAH_S) and Heavy metals. Temperature and humidity and the prevailing wind speed and directions were also determined. The measured concentrations of the various parameters were compared with

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[7] and USEPA air quality guidelines which are designed to offer guidance in reducing the health impacts of air pollution.

Animals are exposed to air pollutants via three pathways: Inhalation of gases or small particles, ingestion of particles suspended in food or water, or Absorption of gases through the skin. An individual's response to a pollutant varies greatly and depends on the type of pollutant involved, the duration of exposure and the amount is taken up by the animal. Factors such as the individual's age, sex, health and reproductive condition also play a role in its response. In addition to affecting individual animals or populations directly, air pollutants also affect wildlife indirectly by causing changes in the ecosystem. As observed by [12], volatile organic compounds (VOC) and nitrogen oxides (NOx) once emitted undergo chemical transformation in the atmosphere in the presence of sunlight to form ozone. Ozone, sulphur (iv) oxide and nitrogen (iv) oxide primarily affect the respiratory system and studies on laboratory animals and humans show that all three pollutants irritate the lining of the lungs and cause respiratory stress [13]. Additionally, Tubonimi *et al* (2008)[14] assessed the quality of the air around some cement industries operating in Port Harcourt Nigeria using WHO recommended methods involving a high-volume sampler, a train of impingers fitted with bubbler devices and digital gas monitors. The results showed low levels of gaseous pollutants. The concentrations of SPM and NO_2 and 7.8µg/m^3 and 20.0µg/m^3 varied between 678.9ug/m^3 and 996.2µg/m^{3}respectively at Atlas cement and were lower than 607.7ug/m^3 and 23,198.5µg/m^3 and 27.45ug/m^3 and 140.7µg/m^3 respectively at Eagle cement area. Statistical analysis showed a significant difference ($P<0.05$) between the indoor and outdoor mean concentrations of SPM in the cement industries. The concentrations of SPM in all the stations and NO_2 at station 1 at Eagle cement exceeded guideline values. These imply serious environmental and health concerns. Cement dust in form of SPM arising from cement unloading, transfer, bagging and loading onto trucks was found to be the major problem in the cement industry and bagging of cement in an open area is better than in an enclosed factory. This is similar to the survey by [15]. In line with these assertions, this study is carried out to assess air quality in parts of Onne, Rivers State south eastern Nigeria.

Materials and Method

Air monitoring points were established between 126m and 395m from the source. This was established by the use of GPS model 2600. Parameters considered during the selection of the monitored site include possible chemical or physical interference, locality, terrain, service, and local activities. Others include wind speed, wind direction, and other meteorological parameters. The materials used for the study include;

EXTECH Anemometer

A multi-parameter digital anemometer Model No. 45170 was used to measure the wind speed and direction in m/s. It was held up in an open space with the consideration of a distance. This was to avoid unnecessary interference from shades. Measurement was taken on an hourly basis. This anemometer is multi-functional, that is, it has the capacity to measure temperature in ^{0}C, Absolute Pressure in Pascal, and Relative Humidity in %.

Noise Meter

Sound Pressure Level Meter with the model TES1352H was used to measure the noise level at each point in decibels. Measurement was taken on an hourly basis for 8hours. The sensor of the noise meter was directed toward the source and the main reading was taken over a period of 2 minutes. The equipment measured noise via the microphone probe that generates signals approximately proportional to sound waves.

Measuring Range: 30 – 130Dba, Accuracy +/- 1.5dB, Resolution: 0.1dB. Frequency: 20HZ TO 8.5KHZ.

Gas Analyzer: A portable gas emission analyzer with Model number GA 21 Plus was used to measure for SO_2 NO_2, CO, H_2S andC_xH_y.This equipment collects and stores data independently. It has a feature that can display this data in an LCD interface. It can be calibrated onsite.

Mini Volume Portable Air Sampler

This gas monitor was used to collecting particulate matter of various sizes such as PM_{10}, PM_{5}, $PM_{2.5}$, PM_{1}, $PM_{0.5}$, and $PM_{0.3}$. This equipment has a percentage membrane filter which was dried at 10^0C and cooled in a desiccator, and weighed to the nearest milligram. The mass concentration was calculated by measuring the mass concentration divided by the volume of air.

The volume of Air

Volume of Air (m^3) = Flow Rate x Time of Sampling

V = q x t. Where q = Flow Rate in liters per minute, t = time of sampling in minutes; 0.001 (the conversion from liters to cubic meters) ; V (m^3) = $0.0001m^3$/l x g 1/min x t min

$$\text{Conc. Of SPM } (ug/m^3) = \frac{1000ug \times Wn\ (mg)}{V\ m^3.} \qquad (1)$$

Where Wn (Mass Change of the Filter); V (m3) (Volume of air sample); 1000 (Conversion from milligram to micrograms).

Description of Study Area

This project was conducted in Onne, Eleme Local Government Area of Rivers State Nigeria. Data acquisition was performed in Onne being the Southeastern part of the state. The sampling points and coordinates are distributed as shown in Table 1.

Table 1. Identification of sampling locations with geographical coordinates

S/N	LONGITUDE	LATITUDE	LOCATION
1.	$7^0$9'8.422"E	$4^0$42'8.978"N	ON 1
2.	$7^0$7'28.413"E	$4^0$42'21.882"N	ON 2
3.	$7^0$7'7.981"E	$4^0$43'59.741''N	ON 3
4.	$7^0$7'11.745"E	$4^0$45'38.136"N	ON 4
5.	$7^0$7'55.835"E	$4^0$45'38.136"N	ON 5
6.	$7^0$948.749"E	$4^0$44'5.117"N	ON 6
7.	$7^0$845.302"E	$4^0$44'40.604"N	ON 7
8.	$7^0$8'42.076"E	$4^0$43'33.932"N	ON 8
9.	$7^0$8'17.88"E	$4^0$45'39.749"N	ON 9
10.Control	$7^0$9'32.618"E	$4^0$45'52.654"N	ON 10

Reconnaissance investigation perfomed in the Onne Port area and Notore company area covered Ten (10) locations including a Control location. The locations and their geographical positions are shown in Table 1 and Fig.1 respectfully. Four (4) sampling points are within the Onne Port area, while five are around Notore company region. The control location is located at the other axis of the East-West road Close to the Ebubu community. The major roads within the study area are the East-West Road and Onne road which lead to the industrial hub of the free trade zone. The topographic map as shown indicates an elevation of -2 meters to 26 meters with lower elevations at the southern and eastern parts of Onne, while the northern and western parts have higher elevations (Fig. 1).

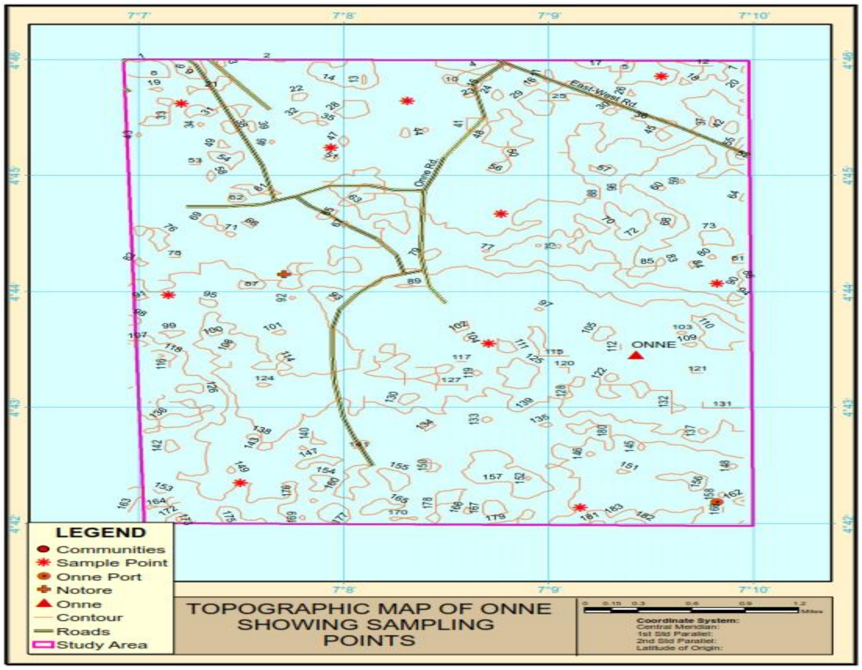

Figure 1. Topographic map of Onne (Study Area).

Weather and Climate

The study area has similar climatic conditions with other parts of the Niger Delta, southern part of Nigeria. Two dominant seasons are prevalent: the wet season, which occurs between March and September, while the dry season occurs between October and February. According to [9], this area is characterized by rainfall having mean annual range from 2000mm to 4000mm. He also stated that 85% of these occur in the wet season which is between August and October.

Geology of Study Area

The area is a part of the Niger Delta basin of Nigeria (Fig. 2). It has an overall regressive sequence and is divided into three formations ranging from Eocene to Recent age [16]. Stratigraphic chronology of these formations underlying the study area include, namely, Benin Formation (youngest in age and on the surface exposures), Agbada Formation and Akata Formation (oldest formation lying in the basal part of the Niger Delta basin).

The study area is considered to be under the dry flat lands and plains since its predominant landform is flat with a weakly dissected alluvial plain which makes part of the Benin Formation. It is also made up of quaternary marine deposits of sand, silt, and clay alluvial deposits. This geomorphology determines the slope, and form of the site and generally the stability of any civil engineering structure.

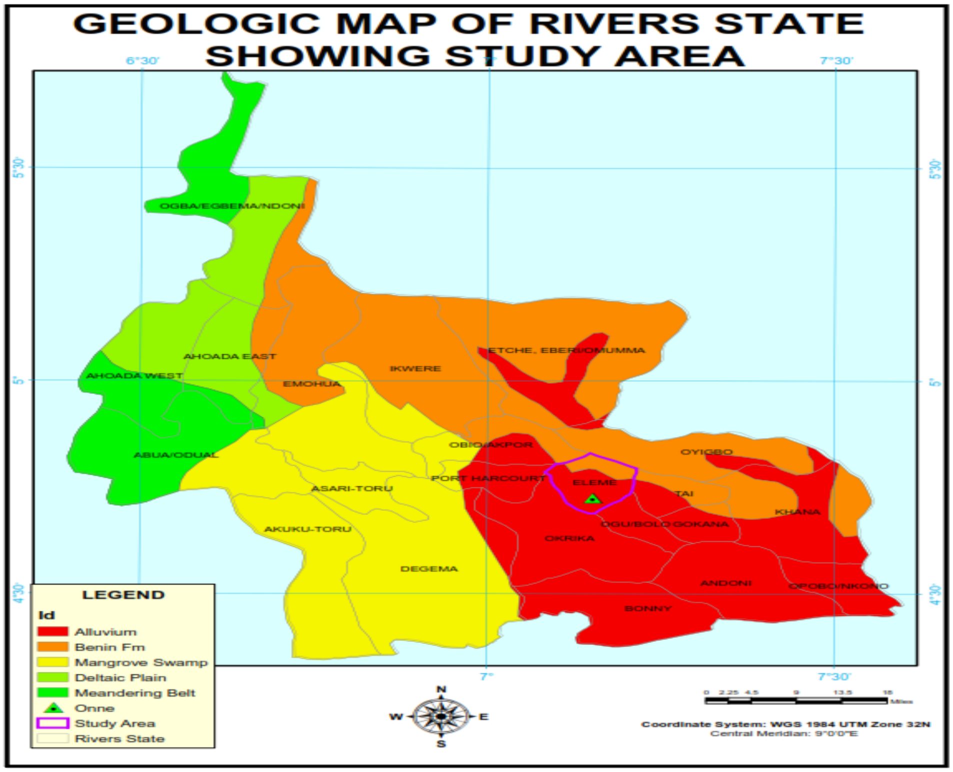

Figure 2. Geologic Map of Rivers State showing Study Area

Reconnaissance Survey

This involves a preliminary site visit to the study area to identify sources of pollution and potential receptors within the area. The geologic map and topographic map were matched with the physical observation of terrain and specific land feature for effective planning of air quality monitoring. At this stage, sampling stations were identified and marked for air sampling and measuring pollutant concentration.

Data acquisition and information management

Data acquisition technology is advancing and ever-changing [17]. Computer systems are now available in most air quality instruments. This has changed data acquisition in a profound way; most data are available in an instantaneous digital format from the instrument. This can be a powerful tool to quickly recognize and mitigate data quality problems. These digital systems should increase data capture and reporting.

Digital data acquisition reduces noise in the recording of gas monitoring data, thereby improving sensitivity [17]. It also records and controls the instrument settings, internal diagnostics, and programmed activities of monitoring and calibration equipment. Such data acquisition systems also typically provide automated data quality assessment as part of the data acquisition process.

Quality assurance and control (qa/qc)

Quality assurance and quality control are essential parts of any air monitoring system. Quality assurance and quality control comprise a program of activities that ensures that measurement meets defined and appropriate standards and objectives for quality, with a stated level of confidence. Quality assurance and control ensure that data are fit for a purpose. Quality assurance activities cover all pre-measurement phases of monitoring, including determining the objectives of monitoring and data quality, designing the system, selecting sites, evaluating equipment, and training operators. Quality control functions directly affect measurement-related activities such as site operation, calibration, data management, field audits, and training. In other words, quality assurance relates to the measurement process, whereas quality control is concerned primarily with output [17].

Data quality

Data quality is related to the need of users for data of sufficient quality for decision making. Each user specifies their needed data quality in the form of their data quality objectives (DQOs). Quality objectives for measuring data are designed to ensure that the end user's DQOs are met. Measuring of quality objectives are concerned with both quantitative objectives (such as representativeness, completeness, promptness, accuracy, precision and detection level) and qualitative objectives (such as site placement, operator training, and sample handling techniques).

Data quality objectives

Data collected for the Ambient Air Quality Monitoring Program are used to make very specific decisions that can have an economic impact on the area represented by the data. Data quality objectives (DQOs) are qualitative and quantitative statements derived from the DQOs Planning Process that clarify the purpose of the study, define the most appropriate type of information to collect, determine the most appropriate conditions from which to collect that information, and specify tolerable levels of potential decision errors [17].

In order to achieve overall monitoring objectives, the following essential requirements are to be met during field measurement:

- Measurements were accurate and precise
- Adaptable to meteorological standards
- Temporal completeness (data capture)
- Spatial representatives and coverage
- Consistency maintained from site to site over time
- International comparability and harmonization
- Developing and validating management tools such as models and geographical information systems
- Quantifying trends to identify future problems or progress in achieving management or control targets

Quality assurance procedures

Quality assurance is a general term for the procedures used to ensure that a particular measurement meets the quality requirements for its intended use [17]. In addition to performing tests to determine bias and precision, additional quality indicators (such as sensitivity, representativeness, completeness, timeliness, documentation quality, and sample custody control) were also evaluated. Quality assurance procedures fall under two categories. These include, quality control - procedures built into the daily sampling and analysis methodologies to ensure data quality and quality assessment - which refers to periodic external evaluations of data quality.

Calibration of Instruments

All the instruments used in this ambient air quality exercise were calibrated using the necessary reagents.
Prior to the implementation of the ambient air monitoring activities, the sampling and analysis instruments and equipment were being checked to ensure that they are within calibration tolerances and any equipment that fails these tolerances was appropriately calibrated. This function was most routinely carried out at the field monitoring location.

Field and Laboratory analytical instruments were calibrated by comparing the instrument's response with sampling standards of known concentration level. The difference between the measured and known concentrations was then used to adjust the instrument to produce the correct response.
Calibration of an analyzer or instrument establishes the quantitative relationship between actual values of a standard, be it a pollutant concentration, a temperature, or a mass value (in ppm, oC or Fg, etc.) and the analyzer's response (chart recorder reading, output volts, digital output, etc.). This relationship is used to convert subsequent analyzer response values to corresponding concentrations. Once an instrument's calibration relationship is established it was checked/verified at reasonable frequencies to verify that it remains in calibration. The Testo 350-XL offers Auto calibration and probe blowback. It also conducts on-site sensor calibration capability including diagnostics and sensor output of 0 – 100%. Flow rate and sensor temperature monitoring for US EPA CTM-030, -034, and ASTM D6522 requirements.

Results and Discussion

The results of the ambient air quality investigation/assessment are shown in Table 2 while the Nigerian Ambient air quality standards and International Finance Corporation (IFC) limits are presented in Table 3.

Table 2. Result of Ambient air quality assessment in Onne

Location	CO (ug/m^3)	TSP (ug/m^3)	C_XH_Y (ug/m^3)	H_2S (ug/m^3)	NO_2 (ug/m^3)	SO_2 (ug/m^3)	VOCs (ug/m^3)	Wind Speed (m/s)	Noise (Dba)	Temperature (^{0}C)	Relative Humidity (%)
ON 1	46.21	49.29	222.12	21.55	122.06	27.02	424.45	4.33	68.0	31.02	78.12
ON 2	49.95	44.42	284.38	21.93	119.76	25.89	595.84	3.7	68.31	31.19	77.22
ON 3	52.88	40.64	335.36	22.33	119.33	24.50	787.90	3.19	68.78	31.36	76.32
ON 4	59.47	37.48	521.32	23.08	124.78	21.00	1211.69	2.36	70.37	31.68	74.63
ON 5	56.81	35.45	390.24	22.97	115.65	24.31	890.22	2.76	69.15	31.48	75.62
ON 6	45.35	50.70	206.42	22.44	122.73	27.39	375.32	4.50	67.99	30.97	78.38
ON 7	50.22	43.09	270.69	21.46	117.91	26.45	568.03	3.73	63.36	31.19	77.17
ON 8	45.22	50.94	207.65	21.43	123.27	27.31	382.29	4.53	68.02	30.98	78.37
ON 9	58.50	30.97	369.90	23.43	110.02	25.42	850.76	2.58	69.07	31.52	75.44
ON 10 Control	54.85	33.59	277.64	23.14	108.9	27.47	607.84	3.13	68.39	31.32	76.41

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Table 3. Nigerian Ambient Air Quality Standard FMENV 1995)[18]/ International Finance Corporation (IFC) limits

POLLUTANTS	FMENV LIMIT	Averaging Time	IFC/WHO (Guidelines)	Averaging Time
Particulates	250 µg/m^3	24-hours; Daily	150 µg/m^3	24-hours; Daily
	600 µg/m^3	1 hour	N/A	N/A
Sulphur oxides Sulphur dioxide (SO_2)	0.01ppm (26µg/m^3)	Daily average of hourly	125 µg/m^3 0.044ppm	24-hours; Daily
	0.1ppm (260µg/m^3)	1 hour	N/A	N/A
Non Methane Hydrocarbon	160 µg/m^3	3-hours	N/A	N/A
Carbon monoxide	10ppm (11.4 µg/m^3)	1 hour	30u g/m^3 (25 ppm)	1 hour
	20ppm (22.8 µg/m^3)	8 hours	10mg/m^3 (10 ppm)	8 hours
Nitrogen Oxides (Nitrogen Dioxide)	0.04-0.06 ppm (75.0 -112 µg/m^3)	1 hour	200 µg/m^3 (0.11ppm)	1 hour

Oxides of Sulphur (SO_x)

The results obtained during the period of this study showed that sulfur dioxide (SO2) ranges from 21ug/m3 to 27.47ug/m3. The locations with the highest values are well above the FMENV (26 µg/m3) and below the IFC (125 µg/m3) average daily exposure limits. Figure 3 shows the concentrations of SO2 in the project area compared with national and international standards. The concentration of So2 in the study area as shown in Figure 3 - 94, indicates that the values are lower than the stipulated standards from International Finance Corporation/ World Bank, but higher than that of Federal Ministry of Environment. The spatial distribution of the SO2 map as represented in Figure 4, shows that concentrations are higher around the Onne Port (ON 1,6, & 8) area than at Notore company. Observation around this area shows that this may be due to high industrial activities around the port as well as fuel combustion in mobile sources such as locomotives, ships, and other equipment in Onne. The concentrations around Notore axis are due to the activities of industrial plants and vehicular movements of trucks, buses, and cars within the vicinity.

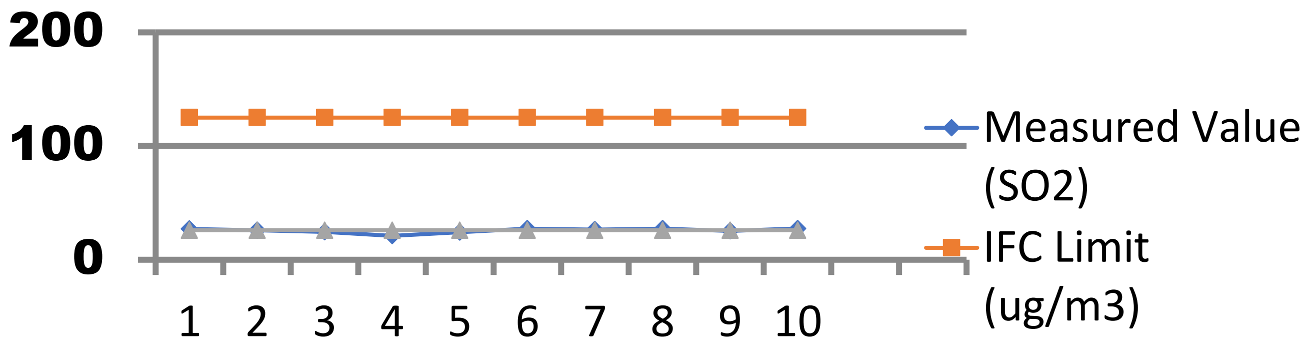

Figure 3. Concentrations of SO_2 in the project area compared with national and international standards

Excess concentration of SO2 can also lead to severe headaches and reduced productivity in plants. One major effect of sulfur dioxide is the formation of acid rain which causes damage to limestone and marble. Excess SO2 can also cause damage to leather, increased rate of corrosion of iron, steel, zinc, and aluminum.

A range of chronic and acute health impacts may result from human exposure to sulfur dioxide (SO2). SO2 irritates the respiratory system; in case of short-term high exposure, a reversible effect on lung functioning may occur, according to individual sensitivity [19].

According to[19], the secondary product H2SO4 of SO2 primarily influences respiratory functioning. Its compounds, such as polynuclear ammonium salts or organosulfates, act mechanically in alveoli and, as easily soluble chemicals, they pass across the mucous membranes of the respiratory tract into the organism [19].

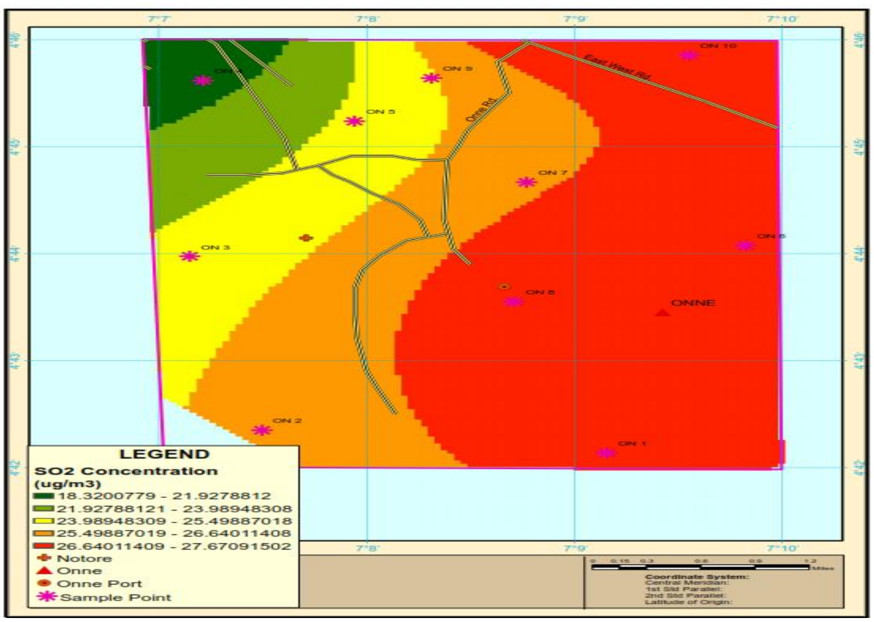

Figure 4: SO_2 spatial distribution map of Onne showing sampling points

Oxides of Nitrogen (NO_X)

Nitrogen oxides are products of high-temperature combustion like vehicle engines, power plants, domestic fires, and industrial combustions. The Nitrogen Oxides of interest are nitric oxide (NO2) and nitrous oxide (NO). Field measurements show that the daily maximum hourly concentration values of NOx (NO and NO2), ranges from 108.9 µg/m3 to 124.78µg/m3. Most of the recorded values were above the daily average hourly values of the FMENV (112µg/m3) and below the IFC (200µg/m3) limits. The concentration levels of this pollutant were low in some sampling stations and high in some locations when compared with the FMENV limit and totally low when compared with the IFC limit during field measurement. This probably shows that no significant high-temperature combustion was going on around the study area. Concentrations of NO2 measured in some of the catchment communities compared with national and international standards are shown in Figures 5 and 6.

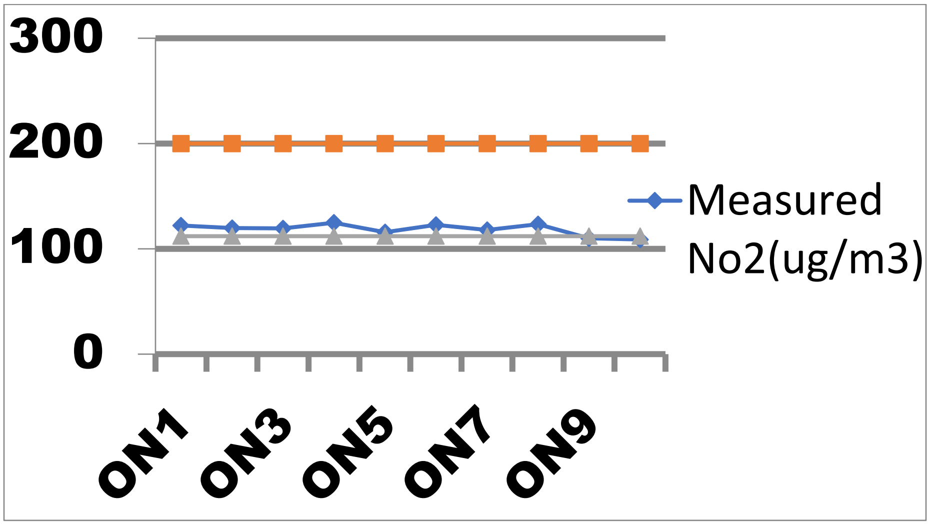

Figure 5: Concentration of Nitrogen dioxide (NO_2) in Ambient Air quality of the Study area

The concentration of Nitrogen dioxide as measured within Onne is higher than the standard set by the Federal Ministry of Environment except for the values obtained at locations ON 9 and ON 10 (Control), However, the concentrations are within the standards set by the International Finance Corporation/World Bank. The spatial distribution map of Nitrogen Oxide as represented in Figure 6 shows a higher concentration around Onne Port as indicated in locations ON 2, ON 6 and ON 8. Concentrations around Notore are not as high as that of Onne Port. These also reflect the high industrial activities around the port.

Exposure to nitrogen dioxide has been associated with a variety of health effects [19]. At very high concentrations, NO2 exposure can result in rapid and severe lung damage. The available evidence suggests that ambient exposure may result in both acute and chronic effects, especially in susceptible population subgroups such as people with asthma [19]. According to [20], combustion of fossil fuels in stationary sources such as power generation machines and motor vehicles are the main anthropogenic sources of oxides of nitrogen. NO can form photochemical smog at higher concentrations, causes leaf damage or affect the photosynthetic activities of plants, and also leads to respiratory problems in mammals.

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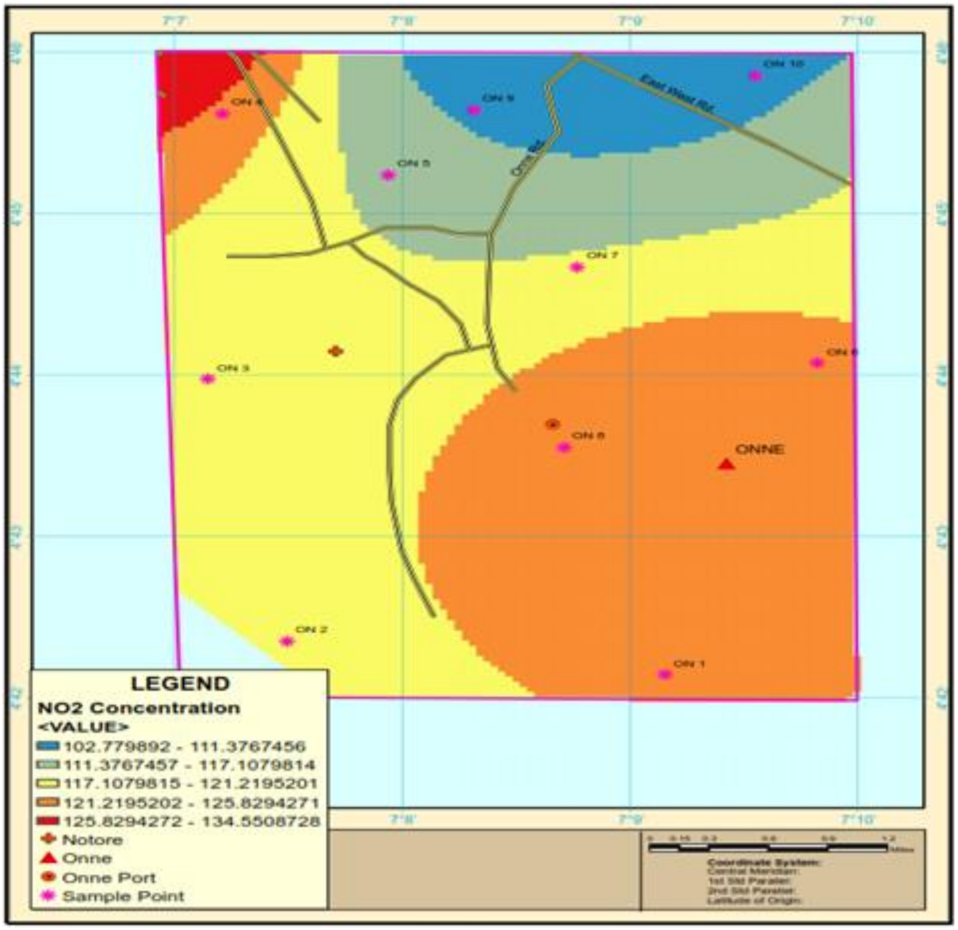

Figure 6. SO_2 Spatial Distribution Map of Onne showing Sampling Points

Carbon Monoxide (CO)

Carbon Monoxide is a product of incomplete combustion (oxidation) of fossil fuels or hydrocarbons. The binding of carbon monoxide (CO) with haemoglobin to form carboxy-haemoglobin (HBCO) reduces the capacity of blood to carry oxygen, and the binding with other haem proteins is directly related to changes in the functions of affected organs, such as the brain, cardiovascular system, exercising skeletal muscle and the developing foetus. At very high concentrations, well above normal ambient levels, Carbon Monoxide causes death [19].

The measured Carbon Monoxide values at the field range from 45.22µg/m^3 to 59.47µg/m^3. These values are above the FMENV limit of 11.4µg/m^3 and IFC limit of 30µg/m^3 for daily average hourly values in Nigeria. Concentrations of CO measured in some of the catchment communities compared with national and international standards are shown in Figure 7.

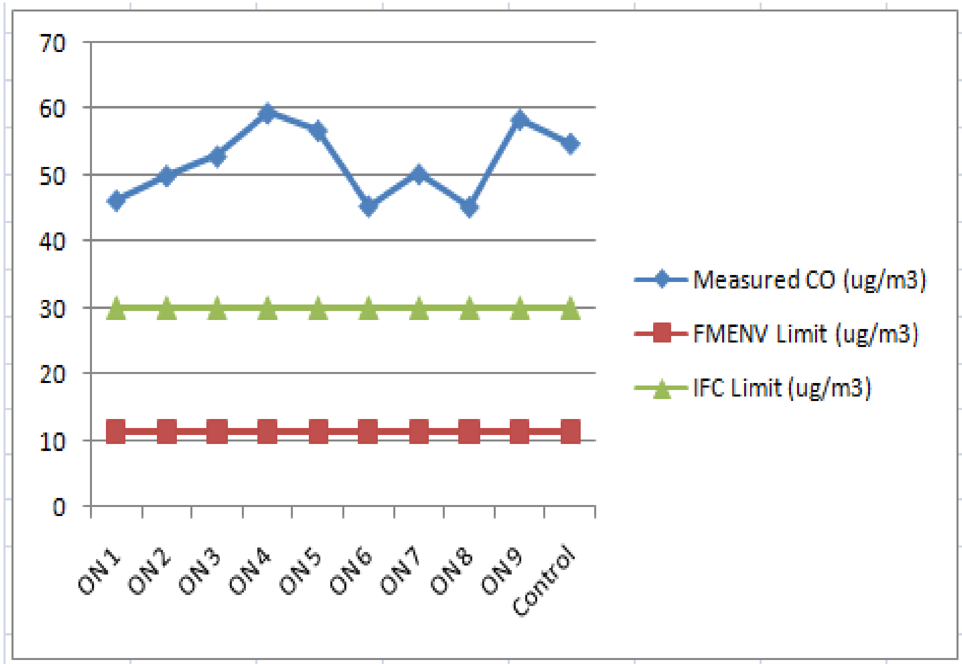

Figure 7:Concentration of Carbon Monoxide (CO) in Ambient Air Quality of the project area

The concentrations measured within this study area are above IFC and Federal Ministry of Environment standards. This abnormally high concentration of carbon monoxide is likely caused by emissions from fuel burning, and other industrial activities. The spatial distribution map of carbon monoxide in Figure 8 indicates higher concentrations around Notore and towards the refinery Northward of the aforementioned company. Lower concentrations abound around the coastal part of Onne including Onne port. This is due to the movement of wind emanating from the sea waves thereby moving the CO contaminants away from the port towards Notore Company. This strong wind movement is evidenced in the Wind Speed Map shown in Figure 9, as the speed is highest within ON 1, 6 and 8 and lowest at ON 4, and 9. The unique reason for this easy movement of CO is because it has a lower molecular weight than some other pollutants.

Khalil and Rasmussen 1990 have shown that human activities such as combustion and oxidation of hydrocarbons are responsible for 60% of CO in the atmosphere while emissions from natural sources account for the remaining 40%. Relatively, short-lived gases such as carbon monoxide, trophospheric ozone, other ambient air pollutants (e.g NOx, and NMVOCs), water vapour, and trophospheric aerosols (e.g. SO2 products and black carbon) vary spatially, do not have a global concentration because they are destroyed quickly and emitted in different amounts in different places and consequently it is difficult to quantify their global radioactive forcing impacts and hence global warming potential GWP [21].

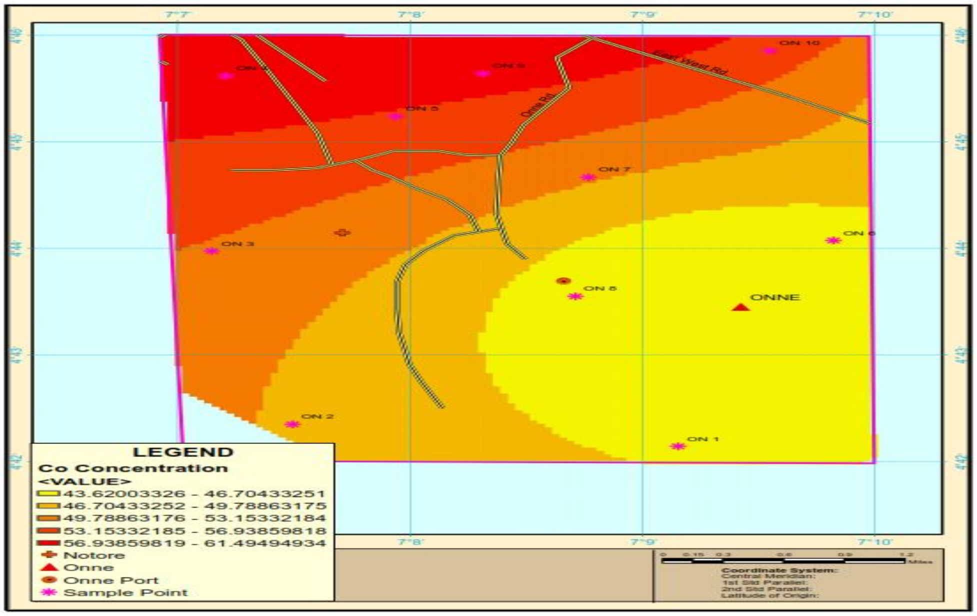

Figure 8: CO Spatial Distribution Map of Onne Showing sampling points

Wind speed/Direction

Generally, average annual rainfall in Port Harcourt area is about 2500mm and the prevailing wind is south westerly [22]. Thus, the wind blows from the south, which is the direction of the Atlantic Ocean. The pattern is such that daytimes are relatively windy compared to generally calm nights. Wind speed in Onne area are lowest between October and January (2.3 – 3.1m/s) and highest between February and September (3.1 – 4.5m/s) with a mean of 3.1m/s.

The wind speeds give rise to pressure variation between 1005 and 1009 millibars which occur at a minimum at dawn and maxima in late afternoon. During high pressure systems, the air is usually still which allows pollution levels to build up but during low pressure systems the weather is often wet and windy, causing pollutants to be dispersed or washed out of the atmosphere by rain.

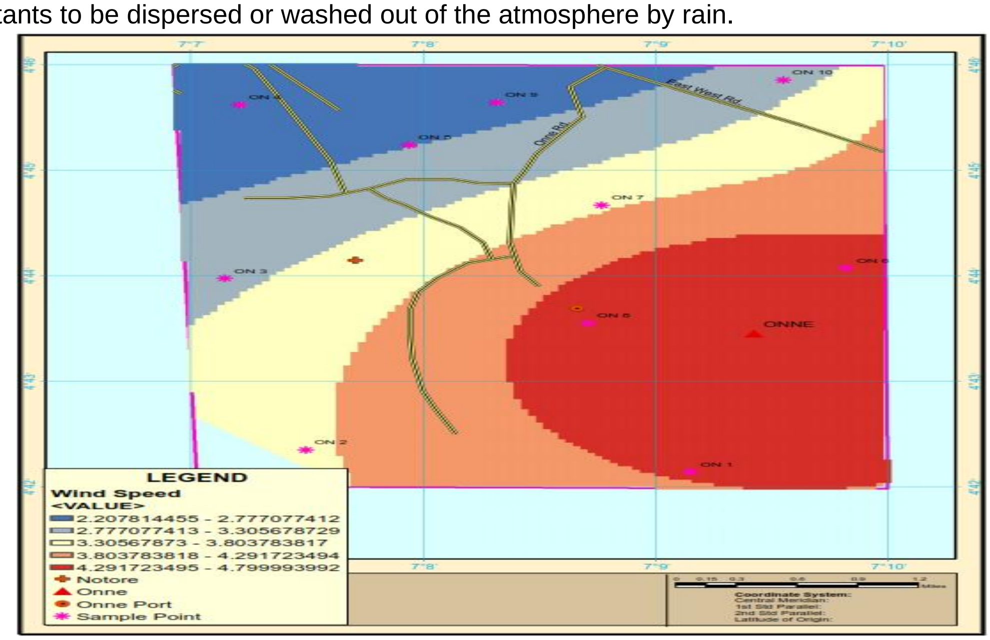

Figure 9: Wind Speed Distribution Map of Onne Showing sampling Points

Total Suspended Particulate (TSP)

These are light particles (dust, fly ash) or other materials found suspended in the atmosphere and carried around by the wind. They are small solid or liquid particles suspended in air. Major sources of TSP are diesel vehicles and coal-burning power plants. Dust is also a major source of TSP especially during the dry months. Dust can come from unpaved roads and construction activities

The FMENV regulatory limit for TSP is 250µg/m^{3}for 24 hour daily average, while World Bank/IFC has a standard of 200µg/m^3 for residential areas and 500µg/m^3 for industries. The concentrations of TSP obtained in this study ranges from 30.97µg/m^3 to 50.94µg/m^3 as shown in Figure 10 and 11. The concentration of TSP as measured was within the standards of FMENV and IFC. The spatial distribution map for TSP shows higher concentrations around the sea port within ON 1, 6, and 8 and lower concentrations outside the zones falling within ON 9 and ON 10. The wind movement doesn't affect the dominance of the pollutants within the seaport due to its weight factor.

Airborne particulate matter represents a complex mixture of organic and inorganic substances [19]. TSP effects on mortality, respiratory and cardiovascular hospital admissions and other health variables have been observed at very low levels [19]. Some studies have suggested that long-term exposure to particulate matter is associated with reduced survival. Other recent studies have shown that the prevalence rates of bronchitis symptoms in children and of reduced lung function in children as well as adults are associated with exposure to particulate matter [19].

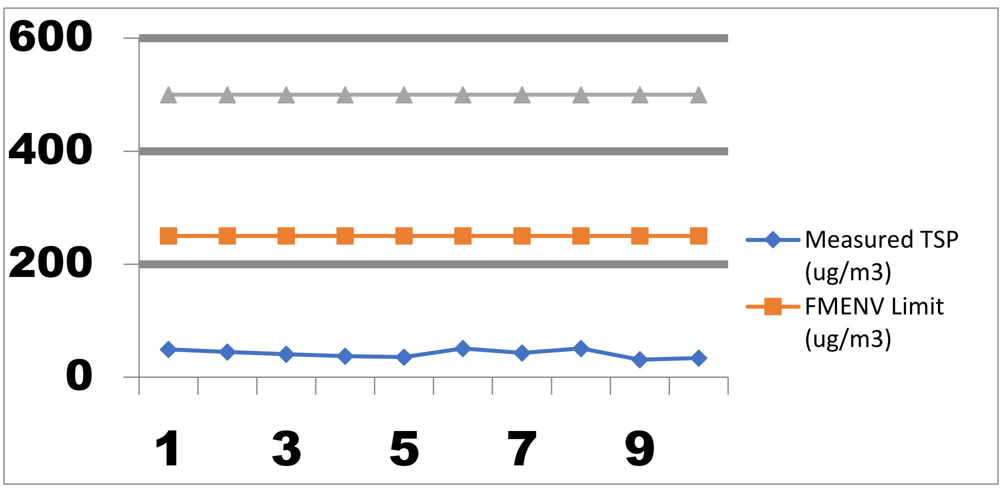

Figure 10: Concentration of Total Suspended Particulate (TSP) Compared with Standards

The authors in [23] reported that the high concentration of PM10 in most Nigerian urban environments have resulted in significant prevalence of cough, catarrh, eye infection, asthma, chronic bronchitis etc. the studies [24-26] specifically correlated high rates of respiratory diseases among urban dwellers with increased PM10 may be produced by natural processes (pollen, salt spray, soil erosion) and by human activity (soot). Their presence as aerosols in the atmosphere may contribute to visibility reduction, pose a threat to public health, or simply be a nuisance because of their soiling potential.

Additionally, [27-28] reported that particles of aerodynamic diameter smaller than 10ug (PM10) and those smaller than 2.5um (PM2.5), and especially the submicrometer-sized particles affect the Earth's climate by scattering and absorbing incoming ultraviolet solar radiation and outgoing terrestrial infrared radiation and by influencing the properties and formation processes of clouds. Thus, they can affect the concentration and size distribution of clouds droplets. In turn they can alter the radioactive properties of cloud, cloud lifetime, the nature and allocation of rain clouds and as a result they interfere with the hydrological cycle.

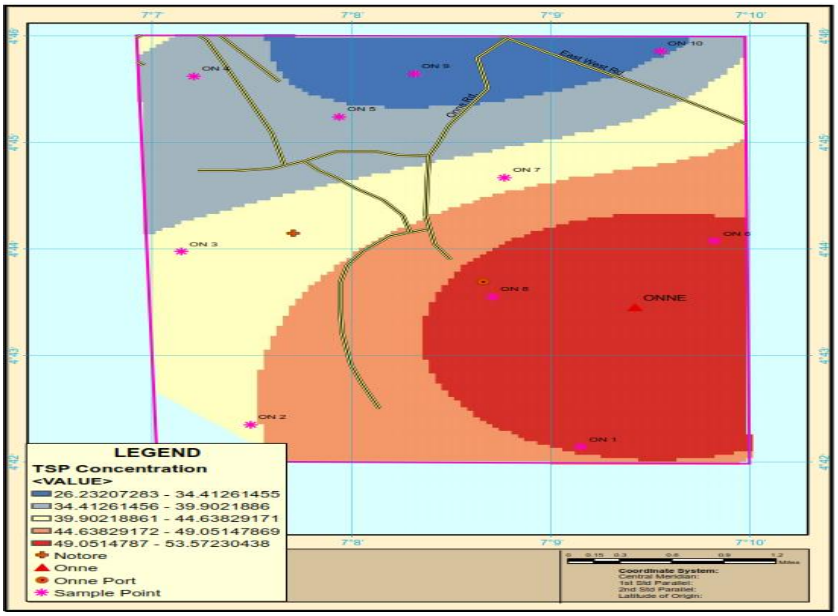

Figure 11: TSP Spatial Distribution Map of Onne Showing Sampling Points

Hydrogen Sulphide (H_2S)

At high temperature, sulphur combines with hydrogen to form hydrogen sulphide (H_2S) gas. Hydrogen Sulphide gas is an extremely toxic gas with the characteristic odour of rotten egg.It is also colourless and corrosive and may be formed during the oxidation or combustion of Sulphur containing fuels, mainly coal containing Sulphur in the presence of air (oxygen). Exposure to concentrations above 0.15 ppm could result in death [19].

Concentration of H_2S measured in the field does not exceed 0.1ppm. H_2S was generally low in many sampling stations. Figure 12 shows the concentrations of H_2S measured during the study. The highest concentrations of Hydrogen Sulphide are recorded at the control point and locations closer to the aforementioned indicating that the source is not around Onne region.

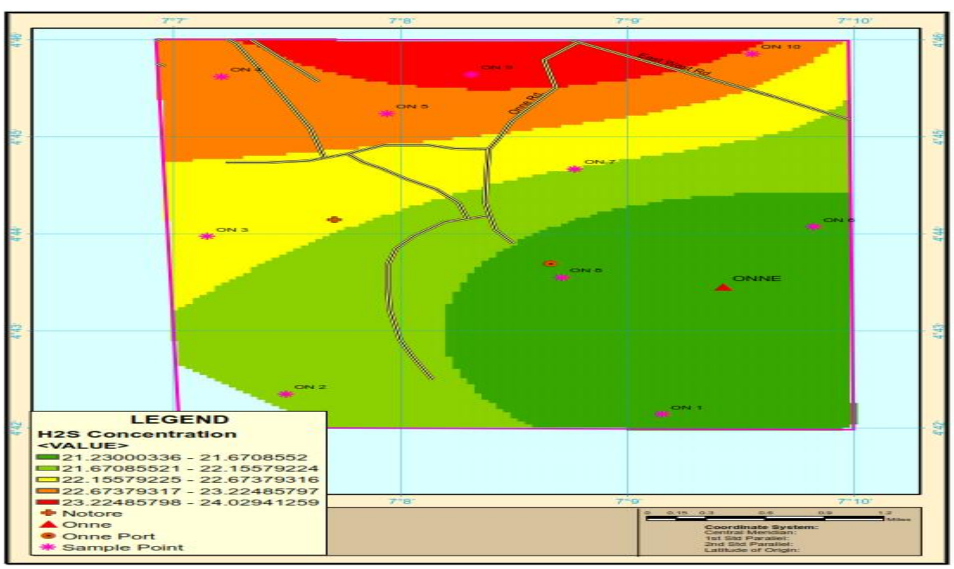

Figure 12: H_2S Spatial Distribution Map of Onne Showing Sampling Points

Volatile Organic Carbon (VOCs)

Chemicals containing hydrogen (H), carbon (C) and possibly other elements, that evaporate easily, are known as volatile organic compounds. Many hundreds of these compounds are present in the atmosphere. In the presence of sunlight and nitrogen oxides (NOx), volatile organic compounds react to form ground-level ozone (O_3), a component of smog. Fossil fuel deposits, including oil sands, are natural sources of volatile organic compounds. Man-made volatile organic compound emissions come from transportation, solvent use, industrial processes and gasoline evaporation. Gasoline evaporation can occur when vehicles are being filled at service stations or when transfers of gasoline are made.

The Figure 13 shows highest concentration at locations ON 4 and lowest value at ON 6. The spatial distribution map of VOCs shows lowest concentrations around Onne port as indicated in locations ON 1, 6, and 8. Higher concentrations are around Notore Company and Northwards closer to the refinery, indicating the source around Notore and around the refinery area.

Others are effects of oil marketing, electrical power generation, solvents, coating other petroleum and petrochemical activities. Some individual volatile organic compounds are believed to be a threat to human health. For example, benzene has been implicated as cancer-causing and hexane as a cause of nervous system disorders.

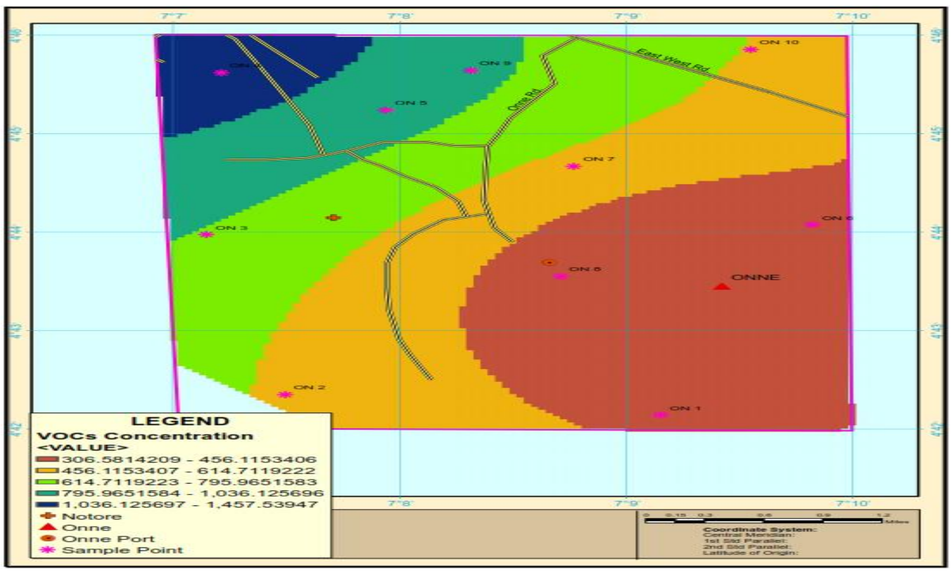

Figure 13: VOCs Spatial Distribution Map of Onne Showing Sampling Points.

Relative humidity

During this study, Relative Humidity of 74.63 – 78.38% were recorded from the different locations. Relative Humidity exerts tremendous influence on the emission of gaseous substances into the atmosphere and also plays a key role in the determination of sizes of Suspended Particulate Matter (SPM).

Temperature

The temperature measurement of the study area ranges from 30.97 to 31.68^{0}C

Hydrocarbon (C_XH_Y)

Hydrocarbons are the principal constituents of petroleum and natural gas. All of them are combustive. Methane, the simplest of hydrocarbons, is also generated as 'marsh gas' by wet decay of organic matter. Hydrocarbon which can as well be classified as VOCs, as indicated as CxHy follows the same concentration pattern as represented in Figure 14.

The highest concentrations were found at locations ON 4, followed by ON 5, 9 and location ON 3 which is within the zone of Notore company. From the dispersion shown in the map in Figure 14, the source of pollution is not attributed to the activities around the seaport, but from the dispersion of the pollutant around the refinery and a little activity of Notore company.

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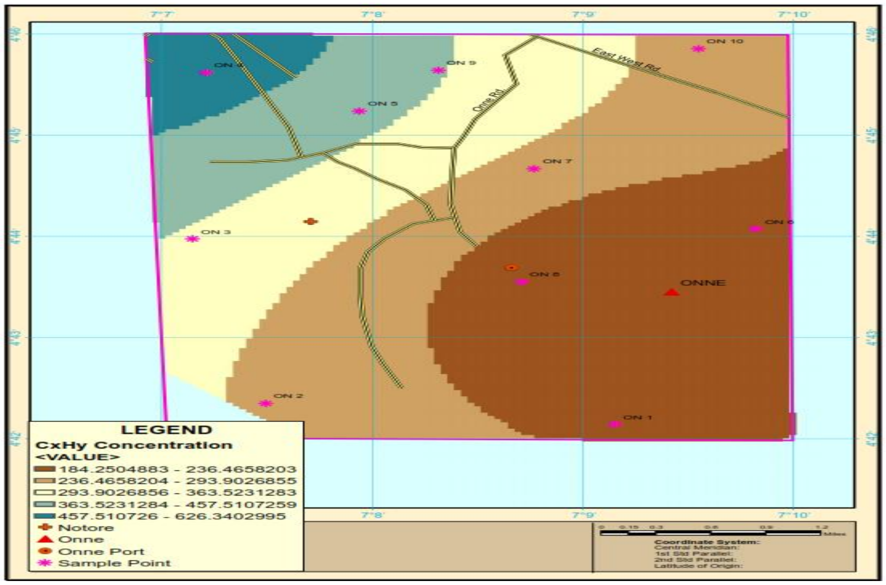

Figure 14: CxHy Spatial Distribution Map of Onne Showing Sampling Points

Noise

This is commonly defined as sound without value, and is also considered an environmental phenomenon to which we are exposed before birth and throughout life. It is a waste product generated in conjunction with various anthropogenic activities.

Noise measured within the study area ranges from 67.9dbA to 71.4dbA. The highest values are recorded at the upper section of Notore close to Refinery indicating the hotspot and where the main source for noise pollution abode as represented in Figure 15. Values at lowest points are at Onne. This may be connected to the movement of the sound waves by coastal winds, which drives the noise generated from industrial activities. Figure 9 affirms this with an increasing wind speed towards the coast of Onne.

The general effect of noise on the hearing of workers has been a topic of debate among scientists for a number of years. Regulations limiting noise exposure of industrial workers have been instituted in many places.

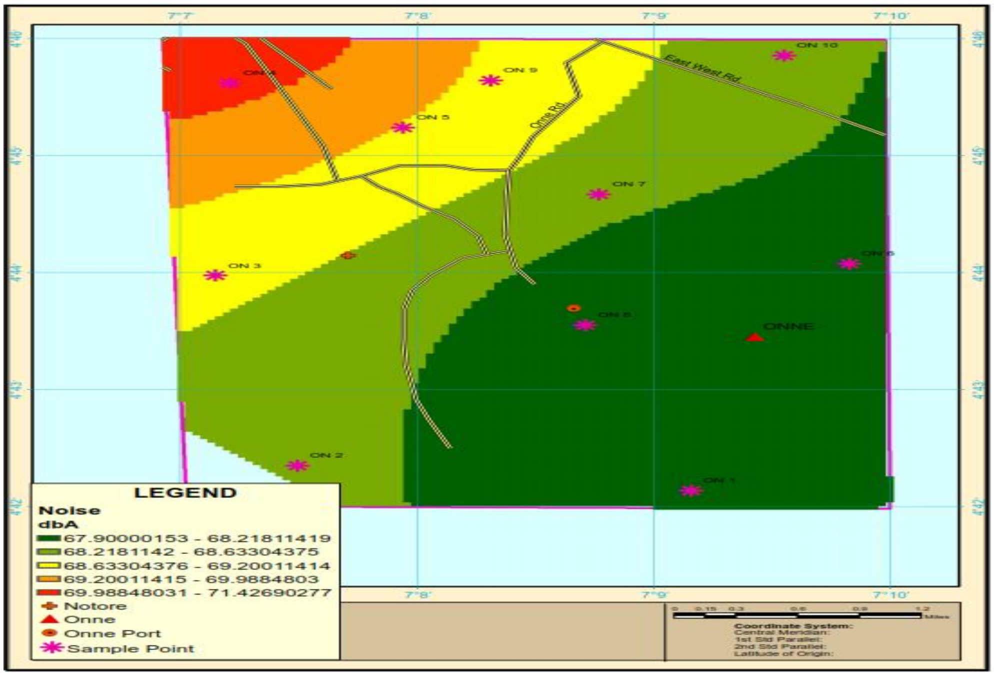

Figure 15: Noise Distribution Map of Onne Showing Sampling Points

For example, in the U.S., the Occupational Noise Exposure Regulation states that industrial employers must limit noise exposure of their employees to 90 dBA for one 8-h period [17]. This permitted maximum noise exposure dose is similar to the Turkey Standard, which is less than 75 dBA for one 7.5 h period and Nigeria Standard is not different from these. The values within the study area are within tolerable limit.

Negative effects of noise on human beings are generally of a physiological and psychological nature. Exposure to continuous and extensive noise at a level higher than 85 dBA may lead to hearing loss. Continuous hearing loss differs from person to person with the level, frequency and duration of the noise exposed.

Air quality index (aqi)

The AQI is an index developed by USEPA for reporting daily air quality. An air quality index is a number used by government agencies to communicate to the public how polluted the air currently is or how polluted it is forecast to become. As the air quality index increases, an increasingly large percentage of the population is likely to experience increasingly severe adverse health effects.

The results of air quality index obtained in this study are shown in Table 4 below.

The Air Quality Index (AQI) of the project area was determined using the formula:

$$API = \frac{1}{n}\sum_{i=1}^{n} A_i \; ; \qquad \mathrm{A_i} = \frac{C_i}{S_i} x100 \qquad (2)$$

Where API = Air pollution Index

C_i = concentration of pollutants i

S_i = Air quality standard for pollutant i

n = number of criteria pollutants

The Air Quality Index (AQI) of the entire study area can be referred to as good based on the level of the recorded parameters from each of the location (Table 4). The air quality index can be referred to as bad if the concentrations of most of the parameters are high in a particular location.

Table 4. Air Quality Index of Onne and Environs

SAMPLE LOCATION	AIR QUALITY INDEX	COMMENT
ON 1	0.33	GOOD
ON 2	0.35	GOOD
ON 3	0.37	GOOD
ON 4	0.42	GOOD
ON 5	0.40	GOOD
ON 6	0.32	GOOD
ON 7	0.35	GOOD
ON 8	0.32	GOOD
ON 9	0.41	GOOD
ON 10 (CONTROL)	0.38	GOOD

Different countries have their own air quality indices, corresponding to different national air quality standards. Computation of the AQI requires an air pollutant concentration over a specified averaging period obtained from an air monitor or model. Taken together, concentration and time represent the dose of the air pollutant.

Health effects corresponding to a given dose are established by epidemiological research. Air pollutants vary in potency, and the function used to concentration to AQI varies by pollutant concentration to AQI varies by pollutant. Air quality index values are typically grouped into ranges.

The AQI can increase due to an increase of air emission (for example during rush hour traffic or when there is an upwind forest fire) or from lack of dilusion of air pollutants. Stagnant air often caused by an anticyclone, temperature inversion, or low wind speeds lets air pollution remain in a local area, leading to high concentration of pollutants, chemical reactions between air contaminants and hazy conditions.

On a day when the AQI is predicted to be elevated due to fine pollution, an agency or public health organization might;

- Advise sensitive groups, such as the elderly, children and those with respiratory or cardiovascular problems to avoid outdoor exertion.
- Declare an "action day" to encourage voluntary measures to reduce air emissions such as using public transportation.
- Recommend the use of mask to reduce fine particles from entering the lungs.
  It tells how clean or polluted air is, and what associated health effects might be of concern. The air quality index focuses on health effects that someone may experience within a few hours or days after breathing polluted air

Table 5 below, show the categories that corresponds to the different level of health concern. The six levels of health concern and what they mean are:

Table 5: Categories of Air Quality Index [17].

Air Quality Index (AQI) Values USEPA	Levels of Health Concern	Colors	Meaning
When the AQI is in this range:	*..air quality conditions are:*	*...as symbolized by this color:*	*Health implication*
0-50	Good	Green	Air quality is considered satisfactory, and air pollution poses little or no risk
51-100	Moderate	Yellow	Air quality is acceptable; however, for some pollutants there may be a moderate health concern for a very small number of people who are unusually sensitive to air pollution.
101-150	Unhealthy for Sensitive Groups	Orange	Members of sensitive groups may experience health effects. The general public is not likely to be affected.
151 to 200	Unhealthy	Red	Everyone may begin to experience health effects; members of sensitive groups may experience more serious health effects.
201 to 300	Very Unhealthy	Purple	Health warnings of emergency conditions. The entire population is more likely to be affected.
301 to 500	Hazardous	Maroon	Health alert: everyone may experience more serious health effects

Conclusion

The study is focused on air assessment with a consideration of several parameters such as CO, TSP, C_xH_y, H_2S, NO_2,SO_2,VOCs, Noise and wind speed. The measured concentration of SO_2 is within IFC limit, but above FMENV limit, NO falls below IFC and Federal Ministry of Environment limit. Wind speed is between 2.21m/s and 4.8m/s and its dominant direction is North East and North West. The Total Suspended Particulate (TSP) fall below FMENV and IFC standard. Hydrogen Sulphide concentration lies between 21.2 to 24ug/m^3, with highest concentration at the Northern part above Notore and towards the refinery. Concentrations of Volatile Organic Carbon (VOCs) are higher around the Onne port, while hydrocarbon concentration is higher close to the refinery, Northward of Notore Company.

Most of the air parameters are within standards except for CO and hydrocarbon concentration. These attest to the overall Air Quality Index indicating good as shown in Table 5. However, some control measures need to be taken to reduce concentration of CO and Hydrocarbon. Carbon monoxide can cause instant death while hydrocarbon is toxic to plants, animals and humans. Although most of the air quality parameters are in conformity with standards (IFC AND FMENV), concentrations are quite significant and can cause serious environmental problems if proper pollution mitigation strategy is not put in place. There is therefore the need for regular air quality monitoring geared towards preventing the exceeding of the air quality limits.

Recommendations

The following are some of the recommendations to ensure that clean air quality is achieved in Onne and environs.

i. There should be an improved traffic control management in Onne and its environs.
ii. Constant air quality monitoring using digital gas monitors/analyzers.
iii. Extensive plantation (trees) to remove a significant amount of pollution from the atmosphere as part of their normal functioning. Vegetation inhibits wind erosion and also serve as wind breaks to lessen wind velocity near the ground. Trees normally increase the quality of air in the city and its surroundings should be considered an integral part of any comprehensive plan aimed at improving overall air quality
iv. Annual inspections of an automobile’s emissions could be a powerful tool in regulating air pollution. Vehicles could be tested each year for emission control and fees would be assessed on the basis of the best results. The fees would encourage the purchase of automobiles that pollute less, and the annual inspections would ensure that pollution control devices are properly maintained.
v. Stationary sources of SO2such as power plants can reduce their SO2 emissions by removing them in the stack before they reach the atmosphere. A highly developed technology for the cleaning of gases in tall stack is scrubbing.
vi. Proper spacing of industries to give room for dilution.
vii. More awareness, collective preventive measures and campaigns against air pollution is needed.
viii. Promoting the use of environmentally friendly clean fuel.
ix. Government policies should be tailored towards having environmentally friendly industries.
x. Compliance with all applicable regulations will help in reducing the menace of pollution in Onne area.

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