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Assessment of Air Quality and Meteorological Variables in Lower Stubbs Creek, Qua Iboe River Estuary, Nigeria

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ABSTRACT

The assessment of air quality and meteorological variables in Lower Stubbs Creek, Qua Iboe River Estuary, Nigeria, was carried out using portable hand-held gas monitors for atmospheric gases and hygrometer, thermometer, anemometer and digital compass for relative humidity, temperature, wind speed, and wind direction. Parameters measured were SO_2, NO_2, H_2S, CO, NH_3, Cl_2, HCN, $PM_{2.5}$, PM_{10}, relative humidity, temperature, wind speed and wind direction. The results for the atmospheric gases followed this decreasing magnitude: PM_{10} (110.35 μm/m^3**)** > $PM_{2.5}$ (55.66 μm/m^3**)** > CO (19.00 ppm) > NH_3 (5.86 ppm) > HCN (1.41 ppm) > H_2S (0.77 ppm) > Cl_2 (0.47 ppm) > NO_2 (0.28 ppm) > SO_2 (0.26 ppm). For the meteorological variables, the mean values for temperature, relative humidity, and wind speed were 25.86 ºC, 67.71%, and 1.17 m/s, respectively. The predominant wind direction was the North Easterly winds. The result for the air quality using 5 criteria pollutants showed that NO_2, SO_2 had Air Quality Index (AQI) values of 0 each, while CO, $PM_{2.5}$ and PM_{10} had AQI values of 224, 151, and 78, respectively. Based on the air quality ratings, the average concentrations of NO_2, and SO_2 in the atmosphere were good while the concentrations of CO, $PM_{2.5}$ and PM_{10} were very unhealthy, unhealthy, and moderate, respectively. This study shows that this region is polluted with CO and particulate matters, hence requires prompt intervention plans and consistent monitoring.

***Keywords*:** Air quality, Lower Stubbs Creek, Air pollution, Meteorology, gas flaring, gaseous emissions, Lower Stubbs Creek, Qua Iboe River Estuary

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1. INTRODUCTION

Air pollution is a global environmental problem predominant in most developed and technologically advanced countries in the world. Air pollution is the introduction of toxic compounds or pollutants into the atmosphere at concentrations high enough to produce undesirable effects on humans, animals, vegetation or materials which significantly alters the natural balance of any ecosystem. Airborne pollutants, such as nitrogen oxides (NO and NO_2), sulfur oxides (SO_2 and SO_3), carbon monoxide (CO), hydrocarbons, and Suspended Particulate Matter (SPM) are constantly being emitted into the atmosphere from diverse anthropogenic activities, such as gas flaring, burning of fossil fuels for energy, automobiles, industry and domestic fuel combustion. These are not without negative impacts on humans and the surrounding ecosystems. For instance, Seyyednejad *et al.* (2011) and Akpoghelie (2016) reported that air pollution results in eye and skin irritation, sneezing, coughing, suffocation, chest pains, and breathing problems. Studies have also shown that these pollutants contribute to global warming, environmental pollution, climate change, acid rain and increased carbon foot print (Osaiyuwu and Ugbebor, 2019). Magaji and Hassan (2015) reported that inhaling polluted air can shorten lifespan of humans by one to three years and also damages our environment. In the same vein, Jo and Herman (2006) stated that hydrocarbon released into in the air undergoes a chemical reaction by combining with photochemical oxidants which may result in lung and eye sicknesses.

Lower Stubbs Creek in Ibeno Local Government Area of Akwa Ibom State, Nigeria, is a typical example of a community highly affected by air pollution from various anthropogenic activities. This is because the region is blessed with vast crude oil resources, thereby making gas flaring highly predominant in the area. These flares originate from oil and gas facilities, most of which are located in the region. According to Onunugbo *et al*. (2011) and Akuro (2012), the danger posed by continuous flaring of associated oil and gas in such a region is that it's a potential source of air pollution which alters the composition of the atmosphere, affects the biotic environment, damages the ozone layer and threatens the health of humans. Within this purview, since air is vital for human survival, its quality needs monitoring from time to time around this community. Although there are a good number of reports on air quality assessment and the adverse effects of air pollution on human health and the environment in various communities, these reports are negligible around Lower Stubbs Creek Community. This lacuna in information obliged this study.

2. MATERIALS AND METHODS

2. 1. Study Area

Lower Stubbs Creek is a small left bank perennial rainforest tributary of Qua Iboe Estuary that is located in the coastal ridges of the Niger Delta of Akwa – Ibom State, Nigeria. The Creek is located between latitudes 4º3' N and 4º8' N and longitudes 6º45' E and 7º55' E (**Figure 1**). The climate of the region is typical of the equatorial region with rainfall through the year. Two seasons, (dry and wet) are, however, discernible in the area. The dry season ranges between November and February with a peak in January. The wet season extends from March to October with a peak in August. The surface water of the aquatic systems is basically warm with temperatures generally greater than 24 ºC. The sea surface temperature shows double peaked cycles which correspond quantitatively to the cycle of the solar heights. Between October and May, sea surface temperature ranges from 27 ºC to 28 ºC while during the rainy season of June to October the range is between 24 ºC and 25 ºC. This variation and decline has been ascribed to an expression of the overall cooling of the South Atlantic Ocean during this period of the year.

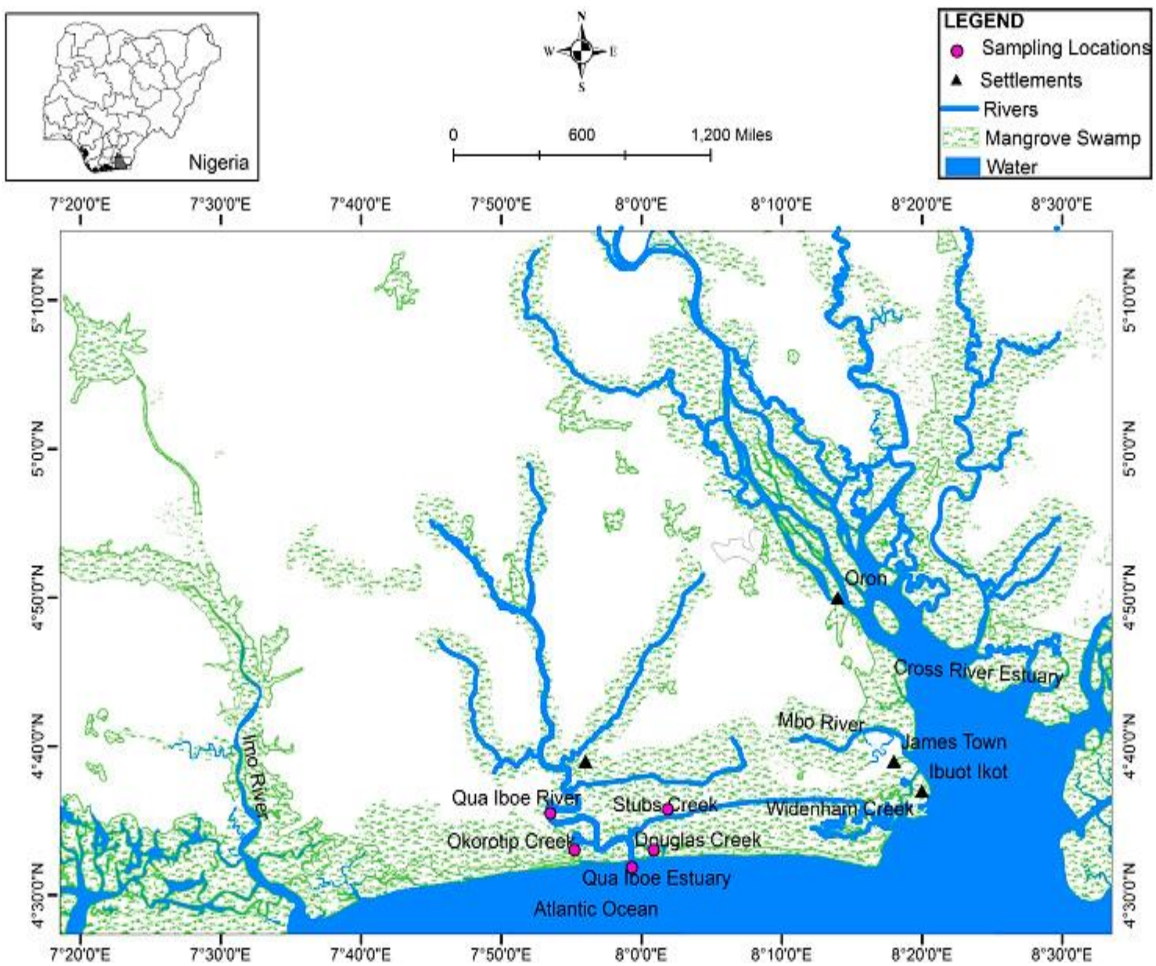

Figure 1. Qua Iboe River Estuary, Nigeria
(Nsikak U. Benson *et al.* 2018)

2. 2. Sampling Technique and Data Collection

Stratified sampling technique was used to determine sampling points. This sampling technique enabled air quality data to be obtained across different locations, which makes it possible for comparison.

2. 3. Precaution/Quality Assurance/Quality Control (QA/QC)

In marking sampling location, special preferences were given to the following: accessibility, availability of open space with good configuration free from shed, meteorological consideration of upward and downward directions**,** areas with minimal local influence from vehicular moment. In sampling, consideration was given to the sensitivity and stability of equipment used, recalibration of equipment and reproducibility of results.

2. 4. Measurement of Gaseous Air Pollutants

Concentrations of air pollutants were measured also at 9 stations in the downward and upward wind directions at a distance of 1.5 m above ground level. Highly sensitive digital portable meters were used for the measurement of NO_2, SO_2, H_2S, HCN, NH_3, TVOC, Cl_2, CO, CH_2O, $PM_{2.5}$ and PM_{10}. The portable meters used in the measurement of gaseous pollutants are presented in **Table 1** below.

Table 1. Measurement of Gaseous Air Pollutants

Parameter	Equipment	Range	Alarm levels
Sulphur dioxide (SO_2)	SO_2 gas monitor Gasman Model 19648H	0-10 ppm	2.0 ppm
Nitrogen dioxide (NO_2)	NO_2 gas monitor Gasman model 19831N	0-10 ppm	3.0 ppm
Hydrogen sulphide (H_2S)	H_2S gas monitor Gasman model 19502H	0-50 ppm	10 ppm
Carbon monoxide (CO)	CO gas monitor Gasman model 19252H	0-500 ppm	50 ppm
Ammonia (NH_3)	NH_3 gas monitor Gasman model 19730H	0-50 ppm	25 ppm
Chlorine (Cl_2)	Cl_2 gas monitor Gasman model 19812H	0-5 ppm	0.5 ppm
Hydrogen Cyanide (HCN)	HCN gas monitor Gasman model 19773H	0-25 ppm	5 ppm
$PM_{2.5}$ and PM_{10},	Air Ae Steward Air Quality Monitor	-	-

2. 5. Determination of Meteorological and Air Quality Parameters

Table 2. Measurement of Meteorological Parameters

Parameter	Equipment
Relative humidity	Hygrometer Model: KTJ TA318
Temperature	Max-Min Thermometer
Wind speed	MASTECH MS6252A Digital Anemometer
Wind direction	Sun Road Digital compass (Altimeter) Model: CR2032

The field meteorological parameters consisted of relative humidity, temperature, wind speed and wind direction. The measurements were taken at 7 stations. The measurements of the meteorological parameters were carried out alongside air quality using *In situ* portable equipment as given in **Table 2**.

2. 6. Data Analysis

Descriptive statistics (means and standard errors) were computed using Graphpad Prism 6. Air quality index of the air pollutants was calculated using the equation:

$$I = \frac{I_{high} - I_{low}}{C_{high} - C_{low}} \times (C - C_{low}) + I_{low}$$

where:

I = the (air quality) index
C = the pollutant concentration
C_{low} = the concentration breakpoint that is $\leq C$
C_{high} = the concentration breakpoint that is $\geq C$
I_{low} = the index breakpoint corresponding to C_{low}
I_{high} = the index breakpoint corresponding to C_{high}.

The ambient air pollutants are then classified into categories as presented in **Table 3**.

Table 3. Rating of Air quality Index

AQI Values	Health concern	Health Effects
0 – 50	Good	None
51 – 100	Moderate	Usually sensitive people should consider reducing prolonged or heavy exertion.
101 – 150	Unhealthy for sensitive groups	Increasing likelihood of respiratory symptoms in sensitive individuals, aggravation of heart or lung disease and premature mortality in persons with cardiopulmonary disease and the elderly
151 – 200	Unhealthy	Increased aggravation of heart or lung disease and premature mortality in persons with cardiopulmonary disease and the elderly; increased respiratory effects in general population
201 – 300	Very unhealthy	Significant increase in respiratory symptoms and aggravation of lung disease, such as asthma; increasing likelihood of respiratory effects in general population.

301 – 500	Hazardous	Serious risk of respiratory symptoms and aggravation of lung disease, such as asthma; respiratory effects likely in general population

3. RESULTS

3. 1. Meteorological and Air Quality of Lower Stubbs Creek

The meteorological and air quality of Lower Stubbs Creek mangrove ecosystem is presented in **Table 4**. For the atmospheric gases, NO_2, SO_2, H_2S, CO, NH3, Cl_2, HCN, $PM_{2.5}$ and PM_{10} and had mean values of 0.26 ppm, 0.26 ppm, 0.77 ppm, 19 ppm, 5.86 ppm, 0.47 ppm, 1.41, 55.66 μ/m^3 and 110.35 μ/m^3, respectively. Generally, the concentrations of atmospheric gases followed this order of decreasing magnitude: PM_{10} (110.35 μ/m^3**)** > $PM_{2.5}$ (55.66 μ/m^3**)** > CO (19.00 ppm) > NH_3 (5.86 ppm) > HCN (1.41 ppm) > H_2S (0.77 ppm) > Cl_2 (0.47 ppm) > NO_2 (0.28 ppm) > SO_2 (0.26 ppm). For the meteorological parameters, temperature, relative humidity and wind speed had mean values of 25.86 ^{o}C, 67.71 % and 1.17 m/s. North Easterly winds was the predominant wind direction.

Table 4. Meteological and air quality of Lower Stubbs Creek mangrove ecosystem

SP	NO_2 ppm	SO_2 ppm	H_2S ppm	CO ppm	NH_3 ppm	Cl_2 ppm	HCN ppm	$PM_{2.5}$ μm/ m^3	PM_{10} μm/m^3	RH %	WD	Temp ^{o}C	Wind Speed m/s
S1	0.30	0.30	0.80	21.00	8.00	0.50	1.00	53.20	110.00	71.50	6NE	25.00	0.80
S2	0.60	0.70	0.90	28.00	8.00	0.60	3.00	85.00	135.50	71.50	4NE	24.50	0.40
S3	0.20	0.20	0.70	20.00	6.00	0.70	2.00	52.30	116.20	72.00	12NE	25.50	0.50
S4	0.20	0.10	0.60	19.00	5.00	0.50	1.00	50.62	105.10	72.00	33NE	26.00	1.00
S5	0.10	0.10	0.70	16.00	4.00	0.30	0.90	60.00	120.00	71.50	15SE	25.00	1.50
S6	0.20	0.20	0.80	12.00	3.00	0.30	1.00	43.52	95.00	54.50	12W	27.00	2.00
S7	0.20	0.20	0.90	17.00	7.00	0.40	1.00	45.00	90.60	61.00	2NE	28.00	2.00
Mean	**0.26**	**0.26**	**0.77**	**19**	**5.86**	**0.47**	**1.41**	**55.66**	**110.35**	**67.71**		**25.86**	**1.17**
FEPA Limits	**0.05**	**0.10**	**0.008**	**10**	**-**	**0.03**	**0.01**	**250**	**150**	**-**	**-**	**-**	**-**

SP – Sampling Points; RH – Relative Humidity; WD – Wind Direction; Temp – Temperature

3. 2. Air Quality Index (AQI) of Lower Stubbs Creek Mangrove Ecosystem

The AQI of Lower Stubbs Creek ecosystem is presented in **Table 5**. From the results, NO_2, SO_2 had AQI values of 0 each while CO, $PM_{2.5}$ and PM_{10} had AQI values of 224, 151, and 78, respectively. Based on the air quality rating and its associated effects, the concentrations of NO_2, and SO_2 in the atmosphere were good while the concentrations of CO, $PM_{2.5}$ and PM_{10} were very unhealthy, unhealthy, and moderate, respectively.

Table 5. Air Quality Index of Lower Stubbs Creek Mangrove Ecosystem

Pollutants	AQI values	Air Quality Rating
NO_2	0	Good
SO_2	0	Good
CO	224	Very unhealthy
$PM_{2.5}$	151	Unhealthy
PM_{10}	78	Moderate

4. DISCUSSION

This study revealed that the concentrations of the atmospheric gases varied across the sampled stations. These variations may be linked to the different intensities of anthropogenic and industrial activities predominating and emitting these gases into the atmosphere. The stations with highest concentration of atmospheric gases may be a pointer to the severity of activities leading to the release of these gases, while stations with low levels of atmospheric gases may depict that activities which led to the release of these gases in the environment were minimal or not intense. The meteorological parameters such as relative humidity, temperature, wind speed and wind direction may also be implicated in the variations observed in the dispersion of these gases.

This is quite true as scholars have affirmed this in related studies. According to Igweze *et al*. (2014), temperature has a pronounce influence on the dispersion of atmospheric gases. Antai (2016) in his findings reported that temperature, wind speed, and humidity have significant influence and effects on the dispersion rates of particulate matters and CO. In the same vein, Ugbebor and Yorkor (2018) reported that pollutant concentrations increase with increasing the wind speed along with the prevailing wind direction.

According to the scholars, periods where the wind is calm usually slow the dispersion rates of gases leading to the ground surface accumulation of pollutants. The mean value for wind speed in this study is in the range reported in by Ugbebor and Yorkor (2018) in an oil and gas facilities in Ogba/Egbema/Ndoni Local Government Area (ONELGA), Rivers State. North easterly wind was dominant in this study and it was found that areas with this wind direction had higher concentrations of most atmospheric pollutants. This may be a pointer to the directional source of these pollutants and further suggest that these areas will experience greater impacts of these gases.

The dominance of the north east winds in this study is also not unrelated to the fact that this study was carried out during the dry season.

The high rankings of gases, such as PM_{10}, $PM_{2.5}$ and CO in terms of concentrations in the study area are not unconnected to the constant oil and gas flaring emissions that are predominant in the area. This is synonymous to the findings of Onunugbo *et al*. (2011), Akuro (2012), McEwen and Johnson (2012) and Giwa *et al*. (2014). These scholars implicated oil and gas flaring activities as being antecedents of the aforementioned gases in their ecosystems of study. Flared gas (FG) is a major contributor to global warming and climate change. This infamous act according to McEwen and Johnson (2012) and Giwa *et al*. (2014) is a primary source of greenhouse gases, particulate matters, precursor gases, volatile organic chemicals (VOCs), polycyclic aromatic hydrocarbon (PAH) and black carbon that pollute the air, soil and water.

Aside from gas flaring activities contributing to the primary source of these gases, vehicular emissions, burning of firewood and fossil fuels cannot be left out as co-contributors of these toxic gases. Gases such as NO_2, SO_2, H_2S, CO, Cl_2 and HCN in the region were above the acceptable limits of FEPA. The elevated levels of these gases may also attribute to gas flaring and vehicular emissions. This may entail the high levels and severe pollution of these gases in the ecosystem. It also expounds that intervention plans are required to reduce the high levels of these pollutants in the area.

The elevated levels of these pollutants are not without environmental and health implications. For instance, NO_2 and SO_2 in high levels, have been reported as major causes of acid rain deposition and fog which can have detrimental impacts on humans and the environments (Mohanty *et al*., 2009). The direct acute effects of NO_2 according to Khan and Siddiqui (2014) include damage of the cell membranes in the lung tissues and constriction of the lung way passages while the indirect effects include nasal irritation, pulmonary discomfort, edema or filling of the inter cellular spaces with the fluid. In China, Cao *et al*. (2011) had reported that increased lung cancer mortality is associated with SO_2. CO had been reported to be toxic to health due to the fact that it combines with hemoglobin to produce carboxyhemoglobin (COHb) which makes oxygen not beimg delivered to bodily tissues (John and Feyisayo, 2013). At 50% level, carboxyhemoglobin in the body may result in seizure, coma, and fatality (John and Feyisayo, 2013). Elevated levels of HCN may result in rapid collapse and cessation of respiration. Kim *et al*. (2014) implicated inhalation of Cl_2 as a potential cause of acute airway obstruction, wheezing, cough, chest tightness and dyspnea. H_2S at low concentrations has pronounced effects on eye and nose which result in insomnia and headache (AndalibMoghadam, 2007).

The air quality index using 5 pollutants criteria revealed that the atmospheric constituent was good in terms of NO_2 and SO_2 levels and very unhealthy, unhealthy, and moderate with CO, $PM_{2.5}$ and PM_{10} concentrations. This may expound that this region is majorly polluted by CO and particulate matters emissions. The high levels of these gases in the area are not also without health implications. Since CO has a high affinity for haemoglobin, its high levels in the body can lead to oxygen deficiency and subsequent death (John and Feyisayo, 2013). Chronic exposures to particulate matters can lead to lung cancer, cardiovascular and respiratory diseases (Khan and Siddiqui, 2014). A very unhealthy levels of the criteria pollutants can cause significant increase in respiratory symptoms and aggravation of lung disease, such as asthma; increasing likelihood of respiratory effects in general population. Increased aggravation of heart or lung disease and premature mortality in persons with cardiopulmonary disease and the elderly; increased respiratory effects in general population are associated with unhealthy levels of these criteria pollutants. With such alarming levels of these pollutants, it is mandatory for appropriate measures to be taken to reduce the emissions of these toxic substances.

5. CONCLUSIONS

This study shows that the levels of atmospheric gases in the region varied from one gas to another. It revealed that oil and gas flaring and other associated anthropogenic activities exerted detrimental impacts on the environment due to a high emission rates of toxic gases. Gases like NO_2, SO_2, H_2S, CO, Cl_2 and HCN were high and above FEPA limits indicating high pollution levels. The air quality index showed that the concentrations of CO, $PM_{2.5}$ and PM_{10} in the region were very unhealthy, unhealthy, and moderate. Conclusively, this study shows that this region is greatly polluted with CO, $PM_{2.5}$ and PM_{10}.

References

[1] Akpoghelie, J.O., Irerhievwie, G.O. Agbaire, P.O., and Orisaremi, A. (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(4): 179-185

[2] Akuro, A. (2012). Air Quality Survey of some locations in the Niger Delta Area. *Journal of Applied Sciences and Environmental Management*, 16 (1): 125-134

[3] AndalibMoghadam, S.H. (2007). 1st Professional Iranian Environmental Conference, Environmental Department of Tehran University, Tehran, Iran. Paper, 76-82.

[4] Antai, R.E. (2016). An Investigative Approach on the Effects of Air and Noise Pollution in Uyo Metropolis, Akwa Ibom State, Nigeria. *Journal of Scientific and Engineering Research*, 3(6): 356-365

[5] Cao, G., Zhang, X., and Zheng, F. (2006). Inventory of black carbon and organic carbon emissions from China. *Atmospheric Environment*, 40: 6516-6527

[6] Giwa, S.O., Adama, O.O., and Akinyemi, O.O. (2014). Baseline black carbon emissions for gas flaring in the Niger Delta region of Nigeria. *Journal of Natural Gas Science and Engineering*, 20: 373-379

[7] Igweze, A.H., Amagoh, M.N., and Ashinze, A.N. (2014). Analysis of rainfall variations in the Niger Delta Region of Nigeria. *IOSR Journal of Environmental Science, Toxicology and Food Technology*, 8(1): 25-30

[8] Jo, P.D. and Herman, R.V.L. (2006). Effect of hydrocarbon on the environment. *Environmental Science and Technology*, 36(5):1130-1135

[9] John, K.S. and Feyisayo, K. (2013). Air Pollution by Carbon Monoxide (CO) Poisonous Gas in Lagos Area Southwestern Nigeria. *Atmospheric and Climate Sciences*, 3: 510-514

[10] Khan, R.R. and Siddiqui, M.J.A. (2014). Review on effects of particulates; sulfur dioxide and nitrogen dioxide on Human Health. *International Research Journal of Environment Sciences*, 3(4): 70-73

[11] Kim, J. Yoon, S. Cho, S. Yu, J. Kim, H. Lim, G., and Kim, J. (2014). Acute health effects of accidental chlorine gas exposure. *Annals of Occupational and Environmental Medicine*, 26 (29): 1-11

[12] Magaji, J. Y. and Hassan S. M. (2015). An assessment of air quality in and around Gwagwalada abattoir, Gwagwalada, Abuja, FCT. *Journal of Environment and Earth Science*, 5 (1): 87-92

[13] Mohanty, C.R., Adapalaa, S., and Meikap, B.C. (2009). Removal of hazardous gaseous pollutants from industrialflue gases by a novel multi-staged fluidized bed desulfurizer. *Journal of Hazardous Materials*, 165: 427-434

[14] Nsikak U. Benson, Adebusayo E. Adedapo, Omowunmi H. Fred-Ahmadu, Akan B. Williams, Essien D. Udosen, Olusegun O. Ayejuyo, and Abass A. Olajire. (2018). New ecological risk indices for evaluating heavy metals contamination in aquatic sediment: A case study of the Gulf of Guinea. *Regional Studies in Marine Science* 18, 44-56

[15] Onunugbo, P.O., Avwiri, G.O., and Chad-Umoren, Y.E. (2011). Impact of gas exploration on the Environmental radioactivity of Ogba/Egbema/Ndoni Area, Nigeria. *Energy and Environment*, 22(8): 1017-1028

[16] Osaiyuwu, R.C. and Ugbebor, J.N. (2019). Air quality assessment of some oil facilities host communities in Rivers State. *Nigerian Journal of Technology*, 38 (1): 242-252.

[17] Seyyednejad, S.M., Majdian, K. Koochak, H., and Niknejad, M. (2011). Air pollution tolerance indices of some plants around industrial zone in south Iran. *Asian Journal of Biological Science*, 4(3): 300-305

[18] Ugbebor, J.N. and Yorkor, B. (2018). Assessment of Ambient Air Quality and Noise Levels around Selected Oil and Gas Facilities in Nigeria. *Journal of Scientific Research & Reports*, 18(6): 1-11.