Determination of Some Air Pollutant and Meteorological Parameters in Abak Market, Abak Municipality of Akwa Ibom State, Nigeria

Jonah, Akanimo Edet
Department of Chemical Sciences Akwa Ibom State Polytechnic, Ikot Osurua
Ikot Ekpene, A.K.S
Email: akan.jonah@gmail.com

Mfon Samuel Obot
Ministry of Science and Technology, Uyo
Email: Obotmfon7@gmail.com

D.O.I: 10.56201/ijccp.v10.no1.2024.pg101.115

Abstract

The determination of some Air Pollutant and Meteorological Parameter in Market, Abak Local Government Area was carried out using standard analytical method; gaseous measuring instrument was used for the analysis. The pollutant monitored were; NO_2, SO_2, H_2S, CO, NH_3, Cl_2, HCN, TVOC, CH_2O, $PM_{2.5}$, PM_{10},Temperature, Relative Humidity (RH), Pressure and wind speed (WS). The results for the concentration of air pollutant and their air quality index AQI reveals as follows; NO_2:(0.15± 0.04 (ppm), AQI = 150), SO_2: (0.20 ± 0.07 (ppm), AQI = 40), H_2S: (0.14 ± 0.06 (ppm), AQI = 70), CO: (4.01± 0.53 (ppm), AQI = 80.2), NH_3: (5.13 ± 0.2 (ppm), AQI = 102.6), Cl_2: (0.48 ± 49.5 (ppm), AQI = 480), HCN: (1.59 ± 0.56 (ppm), AQI = 15,900), TVOC: (3.95 ± 0.74 (mg/m^3), AQI = 790), CH_2O (0.06 ± 0.07 (mg/m^3), AQI = 3,000), $PM_{2.5}$: (83 ± 8.54 $\mu m/m^3$), AQI = 3.32), PM_{10}: (145 ± 4.18($\mu m/m^3$), AQI = 245.76), Temperature: (33.0 ± 0.00 (^0C), Relative Humidity: 66.0 ± 0.00 (0%), Pressure: (1002 ± 1.79kpa), and Wind Speed: (0.78 ± 0.69 (m/s). The result showed that pressure, NO_2 NH_3, Cl_2, HCN, TVOC, CH_2O, $PM_{2.5}$, PM_{10}, Temperature and Relative Humidity were higher than FEPA safe limit while SO_2, H_2S, CO and Wind Speed were within the FFPA safe limit. This result is an indication of presence of possible air pollutants in the air of the study area which may result in many health problem.

Keywords: *Pollution; Air Pollution and Meteorological Parameters*

INTRODUCTION

Background of the Study

One of the major challenging environmental problems that has bedeviled both the developed and developing countries of the world today is air pollution which has recently been linked to increased mobility and mortality rates (Pope *et al., 2002*). Atmospheric pollution is a condition in which certain substances, which include gases (Sulphur dioxide, nitrogen oxides, carbon monoxides, hydrocarbons etc) particulate matters (smoke, dust, fumes, aerosols, etc.),

radioactive materials and many others, are present in such concentrations that may produce undesirable effects on man and ecosystem. Human exposure to air pollutants is unavoidable in today's perspective especially in the urban areas of most developing countries (Berman *et al.*, 2012).

Though, air pollution could be due to natural sources, a major anthropogenic source of air pollution is due to man's quest for a better standard of living and the utilization of natural resources for rapid industrialization, urbanization and consequently causing excessive air pollution. Therefore, air pollution problems have continued to receive a great deal of interest worldwide due to its negative impacts on human health and welfare (Brunekreef and Holgate, 2012).

Among the reported cases of extreme air pollution conditions that affects humanity include the issues of high blood pressure and other cardiovascular problems. Air pollution therefore, is a serious threat to environmental health in many cities of the world today. It is very pertinent to note that this condition is not unconnected to the fact that one of the basic requirements of human health and existence is clean air (Mohammed and Caleb, 2014).

Materials and Method

Study Area

Abak is one of the Local Government Area in Akwa Ibom State. Abak is an urban with public facilities such as government housing estates, hospitals, administrative buildings, schools, markets, Motor Park and residential houses. The location chosen for the study was area with high atmospheric particulates and aerosol. The location is Abak market. The Global position system (GPS) coordinates of the location $04^0\ 58^1\ 55.8^{11}$ N and $007^0\ 47^1\ 24.1^{11}$ E at an elevation of 60M. Abak as semi-urban in a developing country like Nigeria, where constant power supply is yet to be guaranteed is also experiencing constant emission of toxic gases from generators into the atmosphere. This research was undertaken in the morning hours for a period of 3 hours during the dry season of the study area. Thus, the air quality should, be effectively and periodically monitored to identify levels of these toxic gases in the air.

Materials

Equipments used in detecting the air pollution are listed in the table below.

Table 1: Materials used in determining the air pollution

Parameters	Equipment's Model
NO_2	NO_2 gas monitor Gasman Model 19648H
SO_2	SO_2 gas monitor Gasman Model 19831H
H_2S	H_2S gas monitor Gasman Model 19502H
CO	CO gas monitor Gasman Model 19252H
NH_3	NH_3 gas monitor Gasman Model 1973OH
Cl_2	Cl_2 gas monitor Gasman Model 19812h
HCN	HCN gas monitor Gasman Model 19773H
TVOC	TVOC gas Monitor Gasman Model Air Ae Steward air quality monitor
CH_2O	CH_2O gas Monitor Gasman Model Air Ae Steward air quality monitor
$PM_{2.5}$	$PM_{2.5}$ gas Monitor Gasman Model Air Ae Steward air quality monitor
PM_{10}	PM_{10} gas Monitor Gasman Model Air Ae Steward air quality monitor

Other instrument was, Max/Min Thermometer (Model No: KTJTA 318) used for measuring the temperature and digital Anemometer (MASTECH MS 6252A).

Determination of Air Quality Index

Air quality index (AQI) is an overall measure of the status of a place under consideration. On the basis of air quality index "Q", the quality rating of each parameter was obtained by the formula given below (Agar-wal *et al*., 2008)

Q = (O/Ps) X 100

Where:

Q = Quality Ratings

O = Observed value

Ps = Prescribed Standards as Permissible Limit

Subsequently, the geometric mean of this "n" number of quality ratings "Q" was estimated, which is known as AQI.

Result and Discussion

Results

Figure 1: The results of some air pollutants and meteorological parameters in Market in Abak Local Government Area.

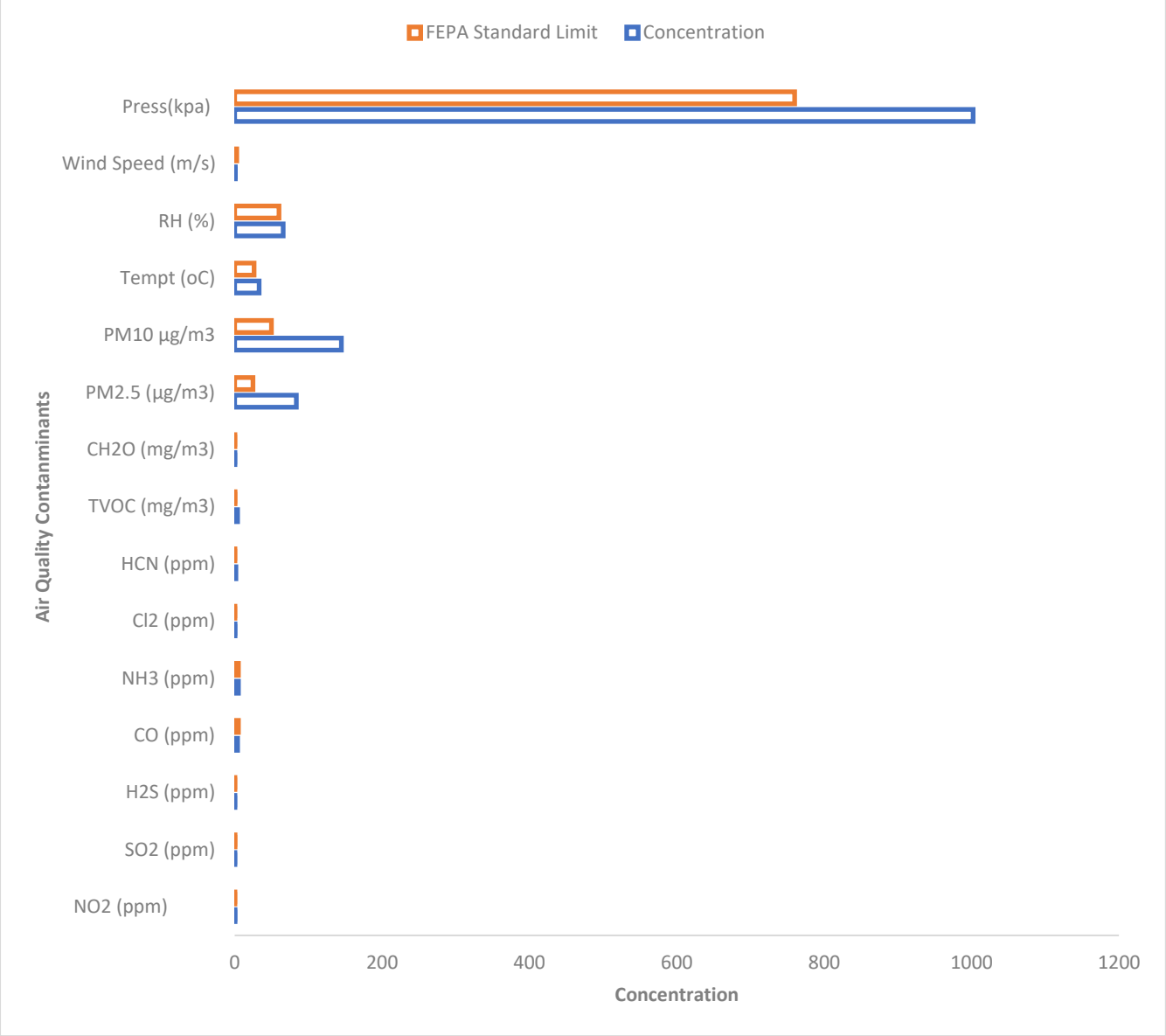

Table 2: The Air Quality Index of Air Pollutants Analyzed

Air Quality Contaminants	**AQI**
NO_2 (ppm)	150
SO_2 (ppm)	40
H_2S (ppm)	70

CO (ppm)	80.2
NH_3 (ppm)	102.6
Cl_2 (ppm)	480
HCN (ppm)	15,900
TVOC (mg/m^3)	790
CH_2O (mg/m^3)	3000
$PM_{2.5}$ ($\mu g/m^3$)	332
PM_{10} ($\mu g/m^3$)	125

AQI – Air Quality Index

Table 3: Air Quality categories based on the air quality index by central pollution control board (CPCB), 2009.

S/N	AQI of Ambient Air	Prescription of Ambient Air Quality
1.	<10	Clean
2.	10 – 25	Very clean
3.	25- 50	Fairly clean
4.	50 – 75	Moderately polluted
5.	75 – 100	Polluted
6.	100 – 125	Heavily polluted
7.	>125	Severely polluted

Source: CPCB (2009)

Discussion

The mean concentration of Nitrogen (IV) oxide (NO_2) recorded 0.15 ± 0.04 (ppm) which is the above range of 0.004 – 0.1 (ppm) recommended by the (FEPA). Although, the level of NO_2 in the study area is lower than 0.18 ± 0.10 obtained by Ibe, (2016). Thus, prolong inhalation of air from the study area may affect the lung and throat of humans and living things. AQI (150) reveal that the air is severely polluted.

Sulphur dioxide (SO_2) recorded a mean concentration of 0.20 ± 0.07 (ppm) which is below the standard limit of 0.05 – 0.5 (ppm) recommended by (FEPA). The concentration in this study is lower than 0.40 ± 0.09 obtained by (Mohammed *et al.,* 2013). However, this shows that the level of SO_2 in the study area is within the safe limit. Though prolong inhalation of air from the study location for a long time by human may cause respiratory problems and severe headache. However, AQI (40) reveals that the air is fairly clean.

The mean concentration of Hydrogen sulphide (H_2S) obtained in this study was 0.14 ± 0.53 (ppm). This value is higher than the range of 0.15 – 0.2 (ppm) recommended by FEPA. The mean in this study is lower than 0.32 ± 0.16 (ppm) reported by (Wrong *et al.,* 2012). Consequently AQI (70) reveals that the air is moderately polluted.

Carbon monoxide (CO) recorded a mean concentration of 4.01 ± 0.53(ppm). This value is below the standard limit of 10.0 – 5.0 (ppm) reported by (Ibe *et al.,* 2016). However, the level of CO in this study is in the safe limit. Although studies have shown that, CO can cause tissue damage after prolong exposure and its affinity for haemoglobin is almost 220 time greater than that of oxygen. Although, the AQI (80.2) reveals that the air is polluted.

Ammonia (NH_3) recorded a mean concentration of 5.13±0.2 (ppm) which is higher than the standard limit of 2.0 – 5.0 (ppm) recommended by FEPA. The mean concentration of NH_3 in this study is lower than 1.13 ± 0.96 (ppm) reported by (Ibe 2016). The high concentrations of ammonia recorded may be accredited to vehicular emission and volatilization from soil and ocean as reported by (Wong *et al.,* 2012). However, the AQI (102.6) reveals that the air is heavily polluted.

The mean concentration of Chlorine (Cl_2) recorded was 0.48 ± 49.5 (ppm). This value is higher than the standard limit of 0.03 – 0.1 (ppm) set by FEPA. The mean concentration of Cl_2 in this work is lower than 0.35 ± 0.19 (ppm) reported by (Gobo *et al.,* 2012). The high level of chlorine recorded in the area under study should be checked and controlled to forestall associated health implications reported by (Weli and Ayoade, 2014). Chlorine level reported in this study may be from burning of rubbish containing PVC and natural sources as sea water. However, the AQI (480) reveals that the air is severely polluted.

Hydrogen cyanide (HCN) recorded a mean concentration of 1.59 ± 0.56 (ppm). This value is higher than 0.01 ppm stipulated standard of FEPA .HCN fall under severely polluted when subjected into air quality standard: AQI (15,900). The present of HCN in the study area may be attributed to emission of gas into the atmosphere by companies and burning of chemical containing material. HCN in higher concentration are known for their effect on the respiratory system and the heart- beat.

The mean concentration of total volatile organic compounds (TVOC) obtained in this study is 3.95 ± 0.74 (mg/m^3). This value is above the standard limit of 0.33 – 0.5mg/m^3

recommended by FEPA. The concentration in this research is lower than 3.40 ± 11.53 mg/m^3 revealed by the (Ibe *et al.*, 2016). High level of TVOC can cause health effect such as eye, nose and throat irritation, headache, loss of coordination, nausea, and damage to the liver, kidney and central nervous system. Common organics can cause cancer in animals, some are suspected to be the cause of cancer in humans. However, the AQI (790) reveals that the air is severely polluted.

Formaldehyde (CH_2O) recorded a mean concentration of 0.36±0.07 (mg/m^3) which is above the standard limit of 0.012 (mg/m^3) recommended by FEPA. Thus, the high level of formaldehyde can enter the blood if inhale. Also when you breathe air containing formaldehyde, most of the formaldehyde is quickly broken down in the cells accumulating in the respiratory tract.

The departments of Health and Human Service (DHHS) and the International Agency for Research on Cancer (IARC) have characterized formaldehyde as a human carcinogen based on studies of inhalation exposures. Consequently, the AQI (3000) reveal that air is severely polluted.

The mean concentration particulate matter of ($PM_{2.5}$) reveals in this work is 83 ± 8.54 (µ/m^3). This value is above the standard limit 25µ/m^3 recommended by FEPA. A study published in the journal of the American medical Association suggests that long-term exposure to $PM_{2.5}$ may lead to plaque deposits in articles, causing vascular inflammation and a hardening of the arteries which can eventually lead to heart attack and stroke. However, the AQI (332) reveals that the air is severely polluted.

Particulate matter (PM_{10}) recorded a mean concentration of 145±4.18 (µg/m^3) which is above the standard limit of 59 (µg/m^3) recommended by FEPA. The mean concentration in this work is higher than 46.00µg/m^3 reveal by (Huang *et al.*, 2015). Exposure to high concentration of PM_{10} can result in a number of health impacts ranging from coughing, wheezing, asthma attacks and bronchitis to high blood pressure, stroke and premature death. Consequently, the AQI (25) reveals that the air is severely polluted.

Temperature (^{0}C) in the study area was found to be 33.00± 0.00. This result is higher than the FEPA stipulated standard for temperature 26.40^{0}C. This indicates that the activities carried out in the area increases the temperature level of the area. (Wong *et al.*, 2008) reported 28.00^{0}C of temperature in their study area which is not accordance with the present result.

The relative humidity of the study area was 66.0 ± 0.00% which is lower than FEPA stipulated standard of 25 – 60%. Low level of (RH) in the area may be attributed to series of industrial activities in the area and other human activities in the environment.

The mean concentration of pressure recorded was 1,002±1.79 (kpa) the value is above the standard limit of 769 (kpa) recommended by FEPA. The high pressure in the area may be harmful to the habitat. (Hassan and Abdulahi, 2002) reported 105.0 ± 0.21 which is lower than the present result.

The mean value of wind speed recorded was 0.78 ± 0.69 (m/s) was within the FEPA permissible limit 2.8m/s which means that the area is safe from any wind hazard.

When comparing the result of the analysis with Air Quality Index (AQI) Nitrogen (IV) (NO_2), Hydrogen cyanide (HCN), Chlorine (Cl_2), Total Volatile Organic Compound (TVOC), Formaldehyde (CH_2O), Particulate Matter ($PM_{2.5}$) were several polluted, Ammonia (NH_3) heavily polluted, Hydrogen sulphide (H_2S) Heavy polluted, and sulphur dioxide (SO_2) was fairly polluted.

TABLE 4: Correlation of gaseous pollutants with some meteorological parameters.

	NO_2	SO_2	H_2S	CO	NH_3	Cl_2	HCN	TVOC	CH_2O	$PM_{2.5}$	PM_{10}	Temp	RH	Press	Wind Speed
NO_2	1														
SO_2	-.897**	1													
H_2S	1	-.897**	1												
CO	-.195	.602*	-.195	1											
NH_3	.834**	-.986**	.834**	-.662*	1										
Cl_2	-.328	.334	-.328	-.006	-.436	1									
HCN	-.161	-.240	-.161	-.888**	.278	.408	1								

TVOC	.125	-.499	.125	-.947**	.517*	.321	.958**	1							
CH_2O	-.866**	.899**	-.866**	.366	-.922**	.700**	.090	-.155	1						
$PM_{2.5}$	.843**	-.719**	.843**	-.170	.594*	.227	.033	.279	-.487	1					
PM_{10}	.426	0	.426	.797**	-.077	-.308	-.944**	-.825**	-.239	.295	1				
Temp	.674*	-.362	.674*	.315	.208	.292	-.358	-.161	-.226	.878**	.632*	1			
RH	-.134	.120	-.134	-.138	-.232	.975**	.478	.447	.529*	.411	-.316	.400	1		
Press	.522*	-.676*	.522*	-.439	.775**	-.881	.000	.144	-.878**	.024	-.000	-.258	-.774**	1	
Wind speed	.731**	-.845**	.731**	-.468	.905**	-.777**	.011	.217	-.972**	.300	.079	-.003	-.624*	.960**	1

** Correlation is significant at the 0.01 level (2 tailed)
* Correlation is significant at the 0.05 level (2 tailed)

Correlation Analysis Correlation matrix as presented in table (4) shows the relationship among the air particulates monitored. NO_2 shows a strong positive correlation with NH_3, $PM_{2.5}$, and Wind Speed at $p< 0.01$ level with ($r = 0.834$, 0.843, and 0.731) respectively. However, there was a positive correlation at $p <0.05$ level with Temperature and Pressure at $p< 0.05$ with r value of 0.674 and 0.522. This is an indication that, the present of these pollutants in the air within the study area may have been emanated from the same source, according to Romic and Romic (2002). However, there was a correlation but negatively at $p < 0.01$ level with SO_2 and CH_2O ($r = -0.897$ and -0.866). This indicated that as NO_2 increases SO_2 and CH_2O decreases. SO_2 shows a strong positive correlation with CH_2O at $p < 0.01$ level ($r = 0.899$). This revealed the common source of this pair of air contaminants. However, there was a positive correlation at $p<0.05$ level with CO with r value of 0.602. This indicates that as SO_2 increases CO decreases. However, there was a negative relationship with H_2S, NH_3, $PM_{2.5}$ and Wind Speed at $p < 0.01$ level with $r = -0.897$, -0.986, -0.719 and -0.845 respectively. There was also negative relationship at $p<0.05$ with Pressure with a value of $r = -676$. Results obtained indicated that they are from different sources.

H_2S correlated positively with NH_3, $PM_{2.5}$ and Wind Speed at $p< 0.01$ level with r value of 0.834, 0.843 and 0.731 respectively. However, there was a positive correlation at $p<0.05$ level with Temperature and Pressure with r value of 0.674 and 0.522. Result shows that the pollutants may be from the same source. However, there was a correlation but negatively at $p < 0.01$ level with CH_2O ($r = -0.866$). This indicated that as H_2S increases CH_2O decreases.

CO correlated positively but significantly with PM_{10} at $p< 0.01$ level limit with r value of 0.797. This result shows that the pollutants may have emanated from the same source. However, there was a negative relationship with HCN and TVOC at $p< 0.01$ level with $r = -0.888$ and -0.947. However, there was a negative relationship with NH_3 at $p<0.05$ with r value of -0.662. Results obtained indicated that they are from different sources.

NH_3 shows a strong positive correlation with TVOC and $PM_{2.5}$ at $p<0.05$ level with $r = 0.517$ and 0.594 respectively. However, there was a positive correlation with Pressure and Wind Speed at $p<0.01$ level with r value of 0.775 and 0.905. This revealed the common source of this pairs of air contaminant. However, there was a correlation but negatively at $p< 0.05$ level with CH_2O ($r = -0.922$). This indicates that as NH_3 decreases, CH_2O increases and vice versa.

Cl_2 correlated positively with CH_2O and RH at $p< 0.01$ level with r value of (0.700 and 0.975) and showed negative significant correlation with Wind Speed at $p<0.01$ with r value of -0.777. The positive correlation shows that the pollutant may be from the same source while the negative indicates that they are from different sources.

HCN correlated positively with TVOC at $p< 0.01$ level with r value of 0.958 and showed negative significant correlation with PM_{10} at $p<0.01$ with r value of -0.944. The positive correlation shows that the pollutant may be from the same source while the negative indicates that they are from different sources.

TVOC shows a strong negative correlation with PM_{10} at $p< 0.01$ level with r value of-0.825. This result shows that, they are of different source and as TVOC increases PM_{10} decreases and vice versa (Romic and Romic, 2002).

CH_2O shows a positive correlation with RH at $p< 0.05$ level with $r = 0.529$ and a negative relationship with Pressure and Wind Speed at $p< 0.01$ level with ($r = -0.878$ and -0.972 respectively). The positive correlation shows that the pollutants may be from the same source while negative indicates that they are from different sources.

$PM_{2.5}$ correlated positively with Temperature at $p<0.01$ level with $r = 0.878$. The positive correlation shows that the pollutants may be from the same source.

Correlation analysis between PM_{10} and Temperature shows a positive relationship at $p< 0.05$ level ($r = 0.632$). This revealed the common source of the pairs of air contaminants.

RH correlated strongly but negatively with Pressure at $p<0.01$ level with ($r = - 0.774$) and at $p<0.05$ with Wind Speed with ($r = -.624$). This indicated that they are from different source.

Pressure correlated strongly but negatively with Wind Speed at $p<0.01$ level with ($r = - 0.960$).This indicated that they are from different source. It also shows that as Pressure increases Wind Speed decreases

Conclusion

Environmental pollution is one of the factors that disturb the habitat of a particular environment. The result of the research revealed that Abak is composed of all the analyzed pollutants. Through H_2S, NH_3, Cl_2, HCN, TVOC, CH_2O, $PM_{2.5}$, PM_{10}, temperature, Relative Humidity and Pressure were higher than the FEPA stipulated standard while H_2S, SO_2, CO and Wind Speed were within the stipulated standard permissible limit. The presence of these pollutants at variable levels indicate possible health implications. The presence of these pollutants may be due to some commercial activities within the area. The high concentration of particulate matter, H_2S, NH_3, Cl_2, HCN, TVOC, CH_2O, may be attributed to smoke emanated from vehicles, combustions of fuel, burning of tires, PVC and decomposition of organic wastes..

REFERENCES

Agarwal, S., Swami, I. B. & Gupta, A. B.(2008). Interpretation of ambient air and Air Quality Parameters in Jaipur City – A case study. *Nature Environment and pollution Technology*.7 (4), 573-578

Anderson, Z. J., Huidberg, M. Jeusen, S. S, Kertzel, M., Loft, S. Sorensen, M, & Raaschou-Nelson. O. (2011). Chronic obstructive pulmonary disease and long-term exposure to traffic related air pollution. Cohort study. *America journal of respiratory and critical care medicine*, 183 (4), 455-461.

Barman, S. C., Kisku, Khan, A. H. Ahmed, T & Sunkula, P. (2012). Assessment of ambient air quality of lucknow city during pre-monsoon. Findings of a random survey. Proceedings of the world environment Day, Junes, 2012, CSIR- Indian Institute of Toxicology Research Mahatma Ganhimarg, Lucknow, India, Pp: l-26

Brunekreef, B. & Holgate, S. T. (2002). Air pollution and Health. *Lancet*, 360: 1233-1242.

CPCB (2009). Standards for liquid equivalent gaseous emission Automobile Exhaust, Noise and Ambient Quality Pollutant control and law series: Ministry of Environment and forests Government of India, New Delhi 2005-2009.

Federal Environmental Protection Agency (FEPA). (1991). National Interim Guidelines and Standards for Industrial Effluents, Gaseous Emissions and Hazardous Wastes in Nigeria. (pp. 1-42). Abuja: Government Press.

Gobo, A. E., Ideruiah. T. J. K., T. F. & Stanley, H. O. (2012). Assessment of air quality and noise around Okrika communities, Rivers State, Nigeria. *J. Applied Sci. Environ. Manage*, 16: 75-83.

Hassan, S. M. & Abdullahi, M. E. (2012). Evaluation of pollutants in ambient air: A case study of Abuja – Nigeria. *Int. J. Sci. Res.*, 2:1-9

Huang, W. E., Long, J., Wang, R. H. & Ma, L. (2015). Characterizing spatial distribution and temperature variation Of PM10 and PM2.5 Mass Concentrations in an Urban Area of Southwest China. *Atmos. Pollut. Res*., 6:842 – 848.

Ibe, F. C. & Ibe, B. O. (2016). Roof runoff water as source of pollution: A case study of some selected roofs in Orlu Metropolis, Imo State, Nigeria. *Int. Lett. Nat. Sci.*, 50:53-61.

Ibe, F. C. & Njoku, P. C., Alinnor, J. I. & Opara, A. I. (2016). Spatial Variation of NO2 and SO2 in the ambient environment of Imo State, Nigeria. *Int. J. Sci. Environ. Technol.* 5:33-46.

Mohammed, Y., Uzain, A. & Ujoy, J. O. (2013). Determination of sulphur dioxide concentrations in ambient air of some selected traffic areas in Kaduna Metropolis. *Res. J. Applied Sci. Eng. Technol.* 6:2923-2930.

Mohammed, Y. & Caleb, J. J. (2014). Assessment of some air pollutants and their corresponding air quality at selected activity areas in Kaduna Metropolis. *Proceedings of the 37th Annual International Conference of Chemical of Nigeria,* Pp. 38-44.

Pope, C. A. Burnetti, M. J., Thun, E. E., Calle, D. Krewski, K. H. & Thuroton, G. D. (2002). Lung cancer. Cardiopulmonary mortality and long-term exposure to fine particulate air pollution. *J. Am. Med. Assoc.* 287:1132-1141.

Romic, M. &Romic, D. (2002). Heavy metal distribution in agricultural top soil in urban areas. *Environ. Geol*., 43, 795 – 805.

Wieli, V. E. & Ayoade, J. O. (2014). Seasonal analysis of atmospheric pollutants concentrations in the urban and rural land use areas of rivers state. Nigeria. *Int. J. Environ. Pollut.* Res. 2:1-16.

Wong, C. M. Vichit-Vadakan, N., Kan, H. & Qian, Z. (2008). Public Health and Air Pollution in Asia (PAPA): A multicity study of short-term effects of air pollution on mortality. *Environ. Health Perspect.* 116:1195-1202.

Wong, T. W., Tam, W. W. S. Lau, A. K. H., Ng. S. K., Yu, I. T. S. & Wong, A. H. S. & Yeung, D. (2012). A study of the air pollution index reporting system. *Tender Ref. AP* 07-085, Final Report/June 27, 2012. Environmental Protection Department (EPD) of Hong Kong.