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Air Quality Monitoring and Its Health Implications in Selected Communities in Kalabari Kingdom Rivers State.

Ida, Ida Ekereke[1], J.N. Ugbebor[2] &V. E. Amah[3]
[1, 2& 3]Centre for Occupational Health, Safety and Environment, University of Port Harcourt, Rivers State.

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ABSTRACT
The study investigated the air quality status in Kalabari Kingdom with a view to determining the Air Quality index (AQI) breakpoint values, and its possible health implications to residents of the region. Air quality parameters determined include nitrogen oxide (NO_2), sulphur dioxide (SO_2), Carbon monoxide (CO), and Particulate matter ($PM_{2.5}$& PM_{10}). Temperature, relative humidity, wind speed, and wind direction are the weather parameters studied. These data were collected for three days at 100 m to 1000 m intervals with regard to distance from the source of the pollutants into the residential area using composite sampling technique. In order to assess the important effect of distance from the source on pollutant concentrations, Pearson Correlation Statistics was used. Results indicate that, pollutants considered were higher at the source but dispersion to the residential area was also evident from the result obtained during the research. From the results obtained, the average Pollution Index of NO_2, SO_2, CO, and $PM_{2.5}$ and PM_{10} were 100.0ppb, 89.5ppb, 188.3ppb, 172.2 ug/m^3, and 102.3 ug/m^3 respectively. Distance from the Source were at 100m, 300m, 500m, 700m and 1000m respectively. The break point for these pollutants from the AQI table was found to be in the range of unhealthy for sensitive groups to very unhealthy. Therefore, results and recommendations have been made and if adopted would go a long way to ensure that the pollutants observed would not have a detrimental effect on the health and well-being of residents.

Keywords: Air Quality Index, Air Pollutant, Air Pollution

I. INTRODUCTION

A layer of air comprising of a combination of gases and suspended particulate matter (solid and liquid) surrounding the Earth is the earth's atmosphere. Air, except for the amount of water vapor, is a combination of gases with a very constant composition. The volume composition of dry air consists of 78% nitrogen, 21% oxygen, 0.03 percent carbon dioxide, etc. In addition to the listed air components, there are also small amounts of dust and other contaminants, such as sulphur dioxide, ozone, and nitrogen oxides [11].

Air pollution is caused by the presence of toxic substances, mostly caused by human activity, in the atmosphere, but it can also be caused by natural events, such as volcanic eruptions, dust storms and wildfires, often decreasing the air's characteristics [11].

As an effect of human activities, the burning of fossil fuels such as coal and oil for energy and road transport, producing air pollutants such as nitrogen and sulphur dioxide, can result in air pollution (anthropogenic sources). Industrial and plant emissions; the release of large quantities of carbon monoxide, hydrocarbons, chemicals and organic compounds into the atmosphere. Agricultural activities; as the use of toxic chemicals emitting pesticides, insecticides, and fertilizers. Waste production is hugely due to the generation of methane in landfills and open dumps of waste [7].It is difficult to define the full degree of possible and actual harm caused by all forms of air pollution. But here are the core effects: air pollution consumes, in many instances, a direct effect on the mechanism of plant evolution on the environment by stopping

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photosynthesis, with serious consequences for the purification of the air we breathe. It also backs to the production, in the way of atmospheric precipitation, of acid rain, ice, frost, snow or fog produced during the burning of fossil fuels also transformed by contact with water vapor in the air. A significant donor to global warming and climate change is air pollution. One of the causes of the greenhouse effect is the abundance of carbon dioxide in the atmosphere. Normally, because they absorb the infra-red radiation released by the earth's surface, the presence of GHG should be beneficial for the planet. Yet an unsustainable accumulation of these gases in the air is the cause of recent climate change. Also, the deterioration of human health may be blamed to our persistent exposure to air pollutants [9].

Due to a multiplicity of factors, such as illegal refining of oil, gas flaring and industrial happenings across the Niger Delta, there is a reduction in air quality. Air Pollution may add to the poor health conditions amongst residence of Kalabari communities. There is little or no implementation/monitoring of government driven policy or program concerning Air quality monitoring around the region. Hence an assessment of the air quality is necessary.Therefore, the aim of this research was to monitor theair quality of selected communities in Kalabari region in Rivers State and establish its health implication base on the AQI.

II. LITERATURE REVIEW

The Air Quality Index, or AQI, which tests air conditions across the country based on concentrations of five major pollutants, is one measure of outdoor air pollution in Nigeria: ground level ozone, particulate pollution (or particulate matter), carbon monoxide, sulphur dioxide, and nitrogen dioxide. Any of these, along with radon, tobacco smoke, volatile organic compounds (VOCs), formaldehyde, asbestos, and other chemicals, also lead to indoor air contamination [1].Air pollution problem can simply be depicted as a system consisting of three basic components: emission sources; atmosphere; and receptor. An emission source is the genesis of air pollution. Major emission sources include transportation, industrial fuel burning, and industrial processes [2].There are various types of air pollutants from various sources with receptor effects unique to their composition. They are broadly divided into types i.e., primary and secondary pollutants. Primary pollutants are those released directly into the air from sources of emissions. Secondary pollutants are produced when primary pollutants experience chemical changes throughout the atmosphere. The pollutants, their causes and impacts on health and the environment are clearly illustrated below: Ozone, carbon monoxide, nitrogen oxide, particulate matter, sulphur dioxide, lead, toxic air pollutants and greenhouse gases ([9]; [10]; [12]; [3]; [4]).

Different reactions and movements happen as particles are released into the air. In the environment, the movement of contaminants is caused by shipping, dispersion, and deposition. Transport is a movement caused by the average wind flow over time [8]. Local turbulence and thermal currents result in dispersion. Processes of deposition, including erosion, scavenging, and sedimentation, cause contaminants in the atmosphere to shift downward, gradually removing the pollutants to the ground surface. Many atmospheric variables, including wind direction and wind speed, terrain type and heating effects, affect the way air pollution is distributed [5]. Atmospheric conditions can simply be defined as either stable or unstable, where stability is determined by wind (which stirs the air) and heating effects, to better understand how atmospheric processes can affect ground level pollution (which cause convection currents). Atmospheric stability has a different effect on emissions emitted from ground level and elevated sources).

Air Quality Standard was last revised in 1990, the Clean Air Act allows the EPA to set national environmental air quality standards for pollutants deemed to be detrimental to public health and the environment. Two types of national standards of ambient air quality are defined by the Clean Air Act. Public health safety is provided by primary criteria, including protecting the health of "sensitive" groups such as asthmatics, infants, and elderly people. Secondary requirements provide for the safety of public health, including protection from reduced visibility and harm to livestock, crops, plants and structures [3].For six major contaminants, which are called "criteria" pollutants, the Environmental Protection Agency (EPA) has set national environmental air quality standards. The standards for pollutants are shown in Table 2.1. Parts per million (ppm) by volume, parts per billion (ppb) by volume and micrograms per cubic meter of air (µg/m3) are the measurement units for the standards. The essence of these standards is to restrict manufacturing industries and manufacturing plants to strictly comply with the emission standards established by the EPA, thereby maintaining the quality of the ambient air.

Table 1: **The National Ambient Air Quality Standards (NAAQS)**

Pollutant [final rule cite]	Primary/ Secondary	Averaging Time	Level	Form
Carbon Monoxide [76 FR 54294, Aug 31, 2011]	Primary	8-hour	9 ppm	Not to be exceeded more than once per year
		1-hour	35 ppm	
Lead [73 FR 66964, Nov 12, 2008]	primary and secondary	Rolling 3 month average	0.15 $\mu g/m^3$	Not to be exceeded
Nitrogen Dioxide [75 FR 6474, Feb 9, 2010] [61 FR 52852, Oct 8, 1996]	primary	1-hour	100 ppb	98th percentile of 1-hour daily maximum concentrations, averaged over 3 years
	primary and secondary	Annual	53 ppb	Annual Mean
Ozone [73 FR 16436, Mar 27, 2008]	primary and secondary	8-hour	0.075 ppm	Annual fourth-highest daily maximum 8-hr concentration, averaged over 3 years
Particle pollution Dec 14, 2012 $PM_{2.5}$	Primary	Annual	12 $\mu g/m^3$	annual mean, averaged over 3 years
	Secondary	Annual	15 $\mu g/m^3$	annual mean, averaged over 3 years
	primary and secondary	24-hour	35 $\mu g/m^3$	98th percentile, averaged over 3 years
PM_{10}	primary and secondary	24-hour	150 $\mu g/m^3$	Not to be exceeded more than once per year on average over 3 years
Sulphur Dioxide [75 FR 35520, Jun 22, 2010] [38 FR 25678, Sept 14, 1973]	Primary	1-hour	75 ppb	99th percentile of 1-hour daily maximum concentrations, averaged over 3 years
	Secondary	3-hour	0.5 ppm	Not to be exceeded more than once per year

Source: [3]

The Air Quality Index

The AQI is an index for reporting daily air quality. It tells you how clean or polluted your air is, and what associated health effects might be a concern for you. The AQI focuses on health affects you may experience within a few hours or days after breathing polluted air. The AQI for five major air pollutants covered by the Clean Air Act is measured by the EPA: ground-level ozone, carbon monoxide, sulphur dioxide, and nitrogen dioxide. To protect public health, the EPA has developed national air quality standards for each of these pollutants. The two contaminants that pose the greatest danger to human health are ozone at ground level and airborne particles. For each pollutant, the AQI value of 100 typically corresponds to a concentration of ambient air equal to the amount of the national public health safety standard for short-term ambient air quality. AQI values at or below 100 are commonly believed to be adequate. When AQI values are over 100, air quality is unhealthy: first for certain disadvantaged groups of people, then for all, as AQI values get higher.The AQI is divided into 7 classifications. Each level correlates to a particular degree of health concern. Also, each level has a special colour. The colour makes it easy for people to determine easily if

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the level of air quality in their communities is reaching unhealthy levels.The index values are shown in the table below, where the concentration of contaminants corresponds to the distribution of their index values.

Table 2: Breakpoints for the AQI

O_3 (ppb)	O_3 (ppb)	$PM_{2.5}$ (µg/m^3)	PM_{10} (µg/m^3)	CO (ppm)	SO_2 (ppb)	NO_2 (ppb)	AQI	AQI
C_{low} - C_{high} (avg)	C_{low} - C_{high} (avg)	C_{low}- C_{high} (avg)	C_{low} - C_{high} (avg)	C_{low} - C_{high} (avg)	C_{low} - C_{high} (avg)	C_{low} - C_{high} (avg)	I_{low} - I_{high}	Category
0-54 (8-hr)	-	0.0-12.0 (24-hr)	0-54 (24-hr)	0.0-4.4 (8-hr)	0-35 (1-hr)	0-53 (1-hr)	0-50	Good
55-70 (8-hr)	-	12.1-35.4 (24-hr)	55-154 (24-hr)	4.5-9.4 (8-hr)	36-75 (1-hr)	54-100 (1-hr)	51-100	Moderate
71-85 (8-hr)	125-164 (1-hr)	35.5-55.4 (24-hr)	155-254 (24-hr)	9.5-12.4 (8-hr)	76-185 (1-hr)	101-360 (1-hr)	101-150	Unhealthy for Sensitive Groups
86-105 (8-hr)	165-204 (1-hr)	55.5-150.4 (24-hr)	255-354 (24-hr)	12.5-15.4 (8-hr)	186-304 (1-hr)	361-649 (1-hr)	151-200	Unhealthy
106-200 (8-hr)	205-404 (1-hr)	150.5-250.4 (24-hr)	355-424 (24-hr)	15.5-30.4 (8-hr)	305-604 (24-hr)	650-1249 (1-hr)	201-300	Very Unhealthy
-	405-504 (1-hr)	250.5-350.4 (24-hr)	425-504 (24-hr)	30.5-40.4 (8-hr)	605-804 (24-hr)	1250-1649 (1-hr)	301-400	Hazardous
-	505-604 (1-hr)	350.5-500.4 (24-hr)	505-604 (24-hr)	40.5-50.4 (8-hr)	805-1004 (24-hr)	1650-2049 (1-hr)	401-500	Very Hazardous

Source: [3]

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III. METHODOLOGY

The study was conducted in Buguma community in Asari Toru Local Govt Area, Harris Town in Degema Local Govt Area and Abonemma Community in Akuku-Toru Local Govt area of Rivers State, Nigeria. The equipment used for the air pollution study includes: a handheld Bosean multi gas tester, GW-HAT200 PM counter, the wind vane for wind direction, handheld GPS to take coordinates, hand-held Kestel 4500 anemometer for atmospheric parameters.The research will make use of primary data sources. Random collection of air samples in the study area using Air Quality Monitoring equipment will collect the primary data. Air pollutant data for NO_2, CO, SO_2, $PM_{2.5}$ and PM_{10} and weather variables were collected with respect to varying distance of about 20m from the area of industrial activities or suspected of illegal refining of crude (locally called kpo fire) into the residential area.The effect of distance from the source on the concentrations of atmospheric pollutants was also examined by Pearson Correlation Statistics. The relationship between weather parameters and air pollutants will be graphically presented using graphs.

$$r = \frac{\sum(x - \bar{x})(y - \bar{y})}{\sqrt{\sum(x - \bar{x})^2}\sqrt{(y - \bar{y})^2}}$$

Where
r = correlation coefficient
X= Independent variable
Y=Dependent variable
X-Mean of X
Y- Mean of Y

Data collected from the Air quality monitoring instrument were analyzed qualitatively using Pearson correlation statistics. Results were presented in tables and charts.

Table 3: Daily Measured Average Pollution Index for Buguma, Degema, Abonemma

LOCATION NAME	COORDINATES	DISTANCE (M)	TEMP °C	REL HUMIDITY	WIND SPEED (M/S)	PI(NO2) (ppb)	PI (SO2) (ppb)	PI (CO) (ppb)	PI(PM2.5) (μg/m³)	PI(PM10) (μg/m³)
BUGUMA										
COMMUNITY JETTY	4°43'15.316"N 6°51'47.002"E	100	30	59.5	1.1	100	89.534	188.391	172.2199	102.398
BUGUMA SANDFILL	4°44'28.480"N 6°51'30.933"E	300	33	62.666	0.933	100	89.534	127.686	127.876	58.0437
JV JETTY	4°44'15.130"N 6°51'18.290"E	500	34.333	65.666	1.1	33.333	104.542	73.634	108.899	49.365
IDO COMMUNITY	4°44'14.737"N 6°51'17.319"E	700	34.666	60	1.533	0	74.525	37.333	81.597	35.185
AGBANI MINESTONE	4°48'17.624"N 6°49'34.921"E	1000	31.666	58.666	1.466	100	111.789	131.862	92.729	40.212
DEGEMA										
HARRISTOWN	4°47'24.306"N 6°46'39.842"E	100	34.333	65.666	1.533	33.333	74.525	48.515	86.402	37.700
OKI MINESTONE	4°47'24.306"N 6°46'39.842"E	300	35	61.333	1.433	0	37.263	41.393	86.522	38.482
ABONEMMA										
ABONEMMA JETTY	4°44'15.18"N 6°46'17.11"E	100	32.666	60.333	1.1666	106.576	126.797	158.821	150.683	93.530
COMMUNITY SECONDARY SCHOOL	4°43'7.31"N 6°47'29.75"E	300	34.666	57.666	1.1666	106.576	37.263	253.718	108.751	51.734
NEW ROAD	4°44'15.18"N 6°46'43.41"E	500	36.333	60.333	1.8	66.666	126.797	173.718	111.517	55.0123

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IV. RESULTS

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Table4: Correlation Coefficient Buguma, Degema, Abonemma

#NAME?	DISTANCE (M)	TEMP °C	REL HUMIDITY	WIND SPEED (M/S)	PI(NO2) (ppb)	PI(SO2) (ppb)	PI (CO) (ppb)	PI($PM_{2.5}$) ($\mu g/m^3$)	PI(PM10) ($\mu g/m^3$)
BUGUMA									
DISTANCE (M)	1								
TEMP ©	0.33043	1							
REL HUMIDITY	-0.282	0.566	1						
WIND SPEED (M/S)	0.80109	0.2	-0.5905	1					
PI (NO2)	-0.253	-0.822	-0.2983	-0.45	1				
PI (SO2)	0.37785	-0.255	0.15866	-0.07	0.4527	1			
PI (CO)	-0.476	-0.958	-0.3586	-0.45	0.9109	0.29307	1		
PI(PM2.5)	-0.873	-0.738	-0.024	-0.69	0.5991	-0.059	0.82815	1	
PI(PM10)	-0.83	-0.772	-0.133	-0.56	0.5332	-0.103	0.81312	0.9838	1
DEGEMA									
DISTANCE (M)	1								
TEMP ©	1	1							
REL HUMIDITY	-1	-1	1						
WIND SPEED (M/S)	-1	-1	1	1					
PI (NO2)	-1	-1	1	1	1				
PI (SO2)	-1	-1	1	1	1	1			
PI (CO)	-1	-1	1	1	1	1	1		
PI(PM2.5)	1	1	-1	-1	-1	-1	-1	1	
PI(PM10)	1	1	-1	-1	-1	-1	-1	1	1
ABONEMMA									
DISTANCE (M)	1								
TEMP ©	0.99863	1							
REL HUMIDITY	0	-0.0524	1						
WIND SPEED (M/S)	0.86603	0.83863	0.5	1					
PI (NO2)	-0.866	-0.8386	-0.5	-1	1				
PI (SO2)	0	-0.0524	1	0.5	-0.5	1			
PI (CO)	0.14594	0.1976	-0.98929	-0.3683	0.36826	-0.9893	1		
PI(PM2.5)	-0.835	-0.8627	0.550207	-0.4481	0.44805	0.55021	-0.6662	1	
PI(PM10)	-0.8286	-0.8568	0.55983	-0.4377	0.43768	0.55983	-0.6748	0.999933	1

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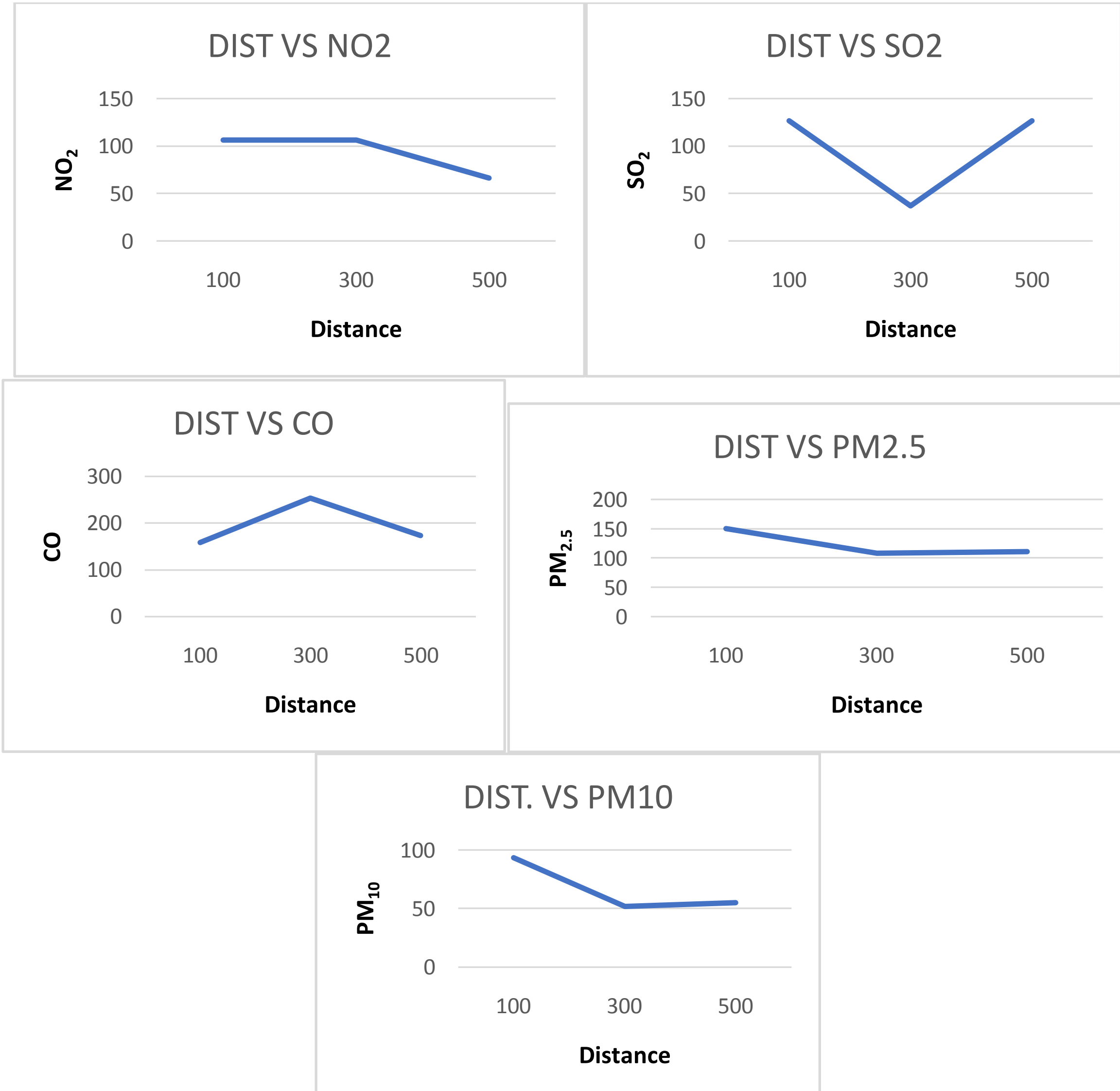

Figure 1: Graph of Distance Vs Pollution Index of Contaminants, Abonemma

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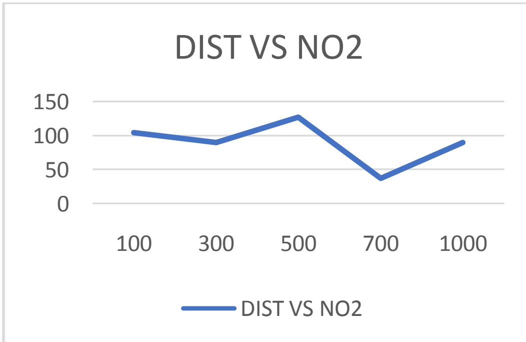

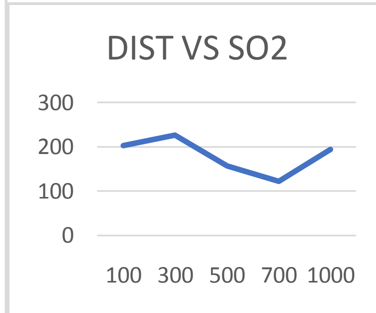

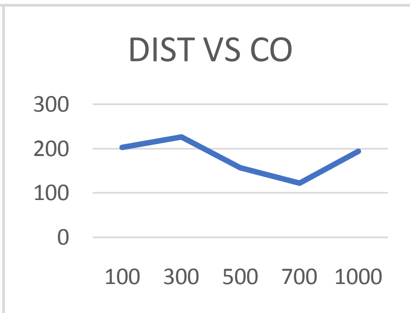

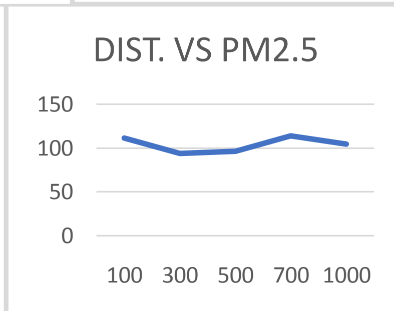

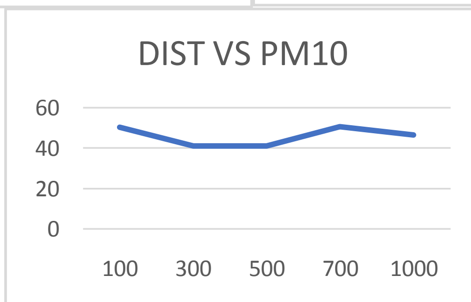

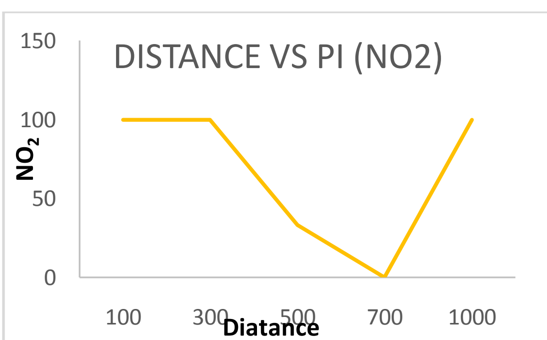

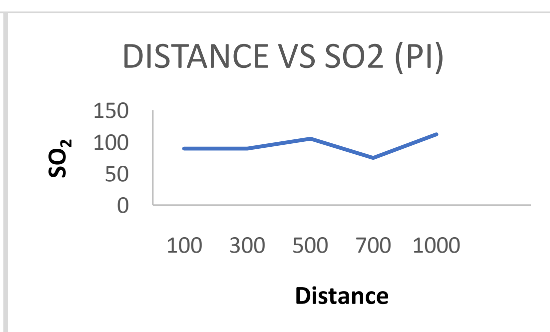

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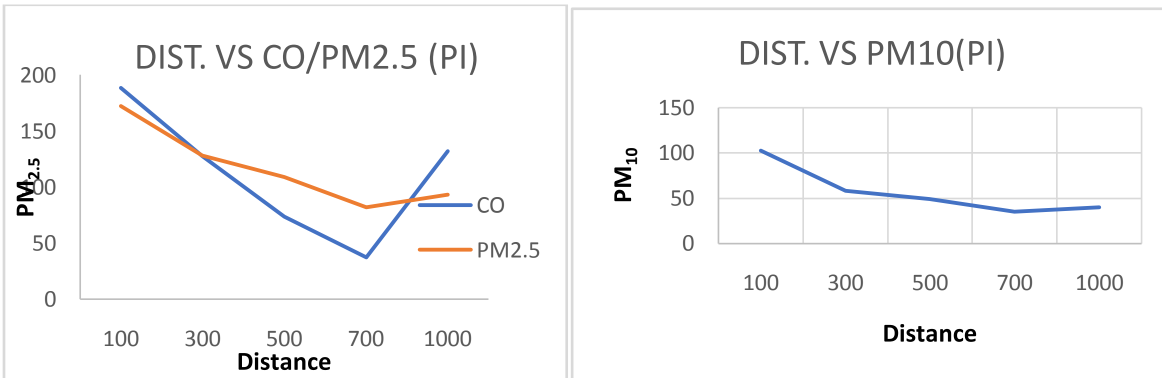
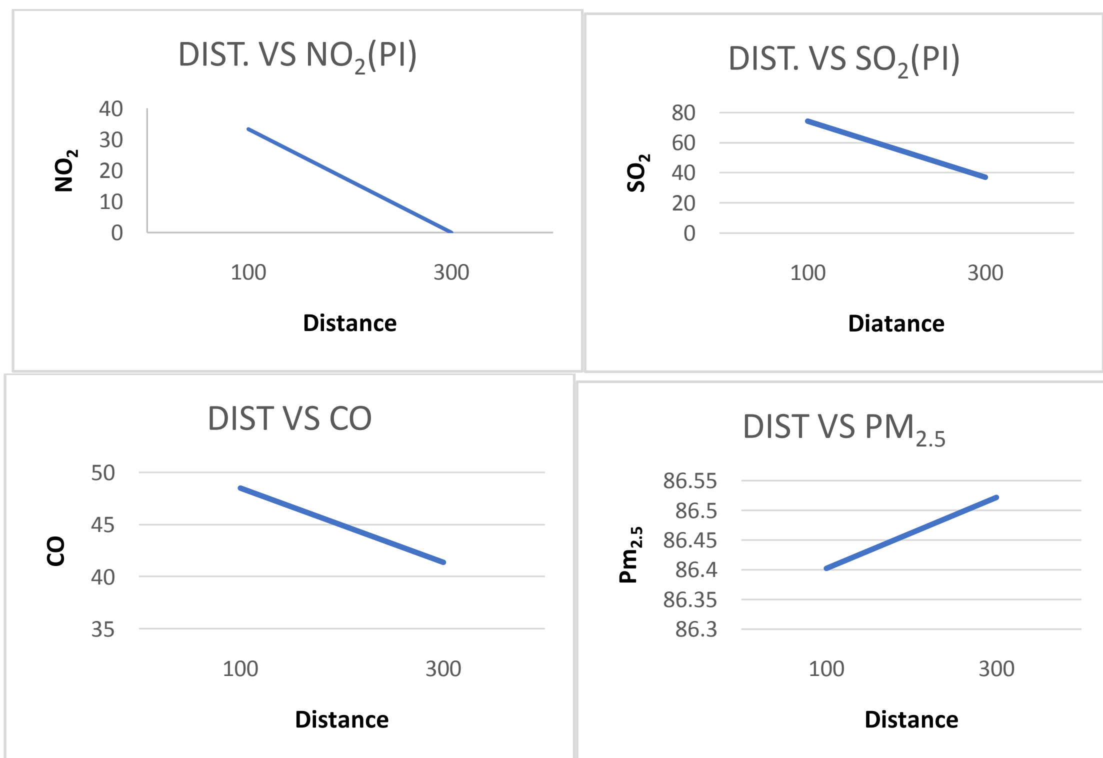


Figure 2: Graph of Distance vs Pollution Index of Contaminants, Buguma



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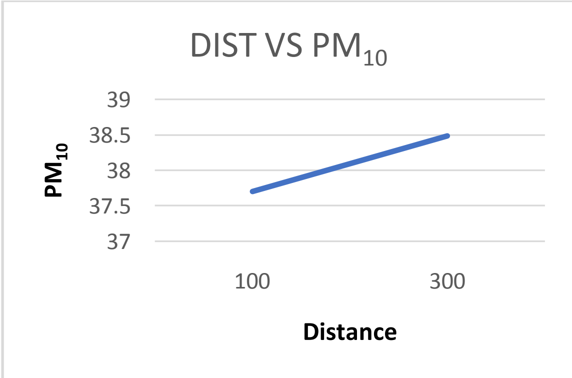

Figure 3: Graph of Distance Vs Pollution Index of Contaminants

The graph above shows graphical relationship between distance and the pollution index (PI) of four air pollutants.

The NO_2 emission index decreases gradually from 100 to 0 over a distance of 700 m before increasing to 100 at (Agbaniminestone), 1000 m from the source of pollution. Also, the pollution index for SO2 ranges between 74.5 and 111.7. The highest pollution index was recorded 1000m away from the source with a value of 111.7. for the first 500m the pollution index increased slightly from 8.5-104.5 before falling to 74.5 at 700m and increasing again to 111.7 at a distance of 1000m from the source.

V. CONCLUSION

Based on the findings of this research, the following conclusions are drawn:

i. The Air Quality index showed that the Air Quality of Abonemma and Buguma from the data and results observed is very low. Therefore, the Air produced in these areas may pose serious threat the health and wellbeing of residents in the near future.

ii. From the results gotten from this study, CO and PM2.5 ranked very high in all the three days of observation. Therefore, there's need to be more conscious of these air pollutants as they have high probability to cause serious ill-health. The elevated levels of CO and PM2.5 are capable of causing serious respiratory challenges and also death and CO is one of the GHG with negative effect causing global warming.

iii. The was an observable relationship existing between the pollutants (NO_2, SO_2, CO $PM_{2.5}$ and PM_{10}) and atmospheric variables (Distance, Relative Humidity, Temperature, Wind direction and Wind speed). This shows that the pollutants can easily dispersed from the point source to other areas farther away.

VI. RECOMMENDATIONS

Based on the findings of the study the following recommendations were made:

i. Children, older adults and other individuals with respiratory diseases should be advised on the health implications that may arise on continuous exposure.

ii. In order to ensure real-time monitoring of the air environment, the government to install real-time air quality monitoring stations in areas observed with high industrial activities, in particular crude oil exploration/exploitation.

iii. The incessant exploitation of crude oil (locally called Kpo fire) can be minimized by building modular refineries, as this is a major contributor to the poor air quality of these regions.

iv. Government to monitor and implement sanctions to IOCs involved in activities that may deplete the air quality of this region and other places

v. Air quality awareness and sensitization campaign and health implications of pollutants to be organized for communities prone to exposure.

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