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Research Article

THE IMPACT OF AIR AND NOISE POLLUTION: A CASE STUDY OF UYO METROPOLIS, AKWA IBOM STATE, NIGERIA

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ABSTRACT

This study was carried out to assess the impact of air air quality and noise pollution in Uyo metropolis, Akwa Ibom State, Nigeria. The air pollutants monitored were PM_{10}, PM_7, PM_4, $PM_{2.5}$, PM_1, TSP, VOCs, NO_2, SO_2, H_2S, CO, NH_3, CH_4 and Noise pollution. Fourteen (14) sampling points and one (1) control location were chosen for this study. The calculated three times monitoring mean values of each sampling point was observed that PM_{10} mean values ranged from 56.0-279.7µg/m^3, PM_7 mean values varied from 45.0-182.4µg/m^3, the mean valuesof PM_4 were between 29.4-82.9µg/m^3, while $PM_{2.5}$ mean values varied from 20.5-51.5µg/m^3 and the mean values recorded for PM_1 ranged 13.8-34.8µg/m^3. TSP mean data was between 74.5-443.0µg/m^3. For gaseous pollutants, VOCs mean values ranged from 308.2-514.5ppm, NO_2 mean data recorded was between 0.13-0.56ppm, while SO_2 mean data was from <0.01 to 0.3ppm, H_2S mean values was <0.01ppm, the CO mean values obtained were between 0.3-0.76ppm, the mean data obtained for NH_3 was between <0.01-2.7ppm, while CH_4 mean values ranged from <1.0–7.0ppm.The mean noise level ranged from 68.8-84.9dB. All the values recorded at the monitoring points for all the air pollutants in the study area were higher than the values recorded at the control point The heavy traffic, congestion, densely population ,road intersection, generator power plants, rotten wastes, agricultural and urban runoff could be attributed to the sources of the air and noise pollution. The research evaluated the variations of the air pollution in relation to the sampling locations. Policy should be made by government for traffic control and

traffic personnel training programme should be enhanced. Environmental education programme should be organized for the public. Policies to ban used/old automobile engines and polluting power generating plants should be made by the relevant authority. Regular and frequent air quality and noise pollution monitoring should be carried out while relevant regulatory agencies should effectively enforce the environmental laws and policies.

INTRODUCTION

Man's environment is under constant threat from his own activities. Man's expanding population, industrialization and intensive agriculture have caused tremendous damage to our environment. Man's ignorance of laws of nature and his over- exploitation of natural resources have further aggravated the problem.

Humans need a continuous supply of food, air and water to exist. Changes in the environment have put the survival of man in danger . Air pollution is woven throughout our modern life. Air pollutant is a chemical, physical (e.g. particulate matter), or biological agent that modifies the natural characteristics of the atmosphere and it is a complex, dynamic and natural gaseous system that is essential to support life on planet earth. Its pollutants constitute various kinds of gases, droplets and particles that reduce the quality of the air.

Air pollution is a by-product of the manner in which we build our cities, produce our goods, transport ourselves and our goods, and generate the energy to heat and light the place where we live, play and work. In other words, it is aggravated because of four developments: increasing traffic, growing cities of rapid economic development and industrialization.

Nature and man's activities have impacted on natural cycles, the result are atmospheric pollutants such as particulate, aerosol, noxious gases (VOCs, NO_2, SO_2, H_2S, CO, NH_3, CH_4) and mechanical noise. Pollutants can be from point sources (e.g. industrial installations) or from mobile sources (e.g. automobiles and other transport systems)(Narayanan, 2009).

Effects of air pollutants are wide ranging in Nigeria. They cause damage to materials and buildings, deteriorate soil and affect vegetation and living organism in our cities. Atmospheric haze is caused by the presence of aerosols , Volatile Organic Compounds (VOCs), Nitrogen Dioxide (NO_2), Sulphur Dioxide, (SO_2),Hydrogen Sulphide (H_2S), Carbon Monoxide (CO), Ammonia (NH_3) and Methane (CH_4). Particulate matter and mechanical noise showing greater health hazards. Particulate matter is brought into contact with pulmonary membrane by sedimentation, impaction, interception and diffusion. Sub-micro range particles (10 – 2 **μm**; PM10 – PM2) pose pulmonary health problems. If the pollutants are chemically reactive or toxic, their physiological effects are more serious and lethal (Narayanan, 2009).The impacts of these pollutants have local, regional and global implication.

Description of the study Area and Significance of the Study:

Uyo, the state capital of Akwa Ibom State of Nigeria, is one of the cities in South –South geo-political zone of the predominantly oil and gas producing area of Niger Delta. Uyo has really been experiencing rapid influx of people of different works of life since its creation as a State Capital of Akwa Ibom State. This results in a fast growing population with commercial activities, private and commercial vehicles for transportation, road and housing construction activities including heavy equipment and truck movement, urbanization, industrialization, deforestation and road traffic. Rapid development and urbanization in Uyo would no doubt create some environmental impacts in the city of such magnitude as to arise the concern that required the present study.

The environmental monitoring shall provide important information feedback about the environmental impacts of man's activities around and within the monitoring locations and also for more effective planning for environmental protection.

Investigating air quality and noise level in this study would entail monitoring and assessment of the presence and concentration of noxious gases in the study area. The gases include Volatile Organic Compounds (VOCs), Nitrogen Dioxide (NO_2), Sulphur Dioxide, (SO_2),Hydrogen Sulphide (H_2S), Carbon Monoxide (CO), Ammonia (NH_3) and Methane (CH_4), including Particulate Matter and Noise level at the selected sampling locations. This is necessary for this study because the noxious gases, particulate matter and noise are dangerous to human health and environment.

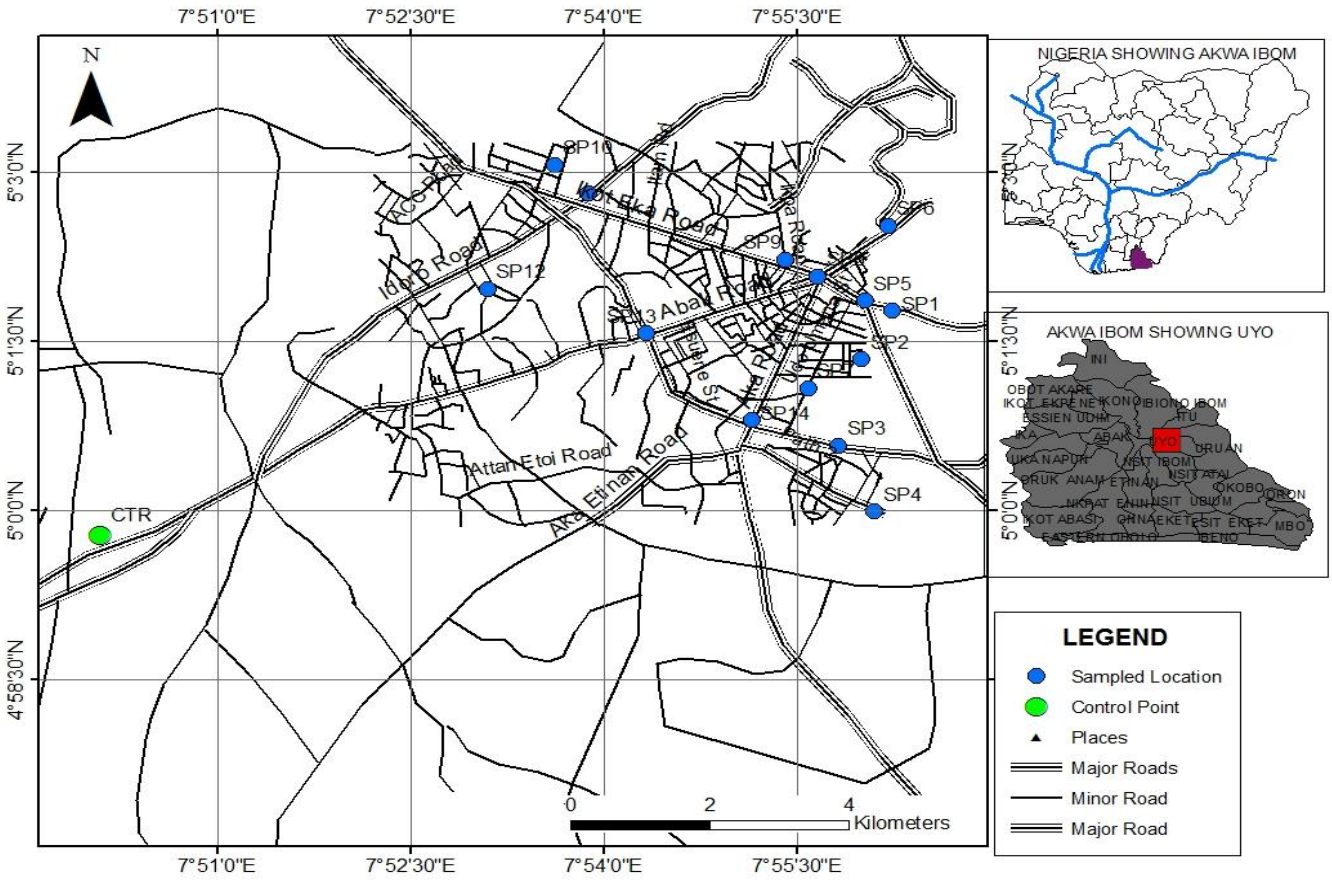

Figure 1: Map of Uyo showing Sampling Point

METHODOLOGY

Research Design:

This study was systematically designed to monitor the ambient air quality and noise pollution in Uyo to meet the current trend of rapid population growth and vehicular in-flow in recent time, to broaden the study scope to close the gap and complement some of the previous studies. The study was also designed to generate applicable data that could provide early warning on environmental damage so that control/mitigation measures can be put in place to prevent or reduce risk to human health or deterioration of the environment.

Site Selections:

Fourteen (14) sampling locations were selected in the study area using World Health Organisation standard for site selection studies for population

The GPS map Model 76Cx Garmin Global Positioning Systems was used to determine geo-references of the sampling locations..

Field Observations:

Field observations were made visually and documented in field notebooks. Photographs were taken to show important features appropriately and activities that may be the sources of the air pollutants.

Nature/ Sources of Data:

The data was from primary sources of the air pollution in Uyo, direct release of gaseous air pollutants from vehicular and power generating plant exhausts via combustion of fossil fuels and particulate pollutants arising from traffic congestion and construction operation.

METHODS OF DATA ANALYSIS

The result of the air pollutants collected during the study was analyzed using descriptive statistics (Mean and Standard Deviation) and regression analysis.

Regression Analysis:

Let y represent the dependent variable (pollutant) and x_1, x_2 and x_3 represent the independent variables (which are the meteorological variables, in this case, temperature (^oC), wind speed (m/s), and humidity (%).

Mathematically,

$$y = a_o + a_1x_1 + a_2x_2 + a_3x_3$$

where, a_1,a_2, and a_3 are constants. Furthermore, a_0 represents the intercept on the vertical axis.

Validity/ Reliability of Instrument:

Prior to mobilization, the portable air quality and noise equipment were certified calibrated. Quality assurance/control measures were done appropriately as per the equipment manufacturer directive and batteries were fully charged while PPEs and field notebook were in order. The guidelines and field work plan to cover sampling activities were designed and documented.

RESULTS

PRESENTATION OF DATA:

The results of respirable particulate matter (RPM) $PM_{10,}$ $PM_{7,}$ $PM_{4,}$ $PM_{2.5}$and $PM_{1,}$ Total Suspended Particulate (TSP) including gaseous air pollutants and noise level that were monitored in Uyo metropolis are presented and discussed.

(i) Respirable Particulate Matter(RPM) (PM_{10}, PM_7, PM_4, $PM_{2.5}$ and PM_1)

(PM_{10}) mean value ranges from 56.0-279.7 µg/m^3 at all the study sites. PM_{10} was recorded at all the sampling sites. The peak period (morning and evening) recorded relatively higher values than off peak period (afternoon).The individual site data range from 35.0 – 520.7 µg/m^3 with the highest value being recorded at the Itam Market by Goodluck Jonathan Flyover.

PM_7 mean data varied across the monitoring sites from 45.0-182.4 µg/m^3while the individual data was from 28.9 – 323.4µg/m^3. Ekomiman Junction (IkotOkuIkono) was a predominant source, which recorded the highest mean observed values.

Levels of mean of PM_4 data varied from 29.4-82.9 µg/$m^3$and the individual values were found to be between 22.5 – 129.7 µg/m^3. The highest mean data was also observed at the Ekomiman Junction (IkotOkuIkono).

Mean variation of $PM_{2.5}$ was between 20.5-51.5 µg/m^3 while the individual data ranged from 14.2 – 79.6µg/m^3. Nwaniba Roundabout by Oron Road was the observed dominant source of $PM_{2.5.}$

Mean variation of PM_1 was between 13.8-34.8 µg/m while the individual data ranged from 7.8 – 55.3µg/m^3. Nwaniba Roundabout by Oron Road was the observed dominant source of $PM_{1.}$

(ii) **Total Suspended Particulates (TSP)**

Total suspended particulates mean value ranged from 74.5-443.0 µg/m^3while the individual data were between 53.9 – 854.1µg/m^3 with the highest value being recorded at the Itam Market by Goodluck Jonathan Flyover .

Air Quality Index of the Study Area for Uyo Metropolis:

The air quality index of the sampling points in Uyo metropolis showing the USEPA index interpretation using colour code to describe the concentration of the air pollutants of PM_{10}, $PM_{2.5}$, CO, SO_2 and NO_2 with associated health effect statement and cautionary statements so that the sensitive groups would be aware of the quality of air in the sampling study area.

Number of Tricycles and Vehicles at Traffic Points:

The number of vehicles and tricycles at heavy traffic and road intersection where long vehicles waiting was observed for about 10 minutes interval and counted at the time of monitoring during morning, afternoon and evening (peak, off peak and peak) periods which could be attributed to be the primary source of air pollution in this study area.

Data Analysis

Effects of Meteorological Variables on Air Quality Parameters:

The effect of the meteorological variables such as temperature **(^oC),** wind speed **(m/s)** and humidity **(%)** on each of the air pollutants monitored at the study area during this research is calculated using regression analysis as presented below.

i. Effects of Temperature (^oC), Wind speed (m/s) and Humidity (%) on PM_{10}

$PM_{10} = 1719.246 + 9.763(T) - 71.088(W/S) - 23.142(H)$

$R=0.728$, $R^2 = 0.530$ (53%), Adj. $R^2 = 0.402$ (40.2%), p-value = 0.034.

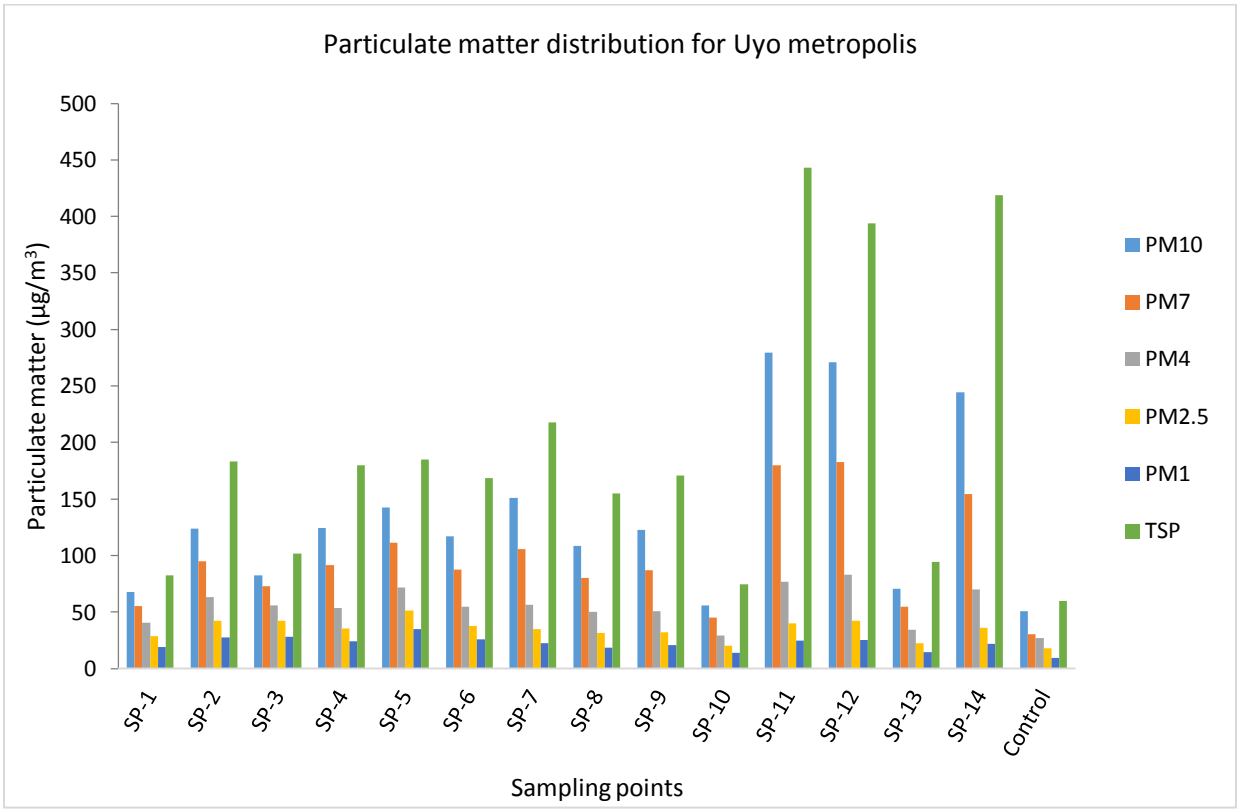

Figure 2: Morning, Afternoon and Evening Mean Values of PM_{10}, PM_7, PM_4,$PM_{2.5}$,PM_1 and TSP of the Study Area

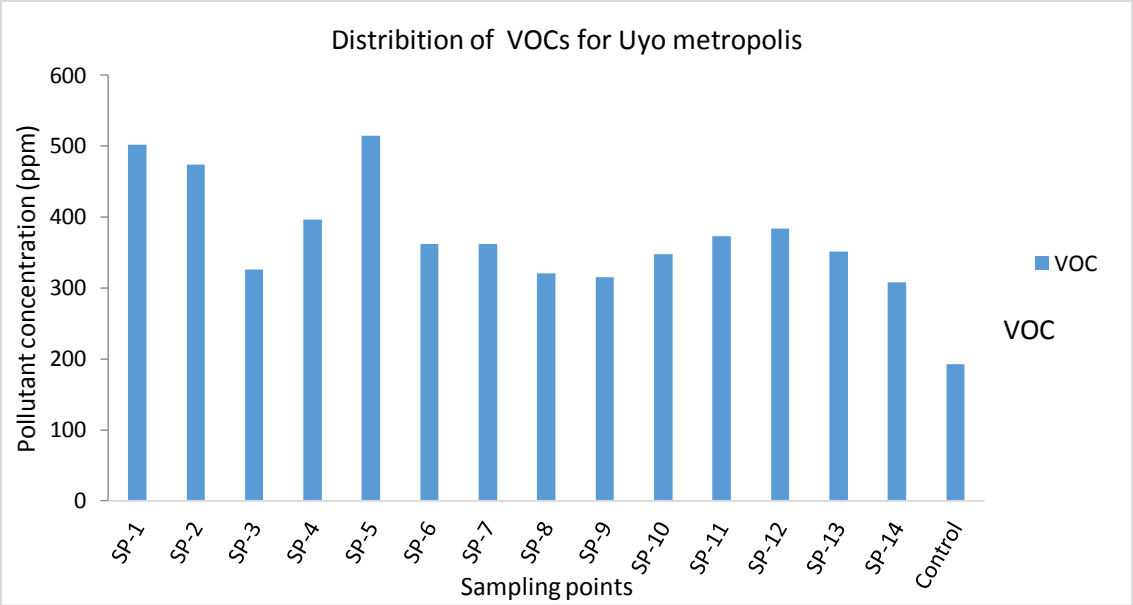

Figure 3: Morning, Afternoon and Evening Mean Values of VOCs of the Study Are

Because the calculated p-value (0.034) is less than the critical p-value (0.05), i.e. p_{cal} (0.034)<p_{crit} (0.05), it is concluded that the meteorological variables (temperature, wind speed and humidity) has significant effect on PM_{10}.

ii. **Effects of Temperature (°C), Wind speed (m/s) and Humidity (%) on PM_7**

$PM_7 = 870.91 + 9.005(T) - 45.793(W/S) - 12.765\ (H)$

R=0.730, R^2 = 0.533 (53.3%), Adj. R^2 = 0.406 (40.6%), p-value = 0.033.

Because the calculated p-value (0.033) is less than the critical p-value (0.05), i.e. p_{cal} (0.033)<p_{crit} (0.05), it is concluded that the meteorological variables (temperature, wind speed and humidity) has significant effect on PM_7.

iii. **Effects of Temperature (°C), Wind speed (m/s) and Humidity (%) on PM_4**

$PM_4 = 206.923 + 3.842(T) - 17.120(W/S) - 3.179(H)$

R=0.638, R^2 = 0.406 (40.6%), Adj. R^2 = 0.245 (24.5%), p-value = 0.113.

Because the calculated p-value (0.113) is greater than the critical p-value (0.05), i.e. p_{cal} (0.113)>p_{crit} (0.05), it is concluded that the meteorological variables (temperature, wind speed and humidity) do not have

significant effect on PM_4.

iv. **Effects of Temperature (^oC), Wind speed (m/s) and Humidity (%) on $PM_{2.5}$**

$PM_{2.5}$ = 10.328 + 2.244(T) – 7.194 (W/S) – 0.437(H)

R=0.462, R^2 = 0.214 (21.4%), Adj. R^2 = 0.00 (0%), p-value = 0.430.

Because the calculated p-value (0.430) is greater than the critical p-value (0.05), i.e. p_{cal} (0.430)>p_{crit} (0.05), it is concluded that the meteorological variables (temperature, wind speed and humidity) do not have significant effect on $PM_{2.5}$.

DISCUSSION

The discussion of the results of respirable particulate matter PM_{10}, PM_7, PM_4, $PM_{2.5}$ and PM_1, Total Suspended Particulate (TSP) including gaseous air pollutants and noise level that were monitored in Uyo metropolis are presented and discusssed

(i) Respirable Particulates Matter (RPM) (PM_{10}, PM_7, PM_4, $PM_{2.5}$ and PM_1)

The predominant source of PM_{10} was Itam Market by Goodluck Jonathan Flyover . This trend can be attributed to high densely people clustered and commercial activities in the market that produced such value of particulates. The reason for the high value recorded could also be attributed to heavy traffic congestion and road intersection where long vehicular waiting was observed at the time of monitoring. The trend of relatively high values was recorded during the peak periods (morning and evening) where many residents were going and returning from works and different businesses. Various studies by Efe, (2006), Akpan, (2014) and Gobo *et al.,* (2012) also reported the same high values of PM_{10} during peak period. Hence, the findings of this study are in agreement that high concentration levels of PM_{10} are as a result of heavy traffic with high densely clustered people with commercial activities around the study location.

Ekomiman Junction (Ikot Oku Ikono) which was congested with people of different classes of business busy with their commercial activities and commercial vehicles including commercial tricycles and over-crowded with passengers at the of time monitoring could be attributed to presence of PM_7 and PM_4. Various studies by Akpan, (2014), Gobo *et al.,* (2012), and Efe, (2006) also reported the same high values of PM_7 and PM_4 during peak periods. Hence, this study is in agreement that high concentration levels of PM_7 and PM_4 is as a result of heavy traffic with high densely clustered people carrying out commercial activities around the study location .This trend of relatively high values was observed during the peak periods (morning and evening) when many people were going and coming back from offices and other businesses.

The highest concentration of PM $_{2.5}$ and PM_1 observed at the Nwaniba Roundabout by Oron Road is attributed to concentration of organic carbon (OC) and elemental Carbon (EC). This carbonaceous species in air could be attributed to the household burning of firewood for cooking, burning coals used to roast suya and corn, diesel exhaust, gasoline powered motor exhaust around the sampling site and paved road dust including the consistent traffic emitting of gaseous pollutants. These could be the attributing sources of the presence of the high values of PM $_{2.5}$ and PM_1 at the time of monitoring.

Various studies by Gobo *et al.,* (2012), Efe, (2006) and Akpan, (2014) also reported the same high values of $PM_{2.5}$ and PM_1 during peak periods. Thus, the findings of this study are in line with several literatures that have reported the same trend. This trend of relatively high values was observed during the peak periods (morning and evening) when many people were going and coming back from offices and other businesses.

(ii) Total Suspended Particulate (TSP)

Itam Market by Goodluck Jonathan Flyover recorded the highest value of TSP in the study location. This could be attributed to the vehicular and pedestal traffic witnessed around this sampling point. The heavy traffic within this place would likely produced dust and other particulates that may increase the value of TSP. The reason for the high value recorded could also be attributed to heavy traffic congestion and road intersection where long vehicular waiting was observed at the time of monitoring. The trend of relatively high values was recorded during the peak periods (morning and evening) where alot of people were rushing out and in from works and different businesses. Several researches in literature Efe, (2006), Akpan, (2014) and Gobo *et al.,* (2012) have revealed meaningful relationship between heavy traffic vehicle emission and air pollution concentrations. Hence, the findings that high concentration levels of TSP is as a result of heavy traffic with high densely clustered people with commercial activities around the study location is in agreement with the previous studies.

PLATE 1.1-1.4 : Some locations in the study area:

Some of the sampling points that were monitored at the study area such as Ekomiman Junction (Ikotokuikono), Itam Main Park, Ibom Plaza Roundabout,Akpan Andem Market by Udoumana, State Secretariat Roundabout Close To Mechanic Village and Four Lane Roundabout By Nwaniba Road are shown. Also shown are some activities that were taking place during the monitoring (Plate 1.1, Plate 1.2, Plate 1.3, Plate 1.4).

PLATE 1.1: EKOMIMAN JUNCTION (IKOTOKUIKONO) (N05^0 00'.351", E007^0 51' .309")

PLATE 1.2: ITAM MAIN PARK (N05^0 03'.064" , E007^0 53' .622")

PLATE 1.3: IBOM PLAZA ROUNDABOUT (N05^0 02'.075" , E007^0 55' .673")

PLATE 1.4: AKPAN ANDEM MARKET BY UDOUMANA (N05^0 01'.081" , E007^0 55' .591")

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