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The Influence of Meteorological Parameters on Respirable and Inhalabe Particle During wet Season

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Keys Words: Respirable Fraction, Inhalable Fraction, Toxicity Potential and Meteorological Parameter and Urban Area.

ABSTRACT: Air Pollution is a problem because human activities threaten to overload the atmosphere with wastes beyond the ability of wind and weather to disperse and dilute these pollutants. An effective air resources management program must take into account, the effects of meteorological parameters on transport and dilution and the natural cleansing processes of the atmosphere. Particulate pollutants tend to coagulate, increase in size and fall to earth. Thus coarse or inhalable particulates generally cause air pollution problems of a localized nature. However, lighter particulate and gaseous pollutant are influenced by action of atmospheric diffusion and may be carried to great distances from their sources of origin. Any study of air pollution should include a study of the weather patterns (meteorology) of the local area because the fate of air pollutants is influenced by the movements and characteristics of the air mass into which they are emitted. The main concentration of respirable suspended particulate matter was 104.17 – 260.42 and the inhalable suspended particulate matter was in a range of 104.17 - 434.03. The correlation of inhalable and respirable suspended particulate matter was good and positive (r = 0.73.); And the correlation of respirable and inhalable fraction with wind speed and temperature were positive while with relative, humidity were negative. The spatial distribution of inhalable and respirable were significant and remarkable ($P<0.05$). @ JASEM

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The concept of miasma or noxious air as etiologic agent of certain diseases and the degradation of the environment has been a compelling issue in the contemporary International Communities and Environmental law. Hence the epidemiological studies and clinical studies of air pollution are second to none. The ultra-fine particles have diameters less than 1.0µm. The international standard organization (ISO) applies the thoraces convection in the classification of particulate matter. In this system, the inhalable fraction comprises those particle that enter the respiratory system during breathing and it corresponds, to the PM_{10} while the respirable fraction comprises those that reach the gust exchange region of the lung and it corresponds to the $PM_{2.5}$ (Chow, 1995; Arya, 1999; Pooley and Mille, 1999; Holman, 1999; Pandis *et al.,* 1995; UNEP/WHO, 1994b)

To better understand the effect that exposure to aerosols has on humans epidemiological, air pollution studies have begun to characterize the spatial and temporal distribution of acid aerosols (Suh *et al.,* 1992). But to fully understand the processes responsible for the spatial and temporal distribution of acid aerosols requires analysis of local and regional meteorology; especially wind speed, wind direction, turbulence and atmospheric stability (Lenschow *et al.,* 2001; Michael, 1997). Chemical reaction also depends on ambient weather conditions because they are influenced by short-wave radiation; air-temperature and air humidity. According to Hosler (1961), the persistence of surface wind speed less than 3.1m/s is usually conducive to the accumulation of air pollutant.

Airborne particulate matter represents a complex mixture of organic and inorganic substances. Mass and composition tend to divide into two principal groups: coarse or inhalable particles mostly larger than 2.5µm in aerodynamic diameter, and fine or respirable particles mostly smaller than 2.5µm in aerodynamic diameter (PM 2.5). The smaller particles contain the secondarily formed aerosols (gas to particle conversion); combustion particles and re-condensed organic and metal vapors. The larger particles usually contain earth crust materials and fugitive dust from roads and industries. The fine fraction contains most of the acidity (hydrogen ion) and mutagenic activity of particulate matter; although in fog some coarse acid droplets are also present (Clark, 1992). Fine or respirable particulate mass ($PM_{2.5}$) is a better predictor of mortality than coarse particulate mass. (The difference between PM_{10} and $PM_{2.5}$ (Schwartz *et al.,*1996).

The deposition of particles in the lung is governed by particle characteristics, anatomy of the respiratory tract tidal volume and breathing pattern (Lippmann *et al.,* 1994;).

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The behavior of particle in air is predicated on their physical and chemical properties. These particles have physiochemical proportion via, mass size, volume, settling velocity, chemical aerodynamic and optical proper, which are important for their role in atmospheric process. Their life span in atmosphere may vary from few seconds to several months. The size density and shape of the particle are of prime importance because these factors influence not only their cleansing rate from environment but also their penetration and deposition in respiratory system.

In developed countries, the difference between the mass concentration of TSP and PM_{10} (inhalable particle) and $PM_{2.5}$ (respirable particle) is usually larger in Urban and industrial areas than in rural areas. This is due to the larger fraction of relatively small secondary particles in rural areas, originating mainly from long-range transport of air pollutants (Tarra Soriand Tsyro, 1998). Sedimentation and deposition of large particle takes place close to the emission sources. Thus, the proportion of $PM_{2.5}$ relative to TSP and PM_{10} is usually higher in rural areas. Typical contributions of Sulfate, nitrate and ammonium particulates to the total $PM_{2.5}$ mass are about 40% in urban areas and 50% in rural regions (Seinfeld and Pandis ,1998).

Atmospheric and terrestrial moisture in its various phase is the final weather element of notable import to air pollution. It is generally appreciated that precipitation that is rain and snow is probably the most effective cleansing agent in the atmosphere [Bleeker 1965].

MATERIALS AND METHODS

Area Of Study: The Town Sapele is situated in the South-south geopolitical region of Nigeria with a population of about 135,800 (NPC 2005/2006). It was once an integral part of the old western region of Nigeria. It is presently a part of Delta State of Nigeria created in August 27, 1991, after having been part of the defunct Mid Western State (1963-1976) and the defunct Bendel State (1976-1991).

This study area is located within the co-ordinates of latitude $005^0\ 50'\ 0''$-$005^0 560''$N and longitude $005^0 37' 0''$ – $005^0 45' 0^0$E. The study area has a total aerial extent of 165.25 square kilometers.
Sapele is located near the junction of Jamieson and Ethiope rivers and about 80 mile (144 kilometers) from the sea, well closer into the timber yielding forest of the interior. Sapele is one of the first-rate wood industries in this region.

However, it is a commercial city with four petroleum and allied industries. The climate is tropical with two distinct seasons, wet and dry.

The major activities among the people of Sapele that generate particulate pollution are usually bush burning as a pre planting preparation, combustion of solid waste as a means of waste disposal, gas flaring, re-suspension of dust from unpaved road, and the production of charcoal which involves the burning of wood in an open space from dawn till dust in four different locations in the city. These charcoal are usually exported to other countries and sometime nearby cities.

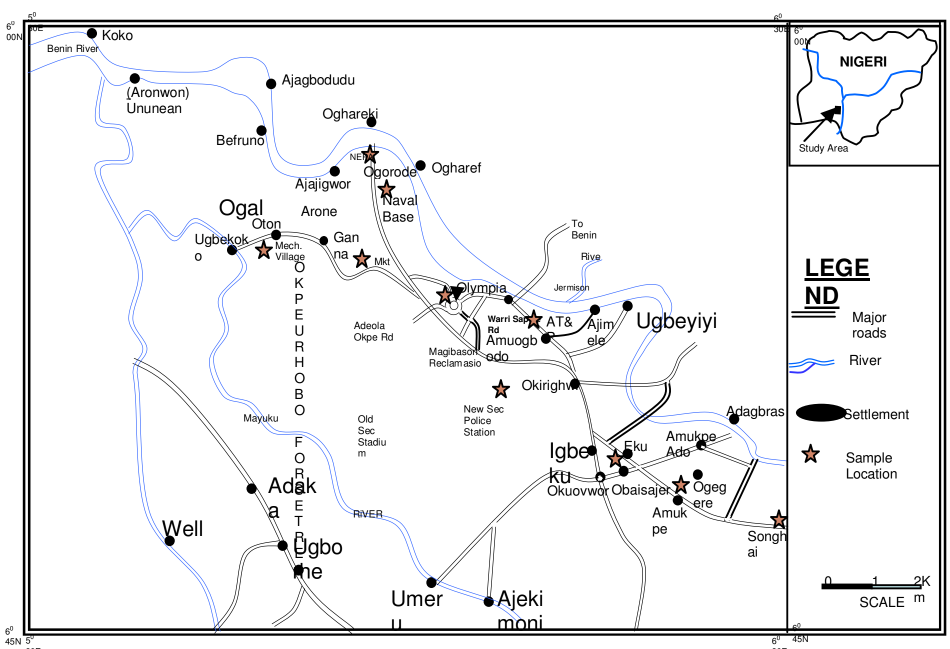

Fig.1 map of Sapele Reflecting the various Sampling locations

Table 1: The Monitoring Sites and their Co-ordinates.

S/N	Site Code	Co-ordinates	Site Description
1.	SP. MV	N05°51'53.5" E005°41'39.0"	The site was created at the Mechanic Village (Shell road)
2.	SP. SG	NO5°51'025" E005°44'37.4"	This site was created at the Songhai.
3.	SP.NOR	NO5°51'06.3" E005°44'45.4"	The site was created at the new Ogorode Road.
4.	SP.RH	NO5°51'33.1" E005°43'06.4"	The site was created in residential houses in Amoukpe Area
5.	SP.OJ	NO5°53'24.8" E005°40'41.9"	The site was created in Olympia Junction
6.	SP.SM	NO5°54'05.9" E005°41'38.9"	The site was created at Sapele Market
7.	SP.IA	NO5°55'16.8" E005°38'48.5"	The site was created at the Industrial Area.
8.	SP.NER	NO5°51'01.9" E005°43'37.8"	The site was created at New Eku Road
9.	SP.SWR	NO5°52'28.6" E005°42'07.8"	The site was created at Sapele Warri Road
10.	SP.OK	NO5°52'27.0" E005°43'40.7"	The site was created at Okireghwere.

In line with the objectives of the study ten monitoring sites were punctiliously selected to represent all the quarters of the city with high pollution sources the sites were created within the vicinities to reflect the variations in traffic volume and human activities. Table 1 represents the monitoring sites and their co-ordinates. The monitoring sites and their co-ordinates were geo-referenced by using GARMIN GPS MAP 765 chart plotting receiver.

Sampler and Analytical Procedure: SKC Air check XR5000 High volume Gravimetric sampler Model 210-5000 serial No. 20537 and the I.O.M multi fraction dust sampler (institute of occupational medicine)

A sampling device was used which includes sampling train with a air mover, a flow measuring device and a sample collection. A flow of air was created by the air mover which allowed the capture of contaminants in the air into the sample collection. The collection mechanism was made of cassette cover front plate, two-o-rings, cassette rear front and the sampler body which was connected to a vacuum pump with a Teflon tube. The inbuilt flow meter had a rating of 1000ml/*min* to 5000m1/min of air samples which was calibrated into 2000ml/min(2l/min). Before sampling, the unit was carefully calibrated against a standard meter to determine the quantity of air flows and all unloaded glass fiber filter and the foam were dried in the desiccators at room temperature. The respirable foam was affixed to 25mm diameter filter for inhalable dust sampling with a flexible sample head to determine the respirable particle. The filter and cassette rear was pre-weighed to determine the initial respirable dust, while the filter, foam and whole cassette together was pre-weighed to determine the initial inhalable. After sampling, the filter, foam, with the whole cassette together was re-weighed to determine the inhalable fractions. The respirable fraction was determined by weighing the cassette rear and the filter only. These particles were collected at a flow rate of 21/min for eight hours and the sampler was placed between heights of 1.5-2m to reflect the breathing zone of man.

The difference between the final weight and the initial weight was the amount of respirable and inhalable dust collected (Shaw, 1987; UNEP / WHO, 1994).

The Concentration in μg/m^3 was calculated by

$$\frac{\text{Final weight (mg)-initial weight (mg)} \quad \text{X } 1000}{\text{Flow rate (m}^3\text{ min) X sampling period (min)}}$$

For a quantitative estimate of the possible impact of the airborne particulate on the health of neighboring receptor, the toxicity potential (TP) of respirable and inhalable suspended particulate matter (REPM &ISPM) were calculated by dividing its concentration for each sampling site with the daily average USEPA National Ambient Air Quality standard level concentration of 155 and 65 μg/m^3 for inhalable and respirable particle (USEPA, 1980).

Meteorological Parameters: Air temperature and humidity were measured simultaneously four times a week during particulate sampling by using RS humidity/Temperature meter with resolution of 0.1%RH and 0.1^{0c}(model RS 1364. RS Component Ltd UK) wind speeds were also measured using LM-8000 Anemometer (Heatmiser uk) with resolution of 0.1 M/S.

RESULTS AND DISCUSSION

The purpose of atmospheric sampling is to develop air quality criteria which are the basis for setting air quality standards. The data generated from this study aimed at determining the spatial distribution of respirable and inhalable fraction captured in this region.

The regulatory limits for the respirable and inhalable fractions are 65 μ g/m^3 and 150 μ g/m^3 by United States National ambient air quality. At the ten monitoring sites created, the 65 μ g/m^3 and 150 μ g/m^3 regulatory limits set by the United States National ambient air quality standard were exceeded, except site 4 and site 10 that falls within the purview of the regulatory limits. For inhalable and for respirable fraction, the regulatory limit in all the sites were clearly exceeded. The high particulate levels measured at all sites are caused by the vehicle, frequent traffic jams and combustion of solid waste and suspended dust.

From Table 2, the highest mean concentration of respirable and inhalable fraction captured was observed in site 8. From table 4 the Toxicity potential for respirable was in the range 1.6 to 5 while that of inhalable 0.67 to 3.

Furthermore, the spatial variation in the data obtained were significant (P<0.05) for respirable and inhalable suspended particulate matter.

*The Correlation between Respirable and Inhalable Suspended Particulate Matter with Wind Speed***.** Stagnation is characterized by calm or very low wind speeds and variable wind directions. These stagnant meteorological conditions may persist for several hours/days. During stagnation condition the dispersion of air pollutants tend to be low and potentially lead to relatively high ground level concentration. The was positive correlation between the respirable Particulate matter and wind speed (r = 0.337) as showed in Figure 3 while inhalable particle also showed positive correlation (r = 0.466) as showed in Figure 2. The effect of wind speed on pollutants is twofold: one effect is that wind speed will determine the travel time of a pollutants from sources to receptor. The other effect is the amount of pollutant dilute in the wind ward direction. According to Hosler, 1961, the persistence of surface wind speeds less than 3.1m/s is usually Conducive to the accumulation of air pollutant.

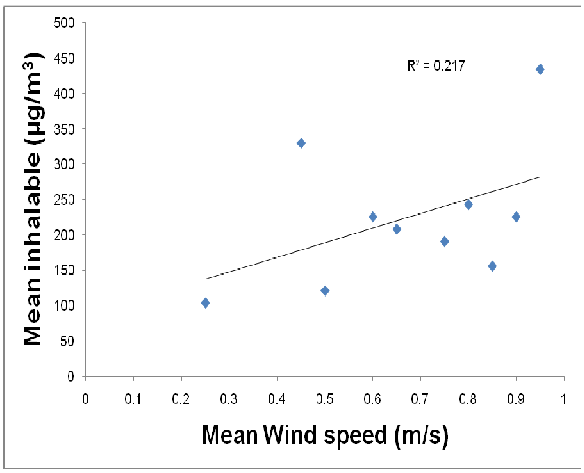

Fig. 2 : Correlation of Mean Inhalable Particles with Mean Wind Speed (scatter plot)

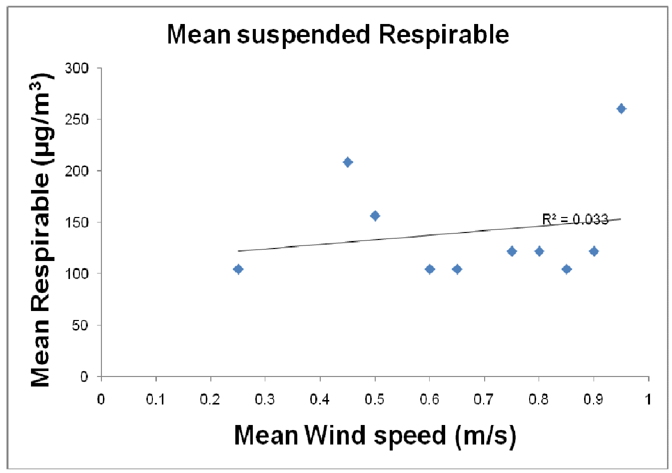

Fig:. 3 Correlation of Mean respirable particles with mean Wind Speed (scatter

*Correlation between Respirable and Inhalable Suspended Particulate Matter and Relative Humidity***.**\The relative humidity correlated negatively with suspended respirable and inhalable particulate matter. The correlation value between respirable particle and relative humidity was (r = 0.547) as showed in Figure 5 while for inhalable particle was (r =0.686) as showed in Figure 4.Humidity is the amount of water vapor in the atmosphere. Particulate matter is hygroscopic in nature. At times, as the relative humidity increases PM decrease. Therefore, the higher the relative humidity, the smaller the particulate in the atmosphere, the adsorption of water vapors onto the particulate matter may increase their settling rates and deposition.

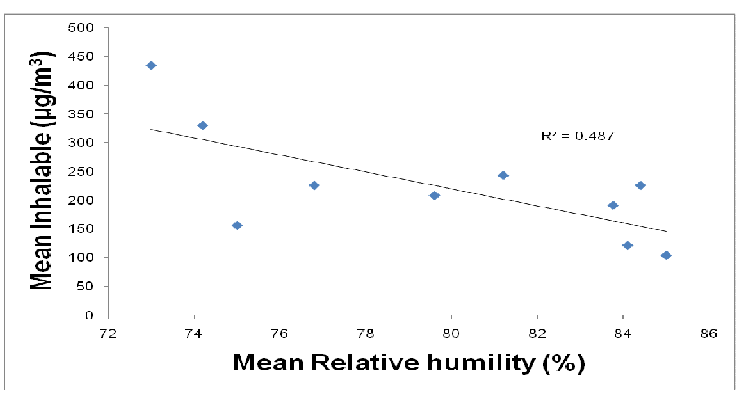

Fig 4: Correlation of Mean Inhalable Particle with Mean Relative Rumidity (scatter plot)

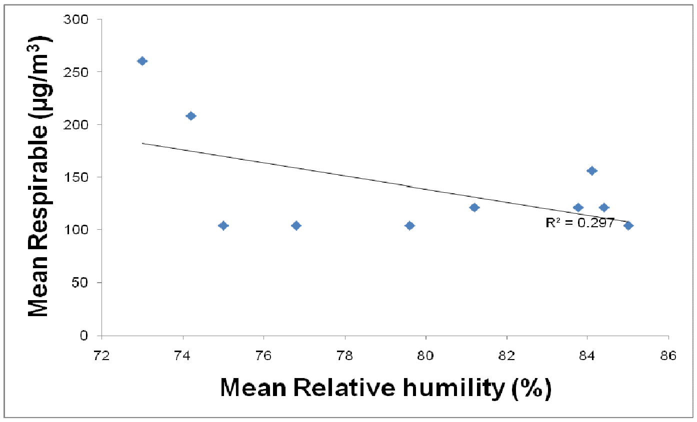

Fig5: Correlation of Mean Respirable Particle with Mean Relative Humidity (scatter plot)

Correlation between Respirable and Inhalable Suspended Particulate Matter with Temperature. Wind speed and relative humidity are not sufficient enough to explain the variability in concentration of suspended particulate matter in the atmosphere hence the correlation of the atmospheric temperature with and respirable and inhalable suspended particulate matter.

However, the correlation value between respirable particle and relative humidity was (r = 0.458) as showed in Figure 7 while for inhalable particle was (r =0.322) as showed in Figure 6.

Higher temperature increases the reactivity of gaseous constitutes in the atmospheric air resulting in greater particulate production. The correlation between mean inhalable particle and mean respirable particle was good and positive (r=0.707) as showed in Figure 8.

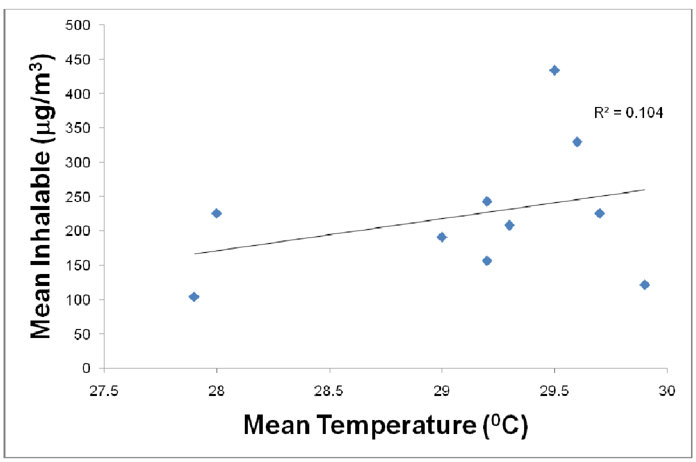

Fig. 6: Correlation of Mean Inhalable Particle with Mean Temperature (scatter plot)

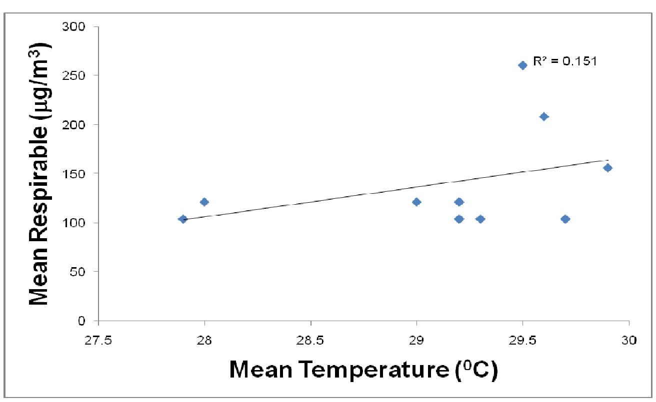

Fig. 7: Correlation of mean Respirable Particle with Mean Temperature (scatter plot)

Correlation of Mean Inhalable Fraction and Mean Respirable Fraction: The correlation shows positive and good correlation (r=0.707) fig below shows the graph.

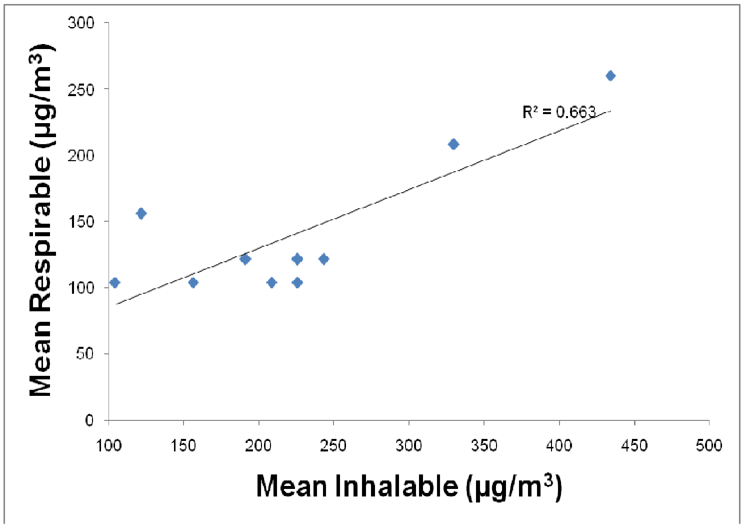

Fig. 8: Correlation of Mean Respirable and Mean Inhalable Particle (scatter plot)

Table 2: The Range, Mean Suspended Inhalable Particulate Matter

S/N.	Site Code	Range μ g/m3	Mean (μ g/m^3	Regulatory Limit
1.	SP. MV	104.17-312.50	156.25 ± 87.15	150 μ g/m
2.	SP. SG	208.33-312.50	225.69 ± 42.52	“
3.	SP. NOR	104.17-312.50	190.97 ± 102.41	“
4.	SP. RH	104.17-104.17	104.17 ± 0.00	“
5.	SP.OJ	208.33-208.33	208.33 ± 0.00	“
6.	SP.SM	104.17-312.50	243.05 ± 53.79	“
7.	SP. IA	208.33-520.00	329.72 ± 102.41	“
8.	SP. NER	312.50-729.17	434.03 ± 138.45	“
9.	SP .SWR	104.17-416.67	225.69 ± 102.41	“
10.	SP.OK	104.17-208.33	121.53 ± 42.52	“

Table 3: The Range, Mean Suspended Respirable Particulate Matter

S/N	Site Code	Range μ g/m^3	Mean μ g/ m^3	Regulatory Limit
1	SP. MV	104.17-104.17	104.17 ± 0.00	65 μ g/m
2	SP. SG	104.17-208.33	121.53 ± 53.78	“
3	SP. NOR	104.17-208.33	121.53 ± 42.52	“
4	SP.RH	104.17-104.17	104.17 ± 0.00	“
5	SP. OJ	104.17-104.17	104.17 ± 0.00	“
6	SP. SM	104.17-208.33	121.53 ± 42.52	“
7	SP. IA	104.17-312.50	208.33 ± 65.88	“
8	SP. NER	208.33-312.50	260.42 ± 57.05	“
9	SP.SP.SWR	104.17-104.17	104.17 ± 0.00	“
10	SP .OK	104.17-208.33	156.25 ± 57.05	“

Table 4: The Toxicity Potential of Respirable and Inhalable Fraction of Various Location Site

S/N.	Site Code	Respirable Particles	Inhalable Particles
1.	SP. MV	1.60	1.04
2.	SP. SQ	1.87	1.50
3.	SP. NOR	1.87	1.27
4.	SP. RH	1.60	0.67
5.	SP. OJ	1.60	1.38
6.	SP .SM	1.87	1.62
7.	SP. IA	3.20	2.19
8.	SP. NER	4.01	2.89
9.	SP.SWR	1.60	1.50
10.	SP.OK	2.40	0.81

Table 5: The Range and Mean Ambient Temperature, Relative Humidity and Wind Speed during Wet Season in Sapele

		Ambient temperature (^oC)		Relative humidity (%)		Wind Speed (m/s)	
S/N	Site code	Range	Mean	Range	Mean	Range	Mean
1.	SP.MV	25.80-33.20	29.20	70.00-82.00	75.00	0.0-1.7	0.85
2	SP.SG	26.70-30.90	28.00	76.20- 96.40	84.40	0.0-1.7	0.90
3	SP.NOR	27.40- 32.00	29.00	75.70-93.80	83.76	0.0-1-5	0.75
4	SP.RH	27.00-29.00	27.90	78.60-93.40	85.00	0.0-0.5	0.25
5	SP.OJ	28.60-30.20	29.30	70.60-90.60	79.60	0.0-1.4	0.65
6	SP.SM	28.90-30.20	29.20	70.70-90.50	81.20	0.0-1.9	0.80
7	SP.IA	27.90-34.00	29.60	65.90-85.10	74.20	0.0-0.9	0.45
8	SP.NER	28.10-31.20	29.60	69.00-79.00	73.00	0.0-1.8	0.95
9	SP.SWR	27.40-3100	29.70	70.00-84.00	76.80	0.0-1.4	0.60
10	SP.OK	28.00-31.00	29.90	76.00-94.00	84.10	0.0-1.0	0.50

Conclusion: The result obtained in this work showed that there was a spatial distribution of respirable and inhalable suspended particulate matter.

The concentration of the respirable particle captured was higher than the inhalable particle in this region. Also, the concentrations of both inhalable and respirable were higher, in comparison to majority of European cities and Asia. However, the ambient temperature and humidity were found to be relatively high with low wind speed.

The poor air quality in Sapele is strongly associated with inadequate vehicle emission control, poor traffic condition, and indiscriminate bush burning as a pre planting operation as well as open space burning of wood timber in order to generate charcoal which is often used as a fuel in this region and above all re-suspended dust.

Therefore, control measures such as improvement of traffic management, better vehicle maintenance, the speeding up of vehicle emission control and the stopping of open space burning of timber wood as well as indiscriminate bush burning in order to abate the pollutant level in this region.

Since there has been minute information on this subject matter, it is hoped that the results obtained will offer sublime information on the level of suspended respirable particulate matter and suspended inhalable particulate matter in this part of the country and may constitute the base line data for future environmental impact assessment.

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