Scientia Africana, Vol. 14 (No.2), December 2015. Pp 1-12
 ISSN 1118 – 1931

IMPACT OF AEROSOL ON RESPIRATORY SYMPTOMS AMONG ADULTS (ABOVE EIGHTEEN YEARS) IN AN URBAN AREA OF NIGERIA

[1]T. F. Ediagbonya, [2] A. E. Tobin,[3] E. E. Ukpebor, and [3] E. F. Okiemien

Department of Chemical Sciences, Ondo State University of Science and Technology, Okitipupa.
Institute of Lassa Fever Research and Control, Irrua Specialist Teaching Hospital, Irrua, Edo state, Nigeria
Air Pollution Research Group, University of Benin , Benin City,Edo State
**Corresponding Author: tf.ediagbonya@gmail.com , tf.ediagbonya@osustech.edu.ng*
Mobile phone;+2348069066577;+2349051956992;+2348175481309
Running Title: Aerosol and its exacerbating effect on human respiratory system

Received: 25-08-15
Accepted: 09-09-15

ABSTRACT

Over the past two decades there has been increasing interest in studies of air pollution and its effects on human. The purpose of this study is to assess the prevalence of respiratory symptoms and to relate these measures to the degree of air pollution in an urban area (Sapele) and to establish a relationship between peak flow rate and the anthropometric measurements among the respondents in an urban area. Four hundred respondents were administered on the frequency and duration of cough, production of phlegm (viscid mucous secreted in abnormal quantities in respiratory passages and sputum) (saliva discharge from respiratory passages), shortness of breath and occurrence of chest illness. The expiratory flow rate was recorded in a standing position using a mini-Wright peak flow meter (Clements Clarke-London UK). Anthropometric measurements; (weight and height) were also done. The aerosol was captured using SKC Air CheckXR5000 high volume Gravimetric Sampler. The mean concentration range of inhalable particle was 132.58-568.18µg/m^{3}and the mean concentration range in respirable particle was 107.17---331.44µg/m^3.The non-smoker had a better peak flow ratethan the smoker and there was prevalence of respiratory symptoms in which cough had the highest percentage. The mean concentration of inhalable and respirable particles obtained in this study were significantly higher than the regulatory limits set by the National Ambient Air Quality Standard (NAAQS).

Key words: Air Pollution, Respiratory Symptom, Urban Area, Peak Flow Rate Meter, High Volume Gravimetric Sampler.

INTRODUCTION

The ambient air concentration of particulate matter is universally high in developing areas because of higher road dust loading contributed from ongoing construction /industrial activities *(Ediagbonya etal., 2013, Ediagbonya etal.,2014,okuo and udiokwere,2005)*. PM10 can easily be transported through the upper respiratory tract into the bronchioles and alveoli of the lung, causing direct health hazards. Most recent studies focus their attentions on respirable or finer particulates ($PM_{2.5}$) because of their ability to penetrate deep into their spiratory system *(Sabrina etal., 2014; Valdes etal.,2013)* Aerosol particles are likely to have a long residence time in the atmosphere and can undergo dispersion and transport processes. As particulate matter is transported from a source to a potential receptor, the pollutant disperses into the surrounding air causing various effects to the floral/fauna inhabitants and the environment *(Ediagbonya et al.,2013).*

There is good evidence of the effects of short-term exposure to Inhalable particulate matter(PM_{10}) on respiratory health, but for mortality, and especially as a consequence of long-term exposure, Respirable particulate matter ($PM_{2.5}$)is a stronger risk factor than the inhalable particulate matter(PM_{10}) (particles in the 2.5–10 µm range). All-cause daily mortality is estimated to increase by 0.2–0.6% per 10 µg/m3 of PM_{10} *(Samoli etal., 2008; WHO, 2000; Stieb etal.,2000)*. Long-term exposure to $PM_{2.5}$ is associated with an increase in the long-term risk of cardiopulmonarymortality by 6–13% per 10 µg/m3 of $PM_{2.5}$ *(Beelen etal., 2008; Pope etal., 2002; Jalaludin etal., 2004).*

Susceptible groups with pre-existing lung or heart disease, as well as elderly people and children, are particularly vulnerable. For example, exposure to particulate matter (PM) affects lung development in children, including reversible deficits in lung function as well as chronically reduced lung growth rate and a deficit in long-term lung function (*Mustapha etal.,2011*). The average adult may require about 14 Kilograms of air each day compared with less than 1.4 Kilogram of food and about 2 Kilograms of water. Compared with the other necessities of life, obligatory continuous consumption is a unique property of air.

One of the major components of particulate matter which is the crystalline silica has also been classified as a known human carcinogen and is associated with systemic autoimmune disease *(International Agency for Research on Cancer, 1997).* The relationship between Silica and pneumoconiosis has been reported in the Azandarian Area *(Mohebbi and Abdi, 2007).* The occurrence of a pneumothorax was associated with complaints of pleuritic chest pain, resting dyspnea, respiratory distress, paroxysmal nocturnal dyspriea and orthopnea crackle. *(Bahrami and Mahjub, 2003).*

Exposure to pollutants can cause adverse health effects. They are also linked to higher mortality rate, heart disease and respiratory illness. *(Ghosh et al, 1996; Hong Kong Environmental Protection Department, 2000).* Patients with pre-existing respiratory or cardiac illness appear to be at particular risk of the most severe adverse health effects caused by exposure to Inhalable particles*(Schwartz and Dockery, 1992; Sunyer et al, 1993).* It has been suggested that plethora of ultra fine particles (particles smaller than 0.1µm) in urban air may be the explanation for the observed health effects of particulate matter (PM) *(Oberdorster et al., 1995; Seaton et al, 1995).* The adverse effects of ultra fine particles on respiratory symptoms, lung function and daily cardiopulmonary mortality have been discussed in several studies. *Wichmann et al, 2000; Wichmann and Peters, 2000; Pentinen et al, 2001).* The peak expiratory flow rate (PEFR) has been shown to be very significant in the routine monitoring of healthy and asthmatic children. *(Peters et al, 1997; Swaminathan, et al, 1993)*

The burgeoning levels of particulate matter pollution can be deadly to humans during serious episodes by aggravating existing health problems through inflammation of respiratory tissues *(Seck et al, 1991).* A serious air pollution episode in London in 1953 resulted in the deaths of 4,000 to 12,000 people *(Bell and Davis, 2001).* Particulate matter can also damage the lung capacity of individuals who are exposed during childhood and adolescence,

Scientia Africanca, Vol. 14 (No.2), December 2015. Pp 1-12
© College of Natural and Applied Sciences, University of Port Harcourt, Printed in Nigeria *ISSN 1118 – 1931*

significantly decreasing their lung capacity through long term exposure *(Li et al, 2003*). The present study was designed to investigate the prevalence of respiratory symptoms and lung function among the people of Sapele in Delta State, and measure the particulate dust concentration as an index of exposure. It is envisaged that the results of this study will add to the body of knowledge about the particulate matter exposure in Nigeria.

MATERIALS AND METHODS

Background of the Study Area

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$45’0^0E. 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 miles (144 kilometers) from the sea, well close 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 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 dusk in four different locations in the city. These charcoal are usually exported to other countries and sometime nearby cities.

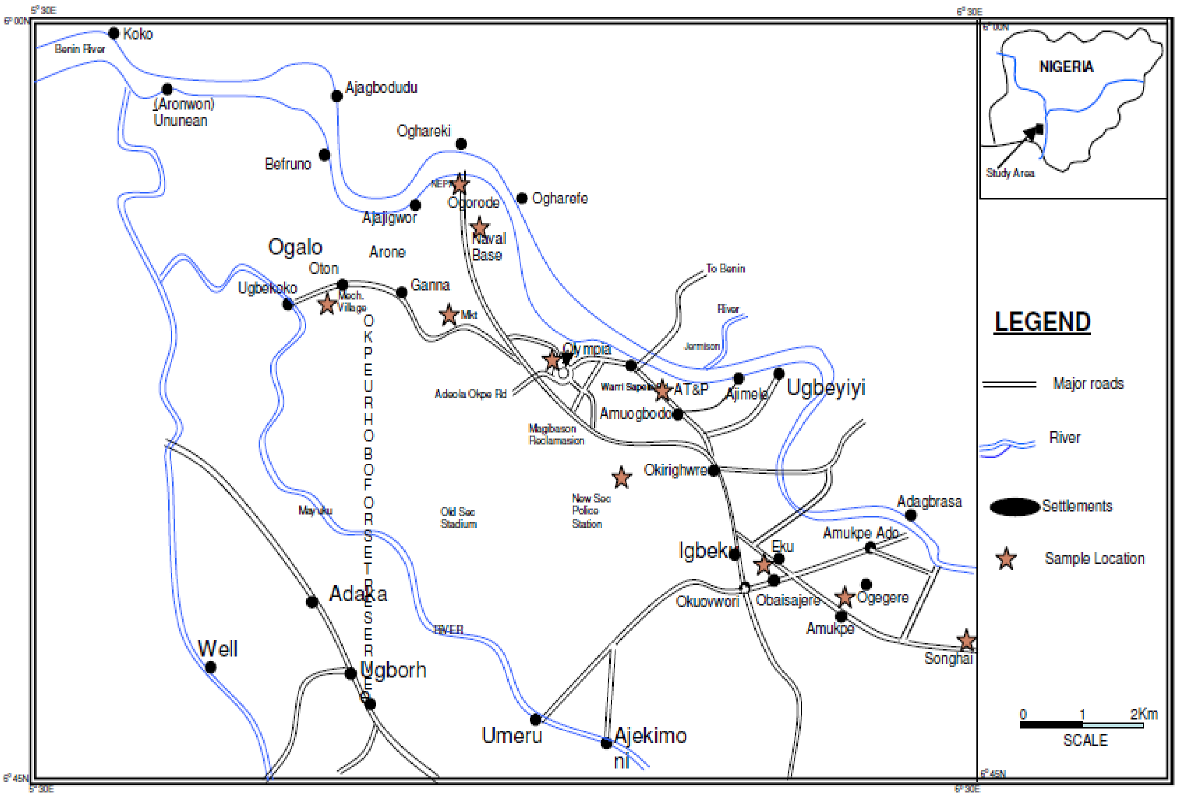

Fig.1 Map of Sapele reflecting the various Sampling locations.

SKC Air check XR5000 High volume Gravimetric sampler Model 210-5000 serial No. 20537 and the Institute of Occupational Medicine (I.O.M.) multi fraction dust sampler were used in this study.

The sampling train was made of an 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 aTeflon tube. The inbuilt flow meter has a rating of 1000 ml/min to 5000 ml/min of air samples which was calibrated into 2000 ml/min (2 l/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 desiccator at room temperature. The respirable foam was affixed to 25 mm diameter filter for inhalable dust sampling with a flexible sample head to determine the respirable particle. The filter and cassette rear were pre-weighed to determine the initial respirable dust, while the filter, foam and whole cassette together were pre-weighed to determine the initial inhalable dust. After sampling, the filter, foam, with the whole cassette together were 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 1.5-2 m to reflect the breathing zone of man. The difference between the final weight and theinitial weight was the amount of respirable and inhalable dust collected (Shaw, 1987; UNEP /WHO, 1994) The concentration in µg/m^3 was calculated using the equation below:

$$Conc.(\mu g/m^3) = \frac{Final\,weight(mg) - Initial\,weight(mg)}{Flow\,rate(m^3/\min) \times sampling\ period\ (\min)} \times 1000$$

Sampling Technique for Respiratory Symptoms

Data was collected by trained research assistants, Community health extension workers in the local government health department. An interviewer-administered structured medical and occupational questionnaire adapted from the British Medical Research Council (MRC) questionnaire on respiratory symptoms (Medical Research Council, 1960), which has been validated and used for studies in the country *(Ugheoke et al., 2009; Ige and Onadeko, 2000)* was applied to assess the prevalence of symptoms among respondents.

In each selected house, random sampling was used to select one respondent from among all eligible respondents. To be eligible, respondents must have lived in the location for not less than one year, and be above 18 years, not been diagnosed to have cardiac or respiratory disease. Four hundred questionnaires were administered. Data was collected using an interviewer administered English language Semi-structured questionnaire focusing on demographic characteristics, history of respiratory symptoms and perception of atmospheric air. Measurement of weight, height and Peak Expiratory Flow Rate (PEFR) were carried out for each study subject. Peak flow rate was assessed using the portable

Scientia Africana, Vol. 14 (No.2), December 2015. Pp 1-12
© College of Natural and Applied Sciences, University of Port Harcourt, Printed in Nigeria *ISSN 1118 – 1931*

Wright's Peak Flow Meter (Clement Clarke International London UK). The technique involved a maximum inspiration followed by a forced expiration into the instrument with maximum effort without hesitation. A test was considered as technically satisfactory if it was without hesitation, laughing or coughing at expiration. Three readings were taken and the highest value recorded as the final reading. Values less than 300L/min] were taken as abnormal, while those greater or equal to 300L-/min were taken as normal. *(Gauderman et al, 2004)*. The administered questionnaires were collated and analyzed using SPSS version Software Package. Results were presented as statements, figures and tables with Chi-square test of association at statistical significance set as 0.05 calculated where appropriate. *(Gauderman et al, 2004)*

RESULTS

A total of 400 respondents participated in the study. The mean age for the study was 32.14±10.54. A greater proportion was between 20-29 age-group in the location. Also, a greater proportion of the respondents were single 206(51.5%) The proportion of the respondents who lived in residential location was 188(47%) while a greater proportion of the respondents were in business premises 212(53%). Respondents with secondary level education were higher with 205(51.3%). The respondents who had resided for less than 4 years had the greatest proportion.

Table 1: Duration of stay of respondents

Duration of stay (years)	Urban Location
1 – 4	235(58.8)
5 – 9	104(26.0)
≥ 10	61(15.2)
Total	400(100.0)

Table 2: shows prevalence of Respiratory symptoms by locations. In terms of self-report of perceived air quality, 98(24.5%) of the respondents described the air they breathe in as clean. From table 2, 42 (10.5%) experienced cough within the past 3 months, 43(21.3%) experienced phlegm while symptoms of difficulty in breathing chest pain and sore throat were low 59 (14.8%), 55 (13.8%) and 41 (10.3%) respectively.

Table 2: Prevalence of Respiratory Symptoms in Sapele (Urban Area) of Respiratory Symptoms in Sapele (Urban Area)

Symptom	Urban
Cough	42(10.5)
Phlegm	43(21.3)
Wheeze	53(13.5)
Difficulty in breathing	59(14.8)
Chest Pain	55(13.8)
Sore throat	41(10.3)

From Table 3, the mean Peak Flow values in the Urban area (Sapele) were quite high (363.26±62.41) L/min, when compared to the normal value of peak flow rate which is > 300

Table 3: Comparison of peak flow rate among respondents in Sapele (Urban Area)

	Smoker (n=136)	**Non-Smoker (n=264)**
PEFR (L/Min)	310.33±59.11	375.08±85.81

Table 4: Abnormality of Peak Flow Rate and Smoking Status

	Peak flow rate		
Smoking Status	Abnormal	Normal	Total
Smokers	20(14.7)	116(85.3)	136
Non Smokers	34(12.9)	230(87.1)	264

Table 5: Spatial variation of measured inhalable fractions (µg/m^3) in Sapele from December 2008 – October 2009

S/N	**Sampling**	**Code**	**Max**	**Min**	**Mean**	**Standard Deviation**
1	Mechanical Village	SP/MV	520.83	104.17	255.68	149.97
2	Songhai	SP/SG	520.83	208.33	321.97	127.19
3	New Ogorode Road	SP/NOR	625	104.17	321.97	183.13
4	Residential House	SP/RH	312.5	104.17	132.58	67.36
5	Olympium Junction	SP/OJ	416.67	104.17	227.27	78.2
6	Sapele Market	SP/SM	625	104.17	303.03	164.4
7	Industrial Area	SP/IA	1250	208.33	549.24	319.67
8	New Eku Road	SP/NER	1041.67	312.5	568.18	330.26
9	Warri Sapele	SP/WSR	416.67	104.17	284.09	114.97
10	Okirighwre	SP/OK	416.67	104.17	189.4	112.37

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

Table 6: Spatial Variation of Measured Respirable Fractions in Sapele (µg/m^3) from December 2008 – October 2009.

S/N	**Sampling Site**	**Site Code**	**Max**	**Min**	**Mean**	**Standard Deviation**
1	Mechanical Village	SP/MV	208.33	104.17	132.57	48.65
2	Songhai	SP/SG	312.5	104.17	170.45	70.23
3	New Ogorode Road	SP/NOR	208.33	104.17	151.51	54.4
4	Residential House	SP/RH	104.17	104.17	104.17	149
5	Olympium Junction	SP/OJ	208.33	104.17	142.05	52.55
6	Sapele Market	SP/SM	208.33	104.17	132.58	48.65
7	Industrial Area	SP/IA	625	104.17	284.09	132.51
8	New Eku Road	SP/NER	625	208.33	331.44	130.26
9	Warri Sapele	SP/WSR	208.33	104.17	123.11	42.13
10	Okinghwre	SP/OK	312.5	104.17	170.45	70.23

Scientia Africana, Vol. 14 (No.2), December 2015. Pp 1-12
© College of Natural and Applied Sciences, University of Port Harcourt, Printed in Nigeria *ISSN 1118 – 1931*

Tables 5 and 6 show the concentration of inhalable and respirable fractions captured using SKC gravimetric sampler. From the data obtained, the permissible limits were exceeded in both respirable and inhalable (except site 4) -respirable 65μg/m^3, inhalable 150μg/m^3 National Ambient Air Quality Standard (NAAQS)

Table 7: Pearson Correlation coefficient of anthropometric measurements on the Peak Respiratory Flow Rate

	PEFR
AGE	-0.34**
WEIGHT	0.07
HEIGHT	0.178**

Age has a significant (P<0.01) weak inverse linear relationships (r=-0.34) with PEFR, weight has no relationship with PEFR while Height has a weak positive linear relationship (r =0.178) with PEFR. See Table 7.

DISCUSSION

The higher prevalence of respiratory symptoms in the study group indicates that that exposure to particulate matter may expose human to a higher risk of developing pulmonary disorders. This finding is in agreement with reports from other comparative studies. *(Kunzli etal.,2000; Okwari et al., 2005)*. Respondents in the study group reported a higher prevalence of cough, and phlegm expectoration compared to chest pain, chest tightness, wheeze or breathlessness. The implication is that upper respiratory tract involvement was more likely, compared to lower respiratory tract involvement, the latter presenting with wheeze, chest pain, breathlessness and tightness. This finding, which has been similarly reported by other investigators *(Ugheoke et al. 2009; Chirdan and Akosu, 2004)* might be as a result of the fact that particulate matter, made up of cellulose and other soluble chemicals including acetic acid and resins, is largely of large diameter fibres that irritate the cough receptors in the trachea and cause mucostasis in the upper respiratory tract, leading to cough and phlegm production. This is supported by area sampling of the study sites which showed concentrations of total particulates significantly higher than the regulatory limits. The results obtained in this study can as well be compared to other study done in Jos in Nigeria *(Ugheoke et al., 2009; Chirdan and Akosu ,2004)*. A comparison of non-smokers with smokers showed prevalence of symptoms higher in non-smoker indicating that particulate matter or aerosol acts on the respiratory tract independent of smoking. Similarly, when comparison was made between non-smokers and smokers, the peak expiratory flow readings were significantly better (P<0.05) in non-smoker as shown in Table 4.This also in agreement with other studies*(Robins et al., 2005; White et al., 2009)* . Tobacco smoke is a complex mixture of over 4,000 compounds, more than 40 of which are known to cause cancer in humans and animals and many of which are strong irritants. Exposure to tobacco smoke is responsible for approximately, 3,000 lung cancer death each year of non-smoking adult and impairs the respiratory health of hundreds of thousands of people. Infants and young people whose parents smoke in their presence are at increased risk of lower respiratory tract infections (pneumonia and bronchitis) and are more likely to have symptoms of respiratory irritation like cough, excess phlegm and wheeze. *(Aguwa et al, 2007).*

In urban areas, the main sources of atmospheric particulate matter are motor traffic, domestic heating, power generation, industrial processes *(e.g. Allan et al., 2010; Aiken et al., 2009)*.The concentration of the particulate matter obtained in this study can compared to other studies(Wilson and Suh,1997;Zakey,2008). Inhalable particle (PM10) levels were alsoassociated with fewer reports of respiratory symptoms such as regular cough, chronic coughor phlegm, and wheezing and breathlessness (Downs etal., 2007;Schindler etal.,2009). Falling levels of regional PM10 were associated with a decliningprevalence of various respiratory symptoms, including chronic cough, bronchitis, common old, nocturnal dry cough and conjunctivitis symptoms (*Bayer etal., 2005)*. The increase of respiratory admissions per mg/m3 of respirable particle($PM_{2.5}$) was found higher *(Moolgavkar,2000;Stieb et al.,2000).*

Particulate matter (PM) is a widespread air pollutant, present wherever people live. The health effects of PM_{10} and $PM_{2.5}$ are well documented. There is no evidence of a safe level of exposure or a threshold below which no adverse health effects occur. Monitoring of Inhalable particle(PM_{10}) and/or Respirable particle($PM_{2.5}$) needs to be improved upon in order to assess population exposure and to assist local authorities in establishing plans for improving air quality. There is evidence that decreased levels of particulate air pollution following a sustained intervention result in health benefits for the population assessed. These benefits can be seen with almost any decrease in level of PM. The health and economic impacts of inaction should be assessed. The Inhalable and Respirable components of the suspended particulate matter generated in Sapele (urban area) in Nigeria clearly exceeded the regulatory limit set by NAAQS. 14.7% of 136smokers had abnormality with the peak flow rate, while 12.9% of 256 of non-smokers had abnormality with the peak flow rate. The highest respiratory symptom was shown in difficulty in breathing (14.8%)

We gratefully acknowledge the support of Mr. Ufuoma Asagba, Mr. Magnus Legmah, Dr.mrs. Justina Ukpebor, Mr. Edward Olumese, Mr. Obozakhai, Mr. Ezeh Joseph Onuwa, Mr. Ogaga Tebehaevu and Mr. Okungbowa Godwin Nosa for their immeasurable assistance.

REFERENCES

Aguwa ,E. N., Okeke T. A., Asuzu, M. C. (2007). *The Prevalence of Occupational Asthma and Rhinitis among wood workers in Seng*. Tan Research Bulletin

Aiken, A. C., Salcedo, D., Cubison, M. J., Huffman, J. A., DeCarlo, P. F., Ulbrich, I. M., Docherty, K. S., Sueper, D., Kimmel, J.R., Worsnop, D. R., Trimborn, A., Northway, M., Stone, E. A.,Schauer, J. J., Volkamer, R. M., Fortner, E., de Foy, B., Wang, J.,Laskin, A., Shutthanandan, V., Zheng, J., Zhang, R., Gaffney, J.,Marley, N. A., Paredes-Miranda, G., Arnott,W. P., Molina, L. T.,Sosa, G., and Jimenez, J. L.(2009): *Mexico City aerosol analysis duringMILAGRO using high resolution aerosol mass spectrometry at the urban supersite (T0) – Part 1: Fine particle*

Scientia Africana, Vol. 14 (No.2), December 2015. Pp 1-12
© College of Natural and Applied Sciences, University of Port Harcourt, Printed in Nigeria *ISSN 1118 – 1931*

composition and organic source apportionment,Atmosheric Chemistry& Physics., 9, 6633–6653

Allan, J. D., Williams, P. I., Morgan, W. T., Martin, C. L., Flynn,M. J., Lee, J., Nemitz, E., Phillips, G. J., Gallagher, M. W., andCoe, H(2010)*Contributions from transport, solid fuel burning and cooking to primary organic aerosols in two UK cities,Atmospheric Chemistry& Physics*. 10, 647–668.

Bahrami, A and R, Mahjub, H. (2003) *Comparative Study of lung function in Iranian Factory Workers exposed to Silica dust*, *East Medicine& Health Journal*. 9, 390-8.

Bayer-Oglesby L, Grize L, Gassner M, Takken-Sahli K, Sennhauser F, Neu U, (2005). *Decline of ambient air pollution levels and improved respiratory health in Swiss children*. *Environmental Health Perspective* 113:1632–1637.

Beelen,R.,Hoek,G.,Brande,P.V.,Alexandra, G.R.,Fischer,P.,Schouten,L.J.,Jerrett, M.,Hughe,E.,Armstrong,B.,Brunekreef,B(2008)*Long-term effects of traffic-related air pollution on mortality in a Dutchcohort (NLCS-AIR Study).Environmental Health Perspectives*, 116(2):196–202.

Pope CA III et al(2002). *Lung cancer, cardiopulmonary mortality, and long-term exposure tofine particulate air pollution*. *Journal of the American Medical Association*, 287(9):1132–1141.

Bell, M.L., and Davis,D.I(2001) *Reassessment of the Lethal London fog of 1952: Novel Indicators of Acute and Chronic Consequences of Acute Exposure to Air Pollution.Environmental Health Perspectives* 109, 389-394.

Brauer, M., Amman, M., Burnett, R.T., Cohen, A., Dentener, F.J., Ezzatti, M (2012). *Exposure assessment for estimation of the global burden of diseaseattributable to outdoor air* pollution. *Environmental Science and Technology*, 46:652–660.

Chirdan, O.O and Akosu, J. (2004) *Respiratory symptoms in workers at Katako wood market, Jos, Plateau state Nigeria*. Journal of Community Medicine Primary Health Care. 16 : 30-36.

Downs, S.H., Schindler, C., Liu,L. J., Keidel, D., Bayer-oglesby, L., Brutche, M.H (2007). *Reduced exposure to PM10 and attenuated age-related decline in lungfunction. The New England Journal of Medicine*, 357:2338–2347.

Ediagbonya, T.F; Ukpebor,E.E; Okieimen, F.E (2014).*Baseline levels and distribution of airborne particulate matter in the urban town of sapele.Nigeria Journal of applied science*.32:67-76

Ediagbonya, T.F; Ukpebor,E.E; Okieimen, F.E(2013).*Correlation of Meterological Parameters and Dust Particles Using Scatter Plot in Rural Community*. *Ife Journal of Science*,15(3):445-453

Gauderman,W.J.,Avol,E.,Gilliland,F.,Vora, H.,Thomas,D.,Berhane,K.,McConnell,R.,Kuenzli,N.,Lurmann,F.,Rappaport,E.,Margolis,H.,Bates,D.,Peter,J (2004) *The effect of Air Pollution on*

Lung Development from 10 to 18 years of age. The New England Journal of Medicine 351,(11): 1057-1067.

Ghosh, S., Pal, A.K and Saxena, N.C., (1996) *Impact of road way traffic and transport on human health: Energy Environment Monitor* 12, 101-107.

Hong Kong Environmental Protection Department (HKEPD), (2000). Environment Hong Kong 2000 Hong Kong Printing Department, Hong Kong.

Ige, O.M and Onadeko, O.B (2000) *Respiratory symptoms and ventilatory function of saw millers in Ibadan Nigeria. Africa Journal Medical Sciences*; 29: 101-104

International Agency for Research on Cancer (1997) IARC Monographs on the evaluation of the carcinogenic risk of chemicals to human: Silica and some Silicates, International Agency for Research on Cancer, Lyon.

Jalaludin, B.B., O'Toole, B.I., Leeder, S.R(2004) *Acute effects of urban ambient air pollution on respiratory symptoms, asthma medication use, and doctor visits for asthma in a cohort of Australian children. Environment& Respiratory* 95 (1):32–42.

Ku¨ nzli,N.,Kaiser,R.,Medina, S.,Studnicka, M.,Chanel, O.,Filliger,P.,Herry,M.,Horak Jr.,F., Puybonnieux-Texier, V., Quenel, P., Schneider, J., Seethaler ,R., Vergnaud ,J.C., Sommer, H., (2000). *Public-health impact of outdoor and traffic-related air pollution: a European assessment. Lancet* 356, 795–801.

Li, N., Sioutas, C., Cho,A., Schmitz, D., Misra, C., Semp, J., Wang, M., Oberley, T., Froines, J .,Nel, A (2003) *Ultrafine Particulate Pollutants Induce Oxidative Stress and Mitochondrial Damage. Environ Health Perspectives* 111(4): 455-460.

Medical Research Council (2004). Committee on the aetiology of Chronic Bronchitis.

Mohebbi, I and Abdi Rad, I. (2007) *Secondary Spontaneous Pneumothorax in rapidly progressive forms of Silicosis: Characterization of pulmonary function measurements and Clinical patterns. Toxicological& Industrial. Health* 23, 125-32.

Moolgavkar,S.H(2000)*Air pollution and hospital admissionsfor chronic obstructive pulmonary disease in three metropolitan areas in the United States. Inhalation Toxicology 12(Suppl*. 4),75–90.

Mustapha,B.A.,Blangiardo,M.,Briggs,J.B.and Hansell,A.L (2011) *Traffic Air Pollution and Other Risk Factors for Respiratory Illness in Schoolchildren in the Niger-Delta Region ofNigeria Environmental Health Perspectives* 19 (10):1478-1482

Oberdorster G., Gelein R.M., Ferin J., and Weiss, B. (1995) *Association of particulate air pollution and acute mortality. Involvement of ultra fine particles? Inhalalation Toxicology*. 7:111-124/PubMed/ISI/

Okwari, O.O., Antai, A.B., Peters, E.J., Osim, E.E.(2005) *Lung function*

Scientia Africana, Vol. 14 (No.2), December 2015. Pp 1-12
© College of Natural and Applied Sciences, University of Port Harcourt, Printed in Nigeria *ISSN 1118 – 1931*

status of workers exposed to wood dust in timber markets in Calabar, Nigeria. Africa Journal Medical Science, 34: 141- 45.

Pentinen, P., Timonen, K.L., Tiittanen, P., Mirme, A., Ruuskanen, J., and Pekkanen, J (2001) *Number concentration and size of particles in Urban air: effects on Spirometric lung function in adult asthmatic subjects. Environmental Health Perspective:* 109 (4): 319-323.

Peters, A., Wichmann, H.E., Tuch, T., Heinrich, J., and Heyder, J., (1997) *Respiratory effects are associated with the number of ultra fine particles. America Journal of Respiratory Critical Care of Medicine* 155: 1376-1383/PubMed/ISI/ChemPort].

Pope III,C.A.,Burnett, R.T.,Thun,M.J.,Calle, E.E.,Krewski,D., Ito, K., Thurston, G.D(2002). *Lung cancer, cardiopulmonary mortality, and long-term exposure to fine particulate air pollution. Journal of the American Medical Association* 287,1132–1141.

Robins, T.G., Batterman, S., Mentz, G.B., Kistnasamy, B., Jack, C., Irusen, E(2005). *Respiratory health and air pollution in South Durban: the Settlers school study. Epidemiology* 16(5):S79.

Sabrina,Y.N.,Jiang Fenhuan, Y.,Ka,L.C.Z (2014) *Water solubility of metals in course PM1 and PM2.5 in typical urban environment in hong kong. Atmospheric pollution research,* 5:236-244

Samoli, E., Analitis, A., Touloumi, G., Schwartz, J., Anderson, H.R., Sunyer, J (2008) *Acute effects of ambient particulate matter on mortality in Europe and North America: results from the APHENA Study*. *Environmental Health Perspectives*, 116(11):1480–1486

Schindler, C et al(2009). *Improvements in PM10 exposure and reduced rates of respiratory symptoms in a cohort of Swiss adults (SAPALDIA). American Journal for RespiratoryandCriticalCareMedicine*,179:1–9.

Schwartz, J. and Dockery,D.W (1992) *Increased Mortality in Philadelphia associated with daily air pollutions concentrations. America.Review Respiratory. Disease.* 145: 600-604 [Medline].

Seaton, A., MacNee, W., Donaldson, K., and Godden, D., (1995) *Particulate air pollution and acute health effects. Lancet*: 345:176-178 [Article/PubMed/ISI/ Chem Port]

Seck, G.,Thioune,C.T and Faltot,P.J (1991) *Peak Expiratory Flow in 542 Senegalese Children and Adolescents. Dakar Medical*, 36(2): 112-9.

SHAW, R.W. (1987). *Air Pollution by particles*. *Scientific American*, **257**: 96-103.

Stieb,D.M., Beveridge, R.C.,Brook, J.R., Smith-Do iron, M.,Burnett, R.T., Dales, R.E., Beaulieu, S., Judek, S., Mamedov, A (2000). Air pollution, aeroallerg ens and cardiorespiratory emergency department visits in Sain John,Canada . Journal of Exposure

Analysis and Environmental Epidemiology 10 (5),461–477.

Sunyer, J., M. Saez, C., Murillo J., Castellsague., Martinez, F and J.M. Anto,J.M (1993) *Air Pollution and emergency room admissions for chronic obstructive pulmonary disease: a 5-year study. America Journal. Epidemiology*137: 701-705 [Astract/Free.Ful/Text]

Swaminathan,S.,Venkatesan,P.,Mukunthan, R(1993) *Peak Expiratory Flow Rate in South Indian Children Indian pediatr*ic.30(2):207-11

Ugheoke, J, Wahab, Z.K, Erhabor, G.E (2009) *Prevalence of respiratory symptoms among sawmills workers in Benin-city*. *International Journal of Tropical Medicine*. 4: 1-3

UNEP/WHO (1994). *GEMS/AIR Methodology reviews. Measurement of suspended particulate matter in ambient air*. WHO/EOS/94.3/UNEP/GEMS/94.UNEP Nairobi.

Valde´s,A , Polve´,M, Munoz .M Toutain,J.P Morata,D (2013) *Geochemical features of aerosols in Santiago de Chile from time series analysis Environmental Earth Science* 69:2073–2090.

White, N., teWaterNaude, J., van der Walt, A., Ravenscroft, G., Roberts ,W.,Ehrlich R. (2009). *Meteorologically estimated exposure but not distance predicts asthma symptoms in schoolchildren in the environs of a petrochemical refinery: a cross-sectional study. Environmental Health* 25:8:45; doi:10.1186/1476-069X-8-45.

WHO (2000) Particulate matter. In: *Air Quality Guidelinesfor Europe*,2nd Edition. World Health OrganizationRegional Publications,European Series,No. 91,pp. 186–198.

Wichmann, H.E and Peters, A., (2000) *Epidemiological evidence of the effects of ultra fine particle exposure. Philosophical Trans Royal Society of London:* 358: 2751-2769 [Article].

Wichmann, H.E., Spix, C., Tuch, T., Wolke, G., Peters, A., and Heinrich, J., et al (2000) *Daily Mortality and fine an ultra fine particle in Erfurt, Germany part 1: role of particle number and particle mass health Effects* Institute Report No. 98.

Wilson, W.H and Suh, H.H (1997) *Fine particle and coarse particles: Concentration relationship relevant to epidemiological studies. Journal of the Air and Waste Management Association* 47, 1238-1249.

Zakey,A.S(2008) *Seasonal and spatial variation of atmospheric particulate matter in a developing megacity,,the greater cairo,eygptAtmosfera* 21 (2): 171-189.