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RESEARCH ARTICLE

Baseline, spatial and temporal variation of total suspended particulate (TSP) matter in Isoko land

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Abstract

In this article, a link is being established between the low life expectancy in Nigeria and the ubiquitous suspended particulate matter as the most common form of air pollutants in Nigeria. Consequently, the baseline, spatial and temporal distributions of total suspended particulate (TSP) airborne particles in Isoko land with numerous oil wells and flow stations have been quantified. Airborne particulate matter quantification was accomplished by using a Microdust Pro real time dust monitor (Casella CEL 176000A). Sampling was done for a year in the seventeen sampling sites created in the study area. The annual baseline concentration ranges of the TSP were 16 to 1035 $\mu g/m^3$. There was uniformity in the distribution of airborne particles (TSP) at the created sampling sites (ANOVA, P=0.7206, F=0.7676, df 16). Temporal variation in the measured data were calculated to be statistically significant (ANOVA, P=2.182E-37, F=31.58, df 11), with higher TSP values reported in the dry season months (Dec 2011 to April 2012). For some of the sampling sites, the measured particles were within the Federal Ministry of Environment (FMNEV) (2000) and World Health Organization (WHO) statutory limits of 250 $\mu g/m^3$ and 150 to 230 $\mu g/m^3$, respectively. At some of the sites the above limits were clearly violated, suggestive of health and environmental concerns. The sources identified to contribute the highest values are farming, cooking with charcoal and firewood (fossil fuel combustion), microbiological sources, temperature and precipitation, the condition of the roads and vehicular traffic (anthropogenic particles).

Introduction

Particulate air pollution has been widely investigated in many parts of the world (Zakey et al., 2008; Efe, 2008; Oluyemi and Asubiojo, 2001). The level of suspended particulate matter pollution has an influence on human health (Sufian, 2011). Suspended particulate matter is a nearly ubiquitous urban pollutant. It is a complex mixture of small and large particles of varying origin and chemical composition. The effects on the health caused by PM depend on the size of the particles. In general, smaller particles are more toxic because of their ability to penetrate deep into the respiratory tract, particles with diameter of 10 µm or more are filtered when inhaled through the nose. While bigger particles remain in the throat, the smaller ones (PM2.5 or PM1) get in the trachea and in the respiratory system. Besides, they are also more toxic since they often consist of heavy metals and cancer causing organic compounds (Hörmann et al., 2005).

Total PM or suspended particulate matter includes all airborne particles, regardless of their size or composition. Total suspended particulate matter (TSP) also refers to all particles surrounded by air in a given volume of air. Size range of particles is a few nanometers to several hundred microns (µm), is an estimate of total air borne particle mass measured by High-Volume Sampler (HVS). It consists of both the respirable and inhalable particulate matter (Microsoft Encarta Encyclopedia, 2001).

Airborne particulate matter contains a large number of genotoxic and carcinogenic substances, such as, the polycyclic aromatic hydrocarbons (PAHs). Particulate matter has been linked to premature mortality, lung cancer, respiratory and cardiovascular health problems (Sufian, 2011). Long-term exposure to particulate matter <10 mm in diameter had a significant negative effect on lung-function proxy for the development of large (forced expiratory volume in one second) and small (mid-expiratory flow between 25 and 75% of the forced vital capacity) airways, respectively (Horak Jr et al., 2002). Particulates are especially dangerous because they have been implicated in the development of lung cancer and higher rates of mortality (Schwela, 2000).

Gas flaring is the controlled burning of natural gases associated with oil production. The consistent flaring has left a devastating effect on the surrounding environment of the Niger Delta Area, where the activities of oil exploration and exploitation is the greatest (Adeniye et al., 1983). With a daily crude oil output in excess of two million barrels per day, Nigeria has over 200 gas flaring sites, some of which have been on continuously for over 20 years. While about 22 billion standard cubic feet (SCF) of natural gas is produced daily, about 75% of this quantity is being flared (Bailey et al., 2000).
Nigeria flares about 17.2 billion^3 m of natural gas per year in conjunction with the exploration of crude oil in the Niger Delta. This high level of gas flaring is equal to approximately one quarter of the current power consumption of the African continent. Gas flaring is a major contributor to the stock of green house gases in the atmosphere thus adding to the climate change chaos. Power generation by coal in South Africa and gas flaring in the Niger Delta are by far the main sources of carbon dioxide emissions in Sub-Saharan Africa (South of the Sahara). For communities next to gas flares, the toxic cocktail may have serious health impacts in the form of respiratory illnesses, asthma, blood disorders, cancer, painful breathing and chronic bronchitis, among others. Flared gas has also been identified as a cause of acid rains that pollute creeks and streams, damage vegetation and corrode roofs of homes. The acid rain results when sulphur and nitrogen oxides mix with moisture in the atmosphere. The objective of this work is to investigate the impact of flow station on air quality in Isoko land. This work could be used as a preliminary study to obtain background information about the level of total suspended particulate matter in Isoko land and also to ascertain the air quality in Isoko land.

Material and Methods

Study area

This study was conducted in six different oil producing communities in Isoko North and South local government areas of Delta state in the southern region of Nigeria. Isoko land lies in the Niger Delta region of Nigeria in West Africa, occupying an area of about 1, 200.km^{-2}, with a residual population of over 750,000 inhabitants by 2006 census. The Isoko land is one of the most densely populated areas in Nigeria, with about 300 persons km^{-2} compared with the average of 130 for Nigeria. The consequence has been shortage of farmland, a shortage accentuated by oil exploration activities in the region.

Isoko land is essentially rural with no urban and two semi-urban centres. Isoko land is within the economic shadow of the vibrant industrial, commercial Warri metropolis. In between these communities are three flow stations namely: Ogini, Uzere and Olomoro. The study area is located within the co-ordinates of latitude N05° 23’ 0” - N05° 36’ 0” Longitude E006° 8’ 0”- E006° 17’ 0”. The study area has a total area of 232.56 km^2 and with a population of 142,582 (Figures 1 and 2) (NPC, 2006). Ozoro and Oleh are the semi-urban communities while the remaining fourcommunities are rural. The rural dwellers engage themselves in farming, hunting, rubber tapping and rural intra-transportation due to the accessibility of these communities via tarred roads. The people also engage in cassava processing, smoking of fishes, and their major way of waste disposal is either by burning or indiscriminate dumping of the waste in the bush. The major source of cooking is through burning of fossil fuel (fire wood or kerosene). However, as mentioned earlier all these communities are within the proximity of three flow stations where associated gas is being flared. All these afore-mentioned activities are veritable generators of particulate matter in the environment.

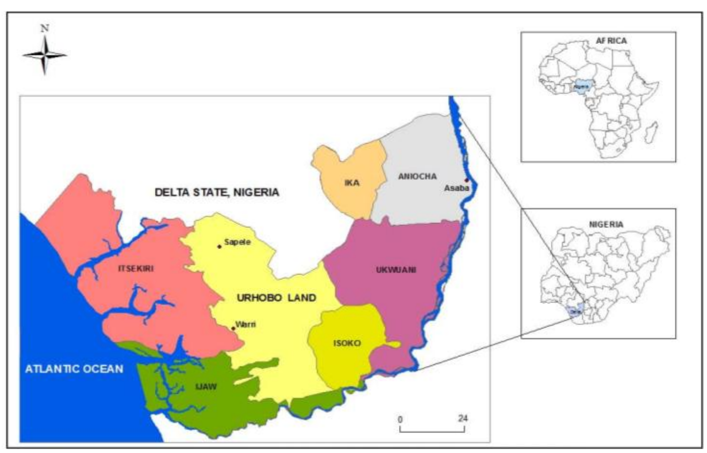

Figure 1. Map of Delta state showing Isoko land.

Sampling and experimental methods

The mass concentrations for TSP presented in this paper were monitored by means of Microdust Pro Dust Kit. Precise measuring of dust (particulate matter) concentration using the monitor "Microdust pro" is possible with the help of an optical method (Baltrėnas and Kvasauskas, 2005). The Microdust Pro measures particulate concentrations using a near forward angle light scattering technique. Infrared light of 880 nm wavelength is projected through the sampling volume where contact with particles causes the light to scatter. The amount of light scattered is proportional to the mass concentration and is measured by the photo detector. By using a narrow angle of scatter (12 to 20°) the majority of light scattered is in the diffracted and refracted components, which minimizes the uncertainty associated with particle color, shape and refractive index. The monitor "Microdust pro" has the highest level of sensibility for measuring inspirable fractions, with the "Microdust pro" it is possible to measure particulate matter with a diameter from 0.1 to 10 µm).

The Microdust Pro which is a rugged, hand-held, data-logging meter for the real-time detection of airborne particulate matter, fumes and aerosols, has a wide range from 0.001 to 2,500 mg.m^{-3} in single meter, data-logger with >15,700 readings, detachable probe, TSP, PM10, PM2.5 (respirable) measurements, firmware calibration and zero in the field, and simultaneous collection of a gravimetric (filtered) sample of the particulate matter. In this way, two averages are collected over the exposure period. One is from the filter, whilst the other is provided by the averaging function within the instrument. It is then possible to derive the difference in these two figures and correct accordingly. Instant real-time trend analysis, shows graphical and numeric particulate matter levels, ideal for walk-through surveys. This method has being used and proven to be accurate and reliable (Baltrėnas and Morkuniene, 2006; Di Napoli et al., 2011; Kazlauskienė et al., 2008; Thatcher et al., 2005). Sampling sites were created in seventeen sampling as shown on Table 1 and sampling was done for a year in the seventeen sampling sites created in the study area.

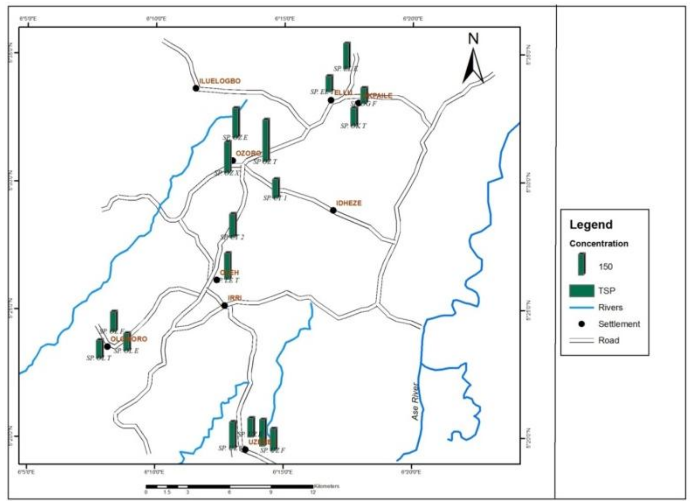

Figure 2. Map of Isoko land reflecting TSP concentrations from the various sampling locations.

Result and Discussion

The total suspended particulate matter distribution within Isoko land shows that the highest TSP levels were recorded in the semi-urban traffic-clogged areas of Ozoro (306 µg/m^3), Oleh (192 µg/m^3), and Uzere (193 µg/m^3), while the lowest values were recorded in Ellu (114 µg/m^3) and Okpaile (112 µg/m^3) the most rural among the various sampling sites (Figure 3). The annual baseline concentration ranges of the TSP were 16 to 1035 µg/m^3.

There was uniformity in the distribution of airborne particles TSP at the created sampling sites (ANOVA, P=0.7206, F=0.7676, df 16). The statistical insignificance in the spatial distributions of the particles was further confirmed by Kruskal-Wallis Test (H=8.14, P=0.95). Temporal variation in the measured data were calculated to be statistically significant (ANOVA, P=2.182E-37, F=31.58, df 11; Kruskal-Wallis Test (H=171.2, P=6.709E-31), with higher TSP values reported in the dry season months (December 2011 to April 2012). For some of the sampling sites, the measured particles were within the federal ministry of Environment (FMNEV) and World Health Organization (WHO) statutory limits of 250 µg/m^3 and 150 to 230 µg/m^3, respectively (WHO, 2005). At some of the sites the above limits were clearly violated, suggestive of health and environmental concerns. Cluster analysis separated the data into two groups (Ukpebor et al., 2010). Analysis of similarity (ANOSIM) confirmed that the groups are separated (R=0.7198, P=0.0002). It also separated the dry season (Dec to April, 2012) from the rainy season (May to Nov). ANOSIM (R=0.8673, P=0.0014) which shows that the groups are clearly separated (Figures 4, 5 and 6).

The TSP values obtained in this research compared well with other similar research work that have been carried out in some parts of Nigeria (Ukpebor et al., 2004; Efe, 2006; Ediagbonya et al., 2012, 2013) though lower than most of those values, reason being that Isoko land is more of a rural area but the values obtained were higher than those obtained from similar research work done in some advanced countries such as England, Australia, and Mexico (Sato et al., 1995; Butler and Crossley 1979; Verrall et al., 1986; Goodman, 1977; Zhao and Zhao, 2012; Putaud et al., 2010); reason being that there are more stringent laws governing oil and gas activities as well as air pollution, also the good condition of infrastructure in those countries (Table 2).

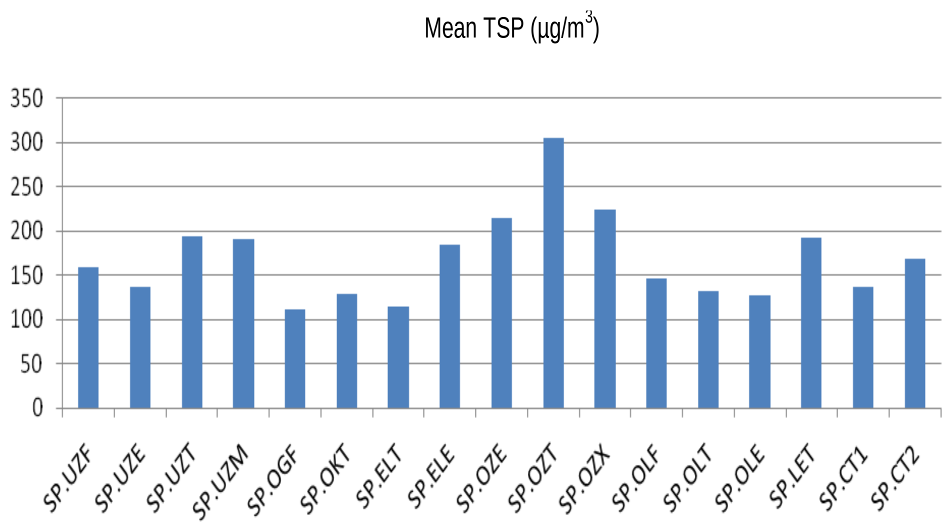

Figure 3. Mean distribution of total suspended particulate matter in Isoko land.

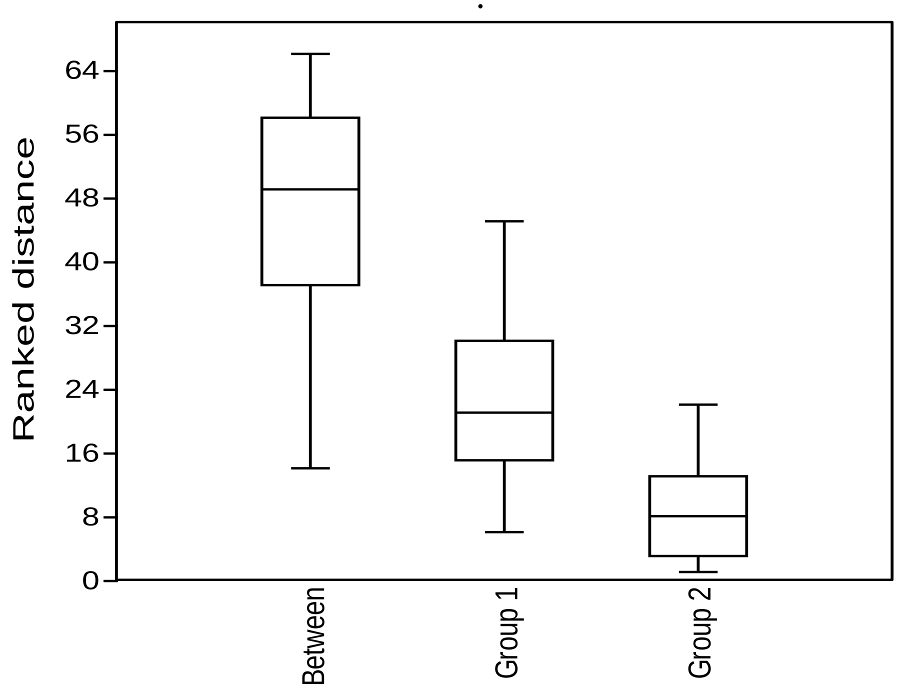

Figure 4. Spatial anosim box plot of total suspended particulate matter in Isoko land

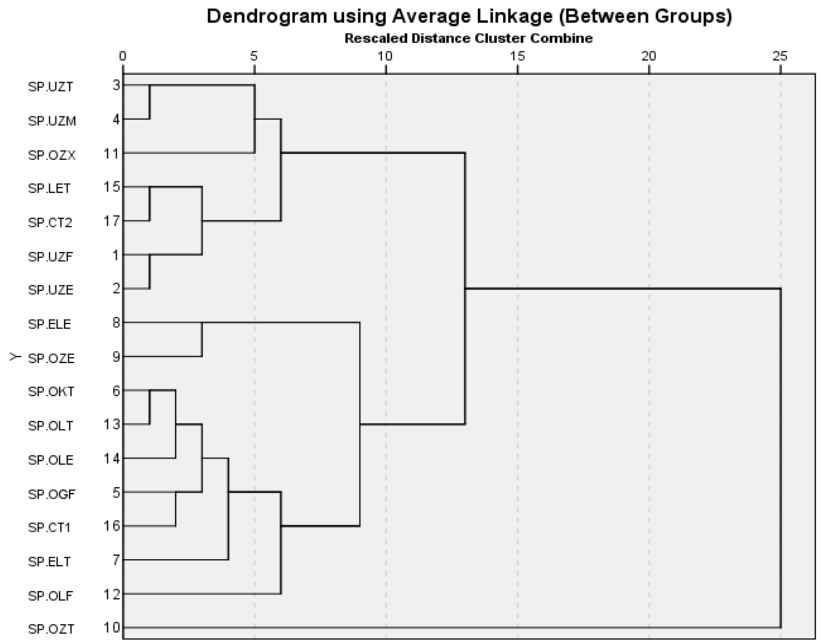

Figure 5. Dendrogram of total suspended particulate matter in Isoko land.

Table 1. Sampling sites, description and their coordinates.

S/N	Sampling site	Site code	Co-ordinates
1	Close to Uzere flow station flare tip	SP.UZF	5° 24’ 25N, 6° 10’ 22E
2	Mango tree along Uzere town entrance from Oleh axis	SP.UZE	5° 24’ 9”N, 6° 10’ 29”E
3	Close to residential houses opposite Uzere Police station	SP.UZT	5° 35’ 25”N, 6° 10’ 55”E
4	Front residential house opposite Uzere Daily Market	SP.UZM	5° 35’ 15”N, 6° 9’ 5”E
5	Close to Ogini flow station flare tip	SP.OGF	5° 35’ 25”N, 6° 16’ 55”E
6	Front residential house in Okpaile Main Town	SP.OKT	5° 35’ 24”N, 6° 16’ 55”E
7	This site was created in front of the Catholic church in Ellu just beside the market	SP.ELT	5° 34’ 18”N, 6°16’ 40”E
8	Front of the Apostolic church, along Ellu/Okpaile road	SP.ELE	5° 34’ 43”N, 6° 16’ 15”E
9	Front of a residential house Ozoro Entrance Agbaza road Junction	SP.OZE	5° 32’ 57”N, 6°13’ 38”E
10	Front of an office building Ala Square by Urude quarters	SP.OZT	5° 30’ 28”N, 6° 12’ 40”E
11	Ozoro Exit (NDC by Express Junction)	SP.OZX	5° 29’ 50”N, 6° 11’ 30”E
12	Close to Olomoro flow station flare tip	SP.OLF	5° 25’ 42”N, 6° 9’ 18”E
13	Olomoro Main Town	SP.OLT	5° 25’ 8”N, 6° 8’ 48”E
14	Olomoro town entrance (Express road Junction)	SP.OLE	5° 24’ 56”N, 6° 8’ 36”E
15	Front of a residential house at Oleh Town close to Nyaga Market	SP.LET	5° 27’ 8”N, 6°12’ 12”E
16	Bush along Ozoro/Idheze road at Ozoro axis	SP.CT1	5° 29’ 14”N, 6° 13’ 58”E
17	Bush along Ozoro/Oleh road at Oleh axis	SP.CT2	5° 26’ 28”N, 6° 12’ 40”E

Table 2. Comparison of total suspended particulate matter results of this study with others.

S/N	Site /location	Range/Mean	References
1	Rural/ Isokoland	**111.67 - 306.08**	**Current study**
2	Urban/Benin City	833.33 - 1.666.56	Ediagbonya et al. (2013)
3	Urban/Benin	555.52 - 675	Ukpebor et al. (2004)
4	Urban/Warri	922 - 2,333	Ukuo and Ndiokwere (2005)
5	Rural/Ewu	816 - 2,600	Ukuo and Ndiokwere (2005)
6	Nairobi/Kenya	69,893 - 254,369	Karue et al. (1992)
7	Urban/Jos	385 - 911	Sinaneit et al. (1988)
8	Urban/Lagos	520 - 800	Baumbach et al. (1995)
9	Urban/Ogbomosho	83 - 1,929	Sonibare et al. (2005)
10	Urban/Lagos	1,033 - 5,700	Akeredolu et al. (1994)
11	Urban/Lagos	100 - 200	Ogunsola et al. (1993)
12	Urban/Ife	120 - 720	Ogunsola et al. (1993)
13	Urban/Mexico	66.6 - 272	Sato et al. (1995)
14	Urban/Baghdad,	514	Kanbour et al. (1990)
15	Urban/Hobart	26.8	Goodman (1977)
16	Urban/Sydney	56	Goodman (1977)
17	Urban/Brisbane	42	Verrall et al. (1986)
18	Sub-Urban/Birmingham	47.5	Butler and Crossley (1979)

References

Adeniye EO, Olu-Sule R, Anyaye A (1983). Environmental and Socioeconomic impacts of oil spillage in the Petroleum producing of Riverine Area in Nigeria: The Petroleum Industry and the Nigerian Environment. Proceedings of 1983 International Oil Seminar, NNPC, 3:130-35.

Akeredolu F.A., Olaniyi H. B., Adejumo JA, Obioh IB, Ogunsola OJ, Ajubiojo OA, Aluwola AF (1994). Determination of elemental composition of TSP from cement industries in Nigeria using EDXRF Techniques Nuclear Instrument and method in Physics Research Ch. A 333, 542-5 45 apportionment of air particulate matter in two constrastive industrial Area in Nigeria. J. Appl. Sci. 5(10):1797-1801.

Bailey W, Crabree M, Tyrie J, Elphick J, Kuchuk F, Romano C, Roodhart C (2000) Water Control; Oil field review: Shell International Exploration and Production Newsletter. 70:17-19.

Baltrėnas P, Kvasauskas M (2005). Experimental investigation of particulate concentration using mass and optical methods. J. Environ. Eng. Landsc. Manag. 8(2):57-64.

Baltrėnas P., Morkuniene J. (2006). Investigation of particulate matter concentration in the air of Zverynas district in Vilnius, J. Environ. Eng. Landsc. Manage. 14(1):2330.

Baumbach G., Vogt U., Hein K.R.G., Oluwole A.F. (1995). Air pollution in a large tropical city with high traffic density. Results of measurement in Lagos, Niger. Sci. Total Environ. 169:25-31.

Butler J.D., Crossley P. (1979). An appraisal of relative airborne sub-urban concentrations of polycyclic aromatic hydrocarbons monitored indoors and outdoors. Sci. Total Environ. 11:53-58.

Ediagbonya T.F., Tobin A.E., Ukpebor E.E. (2013). The level of suspended particulate matter in wood industry (sawmills) in Benin City, Nigeria. J. Environ. Chem. Ecotoxicol. 5(1):1-6.

Ediagbonya T, Ukpebor E.E., Okieimen F.E., Okungbowa GE (2012). Comparative study of TSP, Inhalable Particles and Respirable Particles in Urban and Rural Areas in Niger Delta Region of Nigeria. Greener J. Phys. Sci. 2(3):089-096.

Efe S.I. (2006). Particulate pollution and its Health Implications in Warri Metropolis, Delta State, Niger. Env. Anal. 11:1339-1351.

Efe S.I. (2008). Spatial distribution of particulate air pollution in Nigerian cities: implication for human health. J. Environ. Health Res. 7:2.

Federal Ministry of Environment (2000). Guidelines and standards for Environmental pollution control in Nigeria. P.67

Goodman H.S. (1977). Particulate concentration in air in eastern Australia and Papua New Guinea. Clean Air, August 1977.pp. 40-43

Horak Jr F., Studnicka M., Gartner C., Spengler J.D., Tauber E., Urbanek R., Veiter A., Frischer T. (2002). Particulate matter and lung function growth in children: A 3-yr follow-up study in Austrian schoolchildren. Eur. Respir. J. 19:838-845

Hörmann S., Pfeiler B., Stadlober E. (2005). Analysis and prediction of particulate matter PM10 for the winter season in Graz. Austrian J. Stat. 34(4):307-326.

Kanbour F.I., Altai F.A., Yassin S., Harrison R.M., Kitto A.M.N. (1990). A comparison of smoke shade and gravimetric determination of suspended particulate matter in a semi-arid climate (Baghdad, Iraq). Atmos. Environ. 24A(5):1297-1301.

Karue J., Kinyua A.M., El- Busaidy A.H. (1992). Measured components in total suspended particulate matter in Kenyan urban area. 266:505-511.

Kazlauskienė A., Pottala J., Petronis V. (2008). Research of dustiness on gravelled roads in Lithuania, in The 7th International Conference “Environmental engineering”: Selected papers, Vol. 1. Ed. by D. Čygas, K. D. Froehner, May 22-23, 2008 Vilnius, Lithuania. Vilnius: Technika, pp. 169-174.

Microsoft Encarta Encyclopedia (2001). Air Pollution. Microsoft Corporation. National Population Commission (NPC) (2006). *Population Census of the Federal Republic of Nigeria* (Abuja, Nigeria: NPC).

Ogunsola O.J., Oluwole A.F., Obioh J.B., Asubiojo O.I., Akeredolu F.A., Akanle O.A., Spyrou N.M. (1993). Analysis of suspended air particulate along some motorways in Nigeria by PIXE and EDXRE. Nucl. Inst. Methods Phys. Res. B79:404-407.

Okuo J.M., Ndiokwere C.I. (2005). Elemental characterization and source apportionment of air particulate matter in two contrastive industrial areas in Nigeria. J. Appl. Sci. 5(10):1797-1802.

Oluyemi E.A., Asubiojo O.I. (2001). Ambient air particulate matter in Lagos, Nigeria: A study using Receptor Modeling with X-ray Fluorescence analysis. Bull. Chem. Soc. Ethiop. pp.97-108

Di Napoli M.D., Rivaroli L.R., Talone A., Cannistrà E., Giani A., Giovagnoli M., Nugari, Ruschioni E. (2011). Conservation and environmental conditions in a temporary storage area of Palazzo Soliano in Orvieto, Firenze Art 2011, pp. 88-96

Putaud J.P., Van D.R., Alastuey A., Bauer H., Birmili W., Cyrys J., Raes F. (2010). A European aerosol phenomenology–3: Physical and chemical characteristics of particulate matter from 60 rural, urban, and kerbside sites across Europe. Atmos. Environ. 44(10):1308-1320.

Sato M., Valent G., Coimbrao C.A., Coelho M.C.L.S., Sanihez P, Alonso C.D., Martins M.T. (1995). Mutagencity of air borne particulate organic material from urban and industrial areas of Sao Paulo, Brazil. Mutat. Res. 335:317-330.

Schwela D (2000). "Air pollution and health in urban areas". Rev. Environ. Health 15(1-2):13-42.

Sufian M.E. (2011). Airborne particulate matter (PM10) composition and its genotoxicity at two pilgrimage sites in Makkah, Saudi Arabia. J. Environ. Chem. Ecotoxicol. 3(4):93-102.

Sonibare J.A., Ken dohi F.A., Sibanjo A.O., Latinwo I. (2005). ED-XRF Analysis of Total Suspended Particulates from Enamelware Manufacturing Industry. Am. J. Appl. Sci. 2(2):573-578.

Thatcher T.H., McHugh N.A., Egan R.W., Chapman R.W., Hey J.A., Turner C.K., Redonnet M.R., Seweryniak K.E., Sime P.J., Phipps R.P. (2005). Role of CXCR2 in cigarette smoke–induced lung inflammation. Am. J. Physiol. Lung Cell Mol. Physiol. 289:L322-L328.

Ukpebor E.E., Ukpebor J.E., Efebomo G. (2004). Assessment of the effect of medical waste incinerator on the ambient dose of TSP and NO2. Intl. J. Chem. 14(2):111-117.

Ukpebor E.E., Ukpebor J.E., Ukpebor F.E, Odiase J.I., Okoro D. (2010). Spatial and diurnal variations of Carbon Monoxide (CO) pollution from motor vehicles in an Urban centre. Polish J. Environ. Stud. 19 (4):817-823.

Verrall K.A., Muller W.A., Kingston P.A., Rose H.C., Raftery N.A. (1986). Identification of Sources Contributing to Total Suspended Particulates in Brisbane. Proceedings of Clean Air Conference. Clean Air Society of Australia and New Zealand, Sydney. pp. 290-291.

World Health Organization (WHO) (2005). Updated Air Quality Guidelines; Microsoft Corporation. Available online at: http://whqlibdoc.who.int/hq/2006/WHO_SDE_PHE_OEH_06.02_eng.pdf

Zakey A.S., Abdel-Wahab M.M., Pettersson J.C., Gatari M.J., Hallquist M. (2008). Seasonal and spatial variation of atmospheric particulate matter in a developing megacity, the Greater Cairo, Egypt. Atmos. 21(2):171-189

Zhao Y., Zhao C. (2012). "Concentration and Distribution Analysis of Heavy Metals in Total Suspended Particulates along Shanghai-Nanjing Expressway." *Procedia* Environ. Sci, 13:1405-1411.

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