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Full Length Research Paper

The level of suspended particulate matter in wood industry (sawmills) in Benin City, Nigeria

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There are two sampling approaches for noting the presence of air pollutants, Source sampling and Atmospheric sampling. The source sampling obtains the pollutant count of a particulate source, whereas atmospheric sampling deals with the pollutants within the total air mass surrounding the earth. The purpose of source sampling is to determine the quantity and type of pollutants emitted from a specific source to determine compliance or non compliance with an emission standard. Sawdust particulate matter captured from nine different locations of Benin metropolis, Nigeria, using a portable, programmable SKC Air Check XR5000 high volume Gravimetric Sampler Model 210-5000 serial No. 20537. A flow rate of 21/ min and a sampling duration of eight hours maintained during this study which was conducted between the months of November 2009 to January, 2010. The total suspended particulate (TSP) were in the range of 833.33 - 1,666.56 obtained indicate that the available national Standard, 250 µg/m^3 were clearly exceeded. The spatial variation in data generated was significant and remarkable ($p < 0.05$).

Key words: Total suspended particulate, sawmill, Benin City, gravimetric sampler, toxicity potential.

INTRODUCTION

The systematic study of naturally occurring associations between health effects and pollution has been called the epidemiology of air pollution (WHO, 1987). Natural variability in responsiveness to air pollution is observed in all populations. Generally speaking, susceptibility is great among premature infants, the newborn, the elderly and the infirm. Those with chronic diseases of the lungs or heart are thought to be at particular risk. The effects of air pollution on personal or Community health are; acute sickness or death, insidious or chronic disease, shortening of life or impairment of growth.

Alteration of important physiological functions such as ventilation of the lung transport or oxygen by hemoglobin, dark adaptation (the ability to adjust eye mechanisms for vision in partial darkness) or other functions of the nervous system, untoward systems such as sensory irritation, which is the absence of an obvious cause such as air pollution and discomfort, odour, impairment of visibility, disfigurement of non-living materials (Samara et al., 1990; Kryzanouki and Schuila, 1999; Gorin et al., 2006; WHO, 2002; Glantz, 2002; Middleton et al., 1950; Koritz and Went, 1953; Taylor and Eaton, 1966). Particulate matter can damage vegetation both directly and indirectly. When exposed to particulate dust plants may suffer increased disease leak cells and may be damaged, yield and growth rates may be reduced and plant may even die (Hall et al., 1957; Cameron, 1874; Hasel-hoff et al., 1903). Particulate matter on the leaves or crops, trees and shrubs inhibits photosynthesis and plant growth. Particles carrying heavy metals can contaminate soil and vegetation in urban areas, along high ways and near smelters. Once in the soil heavy metals can accumulate to phytotoxic levels in vegetation and suppress growth. In addition, particulate matter can scatter sunlight and cause a reduction in solar radiation,

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thereby affecting crop productivity. One of the most visible effects of particulate matter is the soiling or staining of building and textiles. Particulate can also cause chemical deterioration of paint, resulting in corrosion of metal objects (Bell and Treshow, 2002; Hack et al., 1986; Ficus et al., 2005; Hogsett et al., 1997; US EPA, 1996; Heagle, 1989; Bussotti and Femorth, 1998; Pelikomen et al., 1992; Seinfield, 1986). Particulate air pollution is a mixture of solid, liquid or solid and liquid particle suspended in the air (Dockery and Pope, 1997). Recent studies have tried to quantify the health effects caused by ambient air pollution (WHO, 2002; Ezzati, 2002). It has been estimated that worldwide closer to 6.4 million of healthy life are lost due to long term exposure to ambient particulate matter (Ezzati, 2002). Studies focusing on morbidity endpoints of long term exposure have been published (Moolgavkar et al., 1995; Li and Roth, 1995; Glantz, 2002; WHO Regional Publications, European series No.23). Mortality and morbidity time series studies have shown much more clearly than before, that cardiovascular deaths and morbidity indicators are related to ambient particulate matter (Pope et al., 1996; Dockery and Brunekreef, 1996; Edet, 2003). Under very clear atmospheric conditions, the TSP level can be as low as 0 - 10 µg/m^3. In a very dirty environment TSP concentration can be as high as 1.500 µg/m^3. The aim of this study is to determine the spatial distribution of particulate matter and its toxicity potential. However, in the last decades and particularly in the current years, the significance of air pollution to health has been recognized as a major public health challenge. Oviawe and Oviawe (1993), have documented in their study that Acute Respiratory Infections (ARTS) Contribute significantly to the burden of illness in Benin City.

MATERIALS AND METHODS

Area of study

The study areas are Egor, IKpoba-Okha and Oredo Local Government Areas that make up the metropolitan city of Benin, the capital of Edo State. It is situated in the tropical rain forest belt and at 122 m above sea level. The inhabitants are mainly Benin-speaking people. The people are combination of Christians, Moslems and traditional African worshippers. The total size of forest reserves in Benin City is about 357.42 km^2; however the Local Governments have free forest zones implying that individuals do not have to collect permits from government to feel trees in these forests. There are about 32 registered sawmills in the Local Government Area, all privately owned, and belonging to a trade organizations "Sawmillers Association" and under a central government regulatory body-the Edo State Forest Resources Management Association. A typical sawmill is a large shed with a proof made of old corrugated zinc and bare floor covered with several layers of sawdust, and supported by 6 - 8 wooden poles. The open shed houses a giant electrically driven band saw, and a circular saw mounted on a fabricated metal table. An office and a storage yard for products (sawn wood) may be built by adjoining the mill. Fresh logs are usually seen lying in the open yard. Sawdust piles surround the machines and may also be kept in a waste dump on the premises, awaiting disposal, usually by burning. There are on the average 10 - 14 staff at each mill, and categories of staff includes a manager, band mill operator with 2 helpers, 2 jack men who use locally constructed jacks to move the fresh logs to the milling machine, an Edger (head rig operator) and 2 helps, 1 - 2 packers, a "saw doctor" and 1 - 2 loaders.

Sampler and analytical procedure

SKC air check XR 5000 high volume gravimetric sampler model 210 - 5000 serial No. 20537

This sampling unit consists of a gas pump with an in built flow rate meter and a filter holder manifold connected to the sampling pump by a Teflon tube. Airborne particulate matter was collected on a Whatman glass fiber filter. The inbuilt gas flow meter has a rating of 1000 to 5000 ml/min of air samples. Before sampling, all unloaded glass fiber filters were dried in desiccators at room temperature and their initial weights were taken. The particulates were collected on the pre-weighed filter by pumping 2000 ml/min (2 L/ min) volume of air through it for eight hours, after sampling, the loaded filters were again desiccated and re-weighed to determine the final weight. The concentration of the total suspended particulates in the air was determined from the difference in weight of the filter paper after and before sampling the duration of the sampling and the flow rate (UNEP/WHO, 1994). The sampler was placed at heights of 1.5 m above ground level to reflect the breathing zone of human.

$$TSP\ (\mu g/m^3) = \frac{Final\ weight(mg) - Initial\ weight\ (mg)}{Flow\ rate\ (m3\ min\ X\ sampling\ period\ (min)} \ X\ 1000$$

RESULTS AND DISCUSSION

The quality and quantity of air pollution could be estimated with regards to different sources of pollution such as transportation, industries, power generation, space heating and refuse burning. The purpose of air monitoring is to develop air quality criteria. Table 1 shows the various sampling sites and descriptions in Benin City. Table 2 shows the various mean concentration of the total suspended particulate matter in the rural locations from wood industry of sawmill. The spatial variation was significant and noticeable ($p < 0.05$). The highest mean concentration was recorded in Site 8 while the lowest mean was recorded in Site 7. When the concentration of a particulate matter is greater than 1,500 µg/m^3 it shows that the place is very polluted. The total suspended particulate matter obtained exceeded the WHO and the Nigeria Ambient Air Quality Standard (150 - 230 for WHO) and 250 (For Nigeria standard in TSP). The values obtained in this study are comparable to some others obtained in other parts of the world. Table 6 shows the comparison of the present study with other studies in Nigeria and other part of the world. Table 2 shows the maximum and minimum valves of the various locations, the standard as well as the total mean. While Table 3 shows the ANOVA of the comparison between the various sites. The comparison between groups was significant and remarkable.

Table 1. Shows the various sites and descriptions.

S/N	Site	Site description
1.	Ogida Sawmill	The site was created at Egor Local Government Area in one of the Sawmills which is 1.5 km North East from the centre of the city.
2.	Egor Sawmill	The site was created at Egor Local Government Area in one of the Sawmills which is 4 km from the centre of the city.
3.	Ekehuan Sawmill	The site was created at Oredo Local Government Area in one of the Sawmills which is 1.5 km North EAST from the centre of the city.
4.	Oluku Sawmill	The site was created at Egor Local Government Area in one of the Sawmills which is 5 km North East from the centre of the city.
5.	Upper Sokpoba Sawmill	The site was created at Ikpoba-Okha Local Government Area in one of the Sawmills which is 2 km South West from the centre of the city.
6.	Dumez Sawmill	The site was created at Ikpoba-Okha Local Government Area in one of the Sawmills which is 1 km South West from the centre of the city.
7.	Uwasota Sawmill	The site was created in Egor Local Government Area in one of the Sawmills which is 4 km North East from the centre of the city.
8.	Eyan Sawmill	The site was created in Ikpoba-Okha Local Government Area in one of the Sawmills which is 4 km South West from the centre of the city.
9.	Federal Sawmill	The site was created in Oredo Local Government Area in one of the Sawmills which is 2 km North East from the centre of the city.

Table 2. Shows the standard deviation and the mean concentration of the total suspended particulate matter.

VAR00028	Mean	N	Std. deviation	Maximum	Minimum
Ogida	1458.3333	3	416.66500	1875.00	1041.67
Egor	1666.5567	3	416.50001	2083.00	1250.00
Ekenwan	1423.6133	3	216.84154	1666.67	1250.00
Oluku	833.3333	3	275.60224	1041.67	520.83
Upper Sakponba	868.0533	3	159.12230	1041.67	729.16
Dumez	1076.3900	3	159.11685	1250.00	937.50
Uwasota	729.1733	3	104.16500	833.33	625.00
Eyan	1875.0000	3	454.04930	2395.83	1562.50
Federal	1562.5000	3	275.59846	1770.83	1250.00
Total	1276.9948	27	467.24934	2395.83	520.83

Toxicity potential (TP)

Because of the exposure to particulate matter everyday, the probability of human health effects exists. Thus, toxicity potentials are calculated viz:

$$TP = \frac{\text{The mass concentration of the total suspended mater}}{\text{The statutory limit sets for ambient particulate matter concentration (250 } \mu g/m^2)}$$

By definition, TP exceeding unity gives cause for concern Table 5 shows the toxicity potentials of the various locations. However, in all the locations the toxicity potentials were greater than one and the toxicity potentials fall within the purview of 2 - 8 while the highest toxicity potential was recorded in sight 8. The toxicity potentials of this study compare with previous study

Table 3. The ANOVA of the comparison between groups in sites.

	Sum of squares	df	Mean square	F	Sig.
Between groups	4049045.429	8	506130.679	5.598	0.001
Within groups	1627325.075	18	90406.949		
Total	5676370.504	26			

Table 4. The Duncan homogeneous subsets.

VAR00028	N	Subset for alpha = 0.05		
		1	2	3
Uwasota	3	729.1733		
Oluku	3	833.3333		
Upper Sakponba	3	868.0533		
Dumez	3	1076.3900	1076.3900	
Ekenwan	3		1423.6133	1423.6133
Ogida	3		1458.3333	1458.3333
Federal	3		1562.5000	1562.5000
Egor	3			1666.5567
Eyan	3			1875.0000
Sig.		0.210	0.084	0.114

Means for groups in homogeneous subsets are displayed. a) Uses Harmonic mean sample size = 3.000.

Table 5. Toxicity potential of TSP concentrations in sawmill.

S/N	Sites	Toxicity potential
1	Ogida Sawmill	5.83
2	Egor Sawmill	6.66
3	Ekenwan Sawmill	5.69
4	Oluku Sawmill	3.33
5	Upper Sakponba Sawmill	3.47
6	Dumez Sawmill	4.31
7	Uwasota Sawmill	2.92
8	Eyan Sawmill	7.50
9	Federal Sawmill	6.25

(Sonibare et al., 2005). The percentage (100%) of the total variance in the analyzed data was explained by the extracted principal component vary from 63.28 to 36.71%. The Duncan multiple range test (DMRT) shown above is Table 4, showing the group of Locations that gave about the significant difference ($p < 0.05$) in the ANOVA result. From it, it is seen that the first group is Sites Uwasota, Oluku, Upper Sakponba, and Dumez, the second group is sites dumez, Ekenwan, Ogida, and federal sawmills; finally Ekenwan, Ogida, Federal Egor and Eyan showed no significant difference ($p < 0.05$). The difference in the mean TSP concentration was found in any of these groups compared with other groups. That is, Uwasota on comparing the Mean TSP with Dumez, Ekenwan, Ogida, Federal, Egor and Eyan sawmills gave a significant change in the mean. For Oluku, comparing its mean TSP with that of Dumez, Ekenwan, Ogida, Federal, Egor and Eyan sawmills gave a significant change in the mean. For Upper Sakponba on comparing its mean TSP with that of Dumez, Ekenwan, Ogida, Federal, Egor and Eyan sawmills gave a significant change in the mean and so on.

Conclusion

The measurement of Total Suspended Particulate was done by using SKC Programmable Air Sampler and glass

Table 6. Comparison of total suspended particulate matter results of this study with others.

Site/location	Range/mean ($\mu gm/^3$)	Sources
Urban/Benin City	833.33 - 1.666.56	Present study
Urban/Benin	555.52 - 675	Ukpebor et al. (2006)
Urban/Lagos	903 - 1413	Obioh et al. (2005)
Urban/Warri	922 - 2.333	Okuo and Ndiokwere (2005)
Rural/Ewu	816 - 2.600	Okuo and Ndiokwere (2005)
Urban/Kenya	9.893 - 24,369	Karue et al. (1992)
Urban/Jos	56.385 - 911	Sinonelt et al. (1988)
Urban/Lagos	520 - 800	Baumbach et al. (1995)
Urban/ Ogbomoso	83 - 1,929	Sonibare et al. (2005)
Urban/Lagos	1,033 - 5.700	Akeredolu et al. (1994)
Urban/Lagos	100 - 200	Ogunsola et al. (1993)
Urban/Ife	120 - 720	
Urban/Mexico	66.6 - 272	Sato et al. (1995)

fibre). The spatial variation was significant and remarkable. The Federal Ministry of Environment (FMENV), Nigeria Environment Regulatory Body sets limits of 250 $\mu g/m^3$ for ambient TSP were exceeded in all the various locations.

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