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Concentrations and source apportionment of total suspended particulate matter in Calabar Air Basin

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Abstract

Increased wave of industrial, commercial and domestic activities in the coastal town of Calabar may probably lead to high TSP concentration in atmospheric environment. The determination of TSP concentration in Calabar Air Basin was carried out on sampling sites covering vehicular source (VS), industrial source (IS), low density residential area (LDRA), high density residential area (HDRA) as well as rural source (RS) to determine levels of concentration for the purpose of source apportionment. TSP was systematically collected directly by the use of a gravimetric high volume air sampler with whatman cellulose filter for a period of two (2) years. The results obtained showed that RS had the lowest TSP concentration of 108.98 µg/m^3, while VS had the highest mean concentration of 269.93 µg/m^3. There were significant differences at 0.001 confident level between concentrations from RS and LDRA; RS and HDRA; RS and VS. Though TSP concentration in Calabar exceeded the World Health Organization (WHO) standard of 40 µg/m, It was lower than those obtained in some Nigerian cities of Lagos (80 - 320 µg/m^3 [rain season] and 520 - 800 µg/m^3 [dry season), Jos (385 - 911 µg/m^3), and in other third world countries of Nairobi (204 - 369 µg/m^3) and Shangai (569 µg/m^3)(Simoneit et al, 1988; Baumbach et al,1995).

Keywords: Suspended Particulate; Calabar Air Basin, Concentrations; Source apportionment

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1. Introduction

Following the creation of 36 states in Nigeria, additional development centres were created in the country and many towns/cities are fast growing in population, as well as industrial, commercial and domestic activities. These activities being incessant due to exploratory/structural development led to additional stress on the environment in the form of total suspended particulate matter, acid precipitation and trace elements. This is evident mostly in the South-South Geopolitical Zone occupying the Niger delta region of the country where environmental groups and state governments demand a higher priority to environmental problems. Perhaps, this is occasioned by the occurrence of some diseases among human, animals and plants population as well as the destruction of total environment U.S.EPA).

The commissioning of an Export Processing Zone (EPZ), the opening of Nigerian Port Authority (NPA) dockyard to receive imported vehicles and other cargo as well as construction of TINAPA have triggered a wave of industrial activities in the coastal town of Calabar. An increased vehicular emission in addition to emissions from industries located within the EPZ premises as well as activities of Calabar cement factory (now UNICEM), Niger mills and Calabar SEROM wood factory is expected. This will probably lead to high TSP concentration in atmospheric environment. Calabar being in the Niger Delta is faced with a wide range of environmental problems including agricultural land degradation, renewable resources degradation, water contamination, solid waste and air pollution (Odemerho, 1983; Adegbulugbe,1995; Grevy,1995; Moffat and Linden,1995 and World Bank,1995).

Particulate matter, heavy metals and gases emitted as a result of these activities are associated with various human health problems (respiratory, reproductive, carcinogenic, neurological) and adverse impacts on the environment (soiling of buildings and material degradation, acidification, clogging of leaf stomata, reduction of visibility). Evidence linking air pollution to human health is conclusive. TSP is a direct contributor to fast aging, asthma, berrylliosis, emphysema and contributing cause to bronchitis, cancer of the gastro-intestinal tract and that of respiratory tract (Akeredolu1989; Ikamaise et al., 2001).

These effects have enormous economic and social consequences ranging from added cost of medical care and building restoration to reduced agricultural output, widespread forest damage, and a generally lower quality of life. There is therefore the need to assess the concentration of TSP. Air quality assessment was carried out in the Calabar Air Basin to quantify the concentration of TSP. Airborne particulate matter is clearly defined and it includes dust, fog, fumes, haze, mists, particles, smog, smoke and soot[9]. The study was limited to collection of total suspended particulate matter from specific locations within the Calabar metropolis and Ikot Okon village outside the Calabar metropolis to serve as a background. Result of this study is presented as a baseline data for TSP concentration for Calabar Air-basin.

2. Materials and methods

2.1. Sampling

TSP was systematically collected directly by the use of a gravimetric high volume air sampler with whatman cellulose filter quarterly for a period of two (2) years. The sampling was carried out at strategic sampling sites within Calabar and its environs. The location of sampler at each sampling site was done with regards to the considerations that samples represent ambient concentration by avoiding air pollution plumes and ensuring that there is free circulation of air as well as security against vandalism. The sampling sites were selected as illustrated in Table 1. Selected sampling sites covered various emission types viz; transportation, industrial, residential (low and high density) and rural. The roundabout selected for transportation is a standard one. It is surrounded by paved roads. It is located by the largest market in Calabar metropolis (Wart market). The premises of the Calabar Free Trade Export Processing Zone were chosen to represent the industrial source. The sampler was located in one of lounges. University of Calabar residential quarters was selected for low-density residential area and the sampler was located in a large field within the quarters away from the houses. For the high-density residential area of Mbukpa, the sampling unit was located in an open field within the premises of a large church compound situated in the heart of this highly populated area. The rural sampling site was located at Ikot Okon, about 30 Km from the town. Here, the sampler was positioned in a field within the premises of a Catholic Church parish house. Ikot Okon is almost surrounded by a rubber plantation (Figure 1). This is a location outside the town to represent the background where none of the stated emission source types will not be apparent in the result (UNEP/WHO,1994a; Chow et al.,1996a).

2.2. Filter conditioning/weighing and sampling technique

Sartorius M5P – 000V001 Electronic Microbalance was used for weighing of fresh and loaded filters. Each filter was weighed Three times obtain a constant and accurate weight before recording. TSP samples were collected from the ambient air by filtration on whatman cellulose filter paper using a portable Nigretti (environmental System) Air Sampler 1000. The sampler was placed on a wooden stool of one metre high. From the stool top to the filter holder was 65 cm and this brought the sampling height to 1.65 metres (figure2). The filter holder was connected to the main unit so that the inlet turns face down to avoid passive particulate loading and also to prevent direct water droplets on the filter on rainy days. The sampler was closely monitored throughout the duration of sampling to ensure accurate sampling collection timing, prevent vandalism and battery failure. Batteries were interchanged after a maximum continuous running period of three hours to avoid reduction in the flow rate which was maintained at 12L/min flow rate. Total sampling time for loading each filter was between six and eight hours depending on battery performance. Sampling was carried out during working hours (8.00am to 6.00pm). The loaded filters after sampling were stored in sealed polythene bags and taken to laboratory where reconditioning and weighing was carried out (UNEP/WHO, 1994a; Adejumo et al., 1994; Chow et al.,1996a; Chan et al., 1997 and Ikamaise et al., 2001).

The TSP was computed using the formula:

$$TSP = \frac{Wp}{Vair}$$

where Wp = *Weight of particulate*

Vair = Volume of air sampled. (Flow rate x sampling time) (Ikamaise et al, 2001).

3. Results and discussions

The TSP concentrations across source types (Table2 & Figure 3) showed that rural site had the lowest annual mean concentration of 108.98μg/m^3, while vehicular source (VS) site recorded the highest mean concentration of 269.93μg/m^3. In Table 2 the concentration of TSP from all source types investigated were significantly more than the concentration obtained from the rural area. Figure 4 compares the concentrations from various sites in Calabar air basin with international and national standards. Concentrations from all sites exceeded the World Health Organization (WHO), while all but one site were within the national air quality standard (Federal ministry of Environment).

The results of particulate matter concentration presented in Table 2, Figures 3 and 4 showed significantly higher particulate concentration in Calabar air basin. These implicate man-made activities, including industrial, commercial, domestic which have added the excess on the background natural contributions. The recorded significant differences in Table 3 between the rural source contribution and urban sources are expected and similar to previous studies on particulate concentrations in Nigeria (Akeredolu, 1989; Ikamaise et al., 2001; Essiett et al., 2007).

Expectedly, the mean concentration of TSP was higher (176.14 μg/m^3) from high-density residential area source contribution (HDRA) compared to the low-density residential area (LDRA) of 138.09. This can be explained by the level of small-scale industrial, commercial as well as domestic activities capable of generating TSP in these areas. (Table 1)

Vehicular emission source (VS) was observed to contribute the highest concentration of TSP. Vehicular emission source has been reported on previous studies as one of the largest sources of TSP in the ambient air (Lowenthal et al., 1994; Baumbach et al., 1995; Essiett et al., 2007 and Oluwande, 1979).

The low concentration of TSP at the industrial zone (IZ) is due to the fact that most of the industries were not yet operational and the few that commenced production at the time of sampling were not run at full capacity. The Export Processing Zone is located near the seashore, which is associated with low airborne particulate matter concentration level[13] (Table 2 & Figure 3).

The result showed that only at VS that the particulate concentration exceeded the ambient air standard of 250μg/m^3, for Nigeria (figure 4). This is probably due to the high level of vehicular emissions especially diesel trucks, which are known to emit high quantity of particulate matter (Lowenthal et al, 1994).

The concentration of particulate at all sampling sites exceeded the World Health Organization (WHO) air quality standard of 40μg/m^3 with factors ranging from 2.72 at the rural to 6.75 at the vehicular source. The TSP concentrations from all contributory sources are generally lower in Calabar compared to other Nigerian cities. For instance, Lagos recorded values ranging from 80-320μg/m^3 (rain season measurement) and 520-800μg/m^3 (dry season values)[16]. Jos recorded values ranging from 385-911μg/m^3 (dry season) (Simoneit et al, 1988).

Compared with cities in other third world countries, values obtained in Calabar are lower. For example, in Nairobi, the range of TSP is 204-369μg/m^3.In Shangai, the mean TSP is 569μg/m^3 and 766μg/m^3 for Beijing[18].

On the other hand, values from Calabar compared to industrialized cities or developed world are high. For example Japan has a mean TSP concentration of 38μg/m^3. Briabane in Australia records 26.6μg/m^3 and London records 28μg/m^3 while Leeds has 25μg/m^3 (Tanaka et al,2000; Chan et al, 1997 and Deacon et al, 1997).

The high TSP values recorded in Nigeria and other third world countries might be connected with the fact that developing nations are pursuing vigorous industrialization without giving commensurate attention to air quality management (Davies and Jixiang, 2000a and William, 1999).

4. Conclusions

Observed TSP values are within Nigeria ministry of environment standard and lower when compared with other third world cities. However, this should not give a false sense of security because adverse effects have been observed at far lower concentrations than what was observed in this study. Biomass combustion, Traffic and traffic-related sources are identified as the two largest contributors to the elemental contamination in the Calabar air basin. A baseline data on particulate and elemental concentrations in the Calabar air basin is provided by this study.

5. Recommendations

Improved inventory of pollution sources in the region should be carried out by the establishment of permanent monitory stations. Developmental projects in the region should be carried out with full implementation of mitigation provisions of the Pre-project environmental impact assessment.

References

U.S. EPA (1982), Air quality Criteria for Particulate Matter and Sulfer Oxides. Report EPA – 600/8-82-029a, b, c, U. S. Envieronmental Protection Agency Research Training Park. NC.

Odemerho, O.F. (1983), “The structure of Environmental problem as perceived in Warri, Bendel State, Nigeria”, *Journal of Environmental Management*, Vol. 19, pp. 65- 77.

Adegbulugbe, A.O. (1995), Energy – Environment interaction: National Surveys (Nigeria). Mimeograph, Centre for Energy and Research Development, Obafemi Awolowo Univeresity, Ile – Ife, Nigeria.

Grevy, P. (1995), *The Niger Delta of Nigeria: Pollution Assessment study Report to the World Bank*, Carl Bro Intl. Glostrup. Denmark.

Moffat, D. and Linden, O. (1995), Perception and Reality: Assessing the Priorities for sustainable Development in the Niger Delta. Ambio Vol. 24, pp. 527-537.

World Bank (1995), Defining Environmental Development Strategy for the Niger Delta. Vol. 1. World Bank Sector Report No. 14266.

Akeredolu, F. (1989), "Atmospheric problems in Nigeria – An overview", *Atmospheric Environment,* Vol. 23 No. 4, pp. 783-792.

Ikamaise, V.C., Ofoezie, I.E. and Akeredolu, F.A. (2001), "Lead, Mercury and Cadmium in air, soil and blood of persons associated with small-scale industrial activities in Ile-Ife, Nigeria", *Global Journal of Pure and Applied Sciences*, Vol. 7 No. 4, pp. 743-748.

UNEP/WHO (1994a), GEMS/AIR methodology review 3, measurement of suspended particulate matter in ambient air, WHO/EOS/94. 3, UNEP/GWMS/94.A.4 UNEP, Nairobi.

Chow J.C., Watson, J.G. Lowenthal, D.H. and Countess, R.J. (1996a), "Source and chemistry of PM 10 in Santa Barbara County, CA", *Atmospheric Environment*, Vol. 30: 1489-1499.

Adejumo, J.A., Obioh, I.B., Ogusola, A.J., Akeredolu, F.A., Olaniyi, H.B., Asubiojo, I.O., Oluwole, A.F., Akanle, A.O. and Spyrou, N.M. (1994), "Atmospheric deposition of major, minor and trace elements within and around three cement factories", *J. Radio. and Nucl. Chem*, Vol.179, pp. 195-204.

Chan, Y.C., Simpson, R.W., Mctainsh, G.H. and Vowels, P.D. (1997), "Characteristics of Chemical Species in PM 2.5 and PM 10 Aerosol on Brisbane, Australia", *Atmospheric Environment*, Vol. 31, pp. 3737-3785

Essiett, A.A., Uwah, I.E., Akpan, I.O. and Ikamise, V. (2007), "Determination of the concentration of total suspended particulate (TSP) in ambient air around Ikot Abasi Aluminium Smelter plant", Nigeria. *Integrated Journal of Science and Engineering*, Vol. 6 No. 1, pp. 63-70.

Oluwande, P.A. (1979), "Automobile Exhaust problems in Nigeria", *Ambio*, Vol. 8 No. 1, pp. 26-29.

Lowenthal, D.H., Zeilinska, B., Chow, J.C., Watson, J.G., Gautam, M., Ferguson, D.H., Neuroth, G.R., and Stevens, K.D. (1994), "Characterization of Heavy duty vehicle emissions", *Atmospheric environment*, Vol. 28, pp. 731-744.

Baumbach, G., Vogt, U., Hein, K.R.G., Oluwole, A.F., Ogunsola, O.J., Olaniyi, H.B. and Akeredolu, F.A. (1995), "Air pollution in a large tropical city with a high traffic density-results of measurements in Lagos, Nigeria", *The Science of the total Environment*, Vol. 169, pp. 25-31.

Simoneit, B.R.T., Cox, R.E. and Stanley, L.J. (1988), "Organic matter in the troposphere-IV lipids in Harmattan Aerosol of Nigeria", *Atmospheric Environment*, Vol. 22, pp. 983-10104.

Davies, B.L. and Jixiang, G. (2000),[a] Airborne Particles Study in Five Cities of China, *Atmospheric Environment*, Vol. 34, pp. 2707-2711.

Tanaka, S., Var, F. and Narita, Y. (2000), The Concentration, Trend and Seasonal variation of metals in the atmosphere of 16 Japanese cities shown by Results of National Air Survailance Network (NASN). Atmospheric Environment, Vol. 34, pp. 2755-2770.

Deacon, A.R., Harrison, R.M., Derwent, R.G., Middleton, D.R. and Moorcroft, S. (1997), "Analysis and interpretation of measurement of suspended particulate matter at urban background sites in the United Kingdom", *Science of Total Environment,* Vol. 203 . pp. 17-30

Williams, M.L. (1999), "Patterns of Air Pollution in Developed Countries", in: Holdgate, S.T., Samet, J.M., Koren, H.S., Maynard, R.L. Eds, *Air Pollution Health*, Academic Press, London, pp. 83-113.

Tables and Figures

Table1. Sampling sites location and sources of emission.

S/N	LOCATION	EMISSION SOURCE TYPES
1	Itiat Orok roundabout	Transportation (Vehicular)
2	Export processing zone premises	Industrial
3	University of Calabar staff quarters	Low density residential area
4	Mbukpa in Calabar South	High density residential area
5	Ikot Okon village	Rural (background)

Table 2. Range and mean concentration of TSP from various source types in Calabar metropolis and the rural source

Source Type	April/June		August/November		Annual	
	Range	Mean	Range	Mean	Range	Mean
LDRA	129.52–154.34	139.64±10.03	119.61-156.94	136.54±13.15	119.61-156.94	138.09±11.80
HDRA	188.45-223.61	201.93±14.47	135.19-170.13	154.35±13.03	135.25-223.61	176.14±24.76
IZ	85.76-109-54	98.65±8.00	110.93-165.10	137.64±20.06	85.76-165.10	118.14±24.76
VS	262.14-289.94	270.71±8.46	253.99-284.54	269.15±6.89	253.99-284.54	269.93±10.33
RURAL	55.72-128.30	93.80±25.45	106.42-156.71	124.16±17.91	55.72-156.71	108.98±26.68

LDRA = Low density residential area
HDRA = High Density residential area
IZ = Industrial area
VS = vehicular source
RURAL = Rural area

Table 3. Comparison of particulate concentrations from various source types with the concentration in the rural area

-Source Type	Mean Concentration (μg/m^3)	Rural Area Concentration (μg/m^3)	T Stat. (t-critical =3.35)
LDRA	138.09 ± 11.80	108.98 ± 26.68	13.99 (0.01)
HDRA	176.14 ± 24.76	108.98 ± 26.68	5.83 (0.01)
EPZ	118.14 ± 24.76	108.98 ± 26.68	0.80 (NS)
VS	269.93 ± 10.33	108.98 ± 26.68	17.68 (0.01)

NS = Not Significant

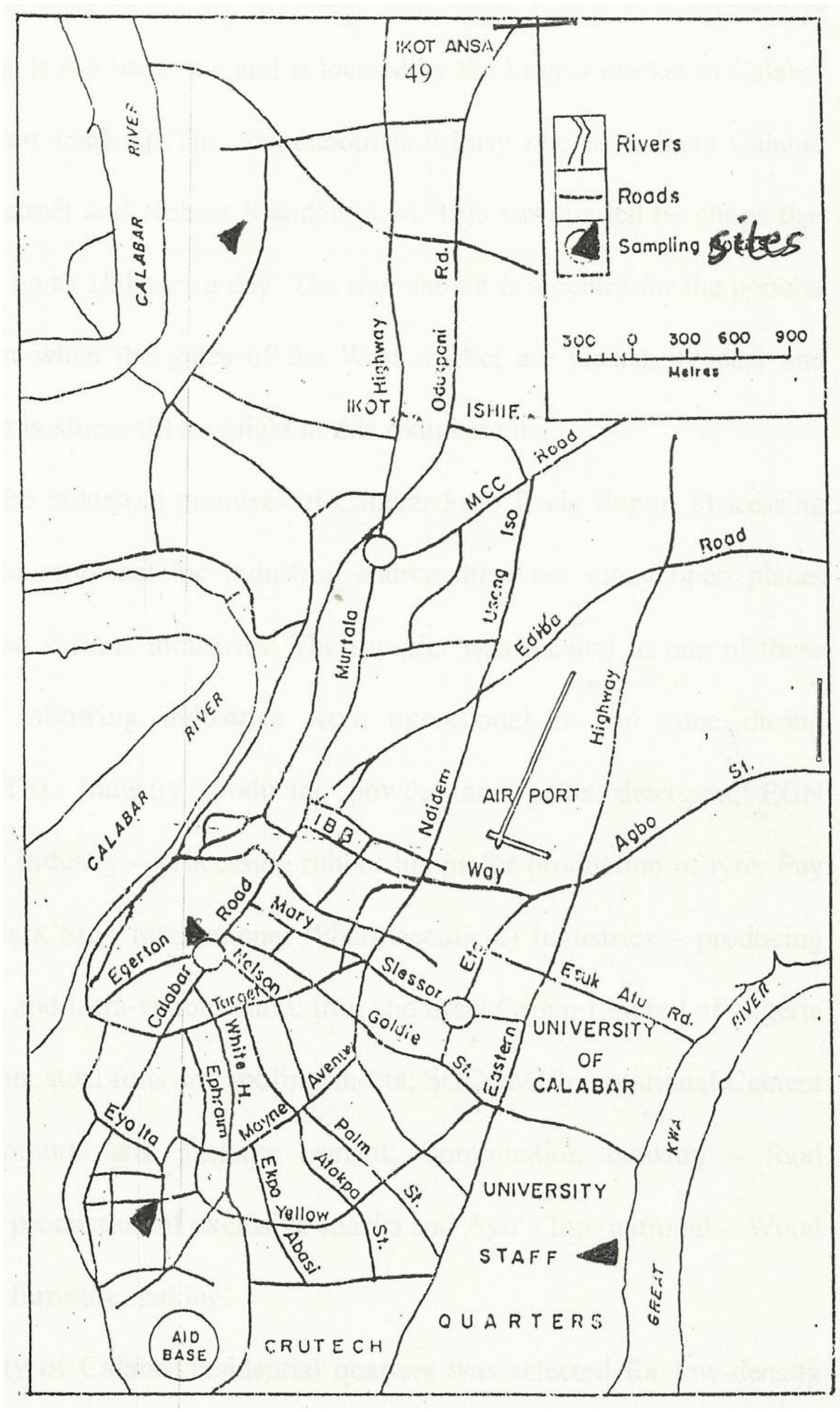

Figure 1. Map of Calabar showing the sampling sites

Figure 2. Gravimetric high volume air sampler

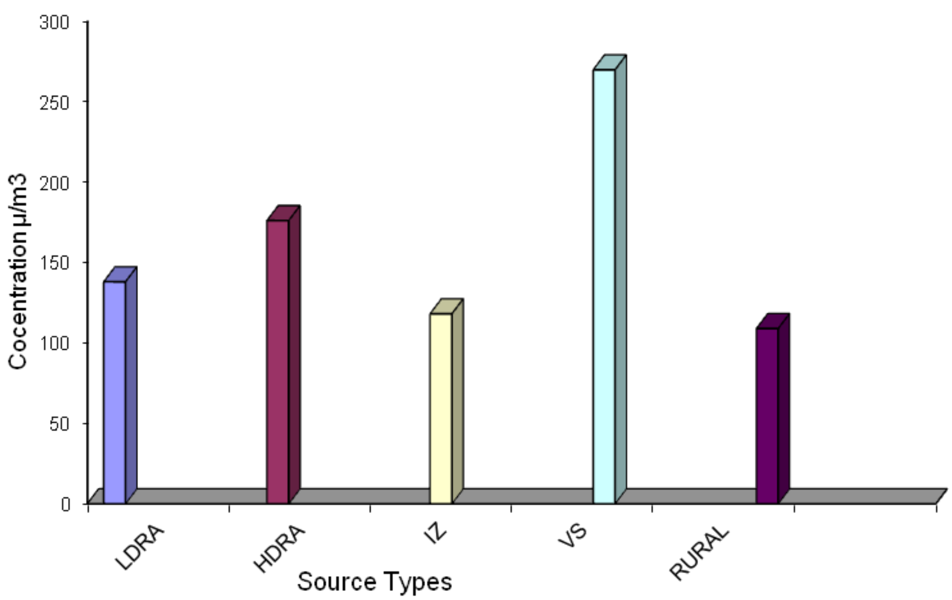

Figure 3. TSP Concentration across various source type in Calabar

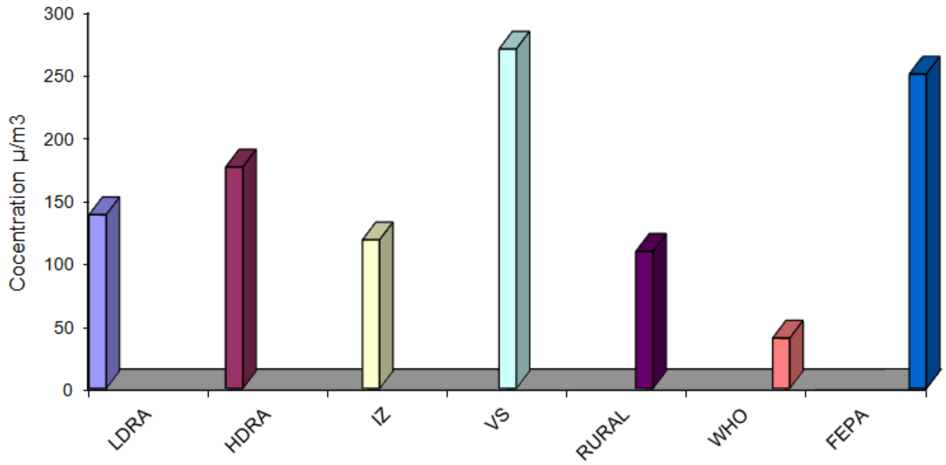

Figure 4. TSP Cocentration across various source types in Calabar with international and national standards