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## PARTICULATE MATTER CONCENTRATION IN THE JOS METROPOLIS

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**ABSTRACT:** An evaluation of particulate matter concentration was carried out in the Jos metropolis, Nigeria. Particulate matter was sampled at twenty four different locations within the city during the harmattan season of December 2007 through March 2008 using suction method. The average concentration of particulate matter obtained for the metropolis was  $12.2 \pm 4.4\text{mgm}^{-3}$ . A major contribution of this survey was the production of a contour plot which depicts particulate matter concentration distribution for Jos metropolis. Areas with high concentration include; Bauchi road motor park entrance  $19.29\text{mgm}^{-3}$ , Farin Gada  $17.68\text{mgm}^{-3}$ , Nassarawa Gwom  $17.68\text{mgm}^{-3}$ , Dilimi Junction  $17.08\text{mgm}^{-3}$ , Kwararafa market  $15.54\text{mgm}^{-3}$ , Katako  $15.01\text{mgm}^{-3}$  and Nasco Factory  $13.39\text{mgm}^{-3}$ . The least concentration of particulate matter was obtained in a residential area, Rayfield as  $4.29\text{mgm}^{-3}$ .

### INTRODUCTION

Polluting substances are emitted into the atmosphere from various sources; such substances can adversely affect agricultural land and crops, damage materials, cause visibility problems and can have harmful effects on human health and that of other living organisms. The most commonly found air pollutants include particulate matter, ozone (ground level ozone) lead, nitrogen oxides, sulphur oxides and carbon monoxide (US EPA, 2008). The World Health Organization (WHO) has identified particulate matter as the most significant in terms of its effects on health. Particulate matter has been linked to a range of serious respiratory and cardiovascular health problems. Recent prospective studies in India observed 30% to 50% increase in lung cancer rates associated with respirable particles (Chowgule, 2007). Particles are viewed in two broad categories – the primary particles and the secondary particles. The size of particles is directly linked to their potential of causing health problems and their residence time in the atmosphere. The smaller sized particulates tend to have greater adverse effects on health and also have greater residence time in the atmosphere (Kyle, 1991). Other effects of particulate matter in the atmosphere include modification in the transfer of solar radiation, impairment of visibility, nucleation of clouds and rain, and influence on the processes of photosynthesis in green plants, atmospheric electricity and chemistry (Utah and Ahmad, 1998; Utah et al, 2005; Makama and Utah, 2006). This research work centered on determining the concentration of particulate matter emanating from industrial, road transport and domestic processes in the Jos Metropolis and thereby obtaining the contour plots of particulate matter concentration distribution of the city.

### MATERIALS AND METHOD

Solids existing as particulate matter in the air are generally sampled by suction of part of the air for analysis. In this work samples were collected by sucking a known volume of air through filter papers in a plastic funnel by using a high vacuum pump, model E<sub>2</sub>m<sub>2</sub>. The filter papers were marked for identification, lightly smeared with vaseline and then pre-weighed in the Laboratory, University of Jos. The smearing of vaseline was to enable particulate matter sampled within two hours to be retained for subsequent laboratory analysis. Each of the

marked, smeared and pre-weighed filter paper was placed separately in a tightly closed container thoroughly cleaned with methylated spirit and then taken to the sampling site. Particulates were sampled for two hours at twenty four different locations in the Jos metropolis and sampling time was normally between 12noon and 5pm since concentration of PM is around this time.

For measurement of mass of the filter paper, the Gallenkamp top loading digital model JA3003A with maximum reading of 200g and sensitivity 0.001g was used. The mass of filter paper before sampling was recorded as  $M_f$  grams. After the filtering process at sampling site whereby particulates were collected on the filter; the filter paper was reweighed. The mass of the filter paper plus particulates was recorded as  $M_{fp}$  grams. The actual mass of particulate matter deposited was determined by subtracting  $M_f$  from  $M_{fp}$ .

The average mass of particulate matter captured at each sampling site was determined as  $M_p$  grams. To determine the exact location of a sampling point, the global positioning system (GPS) with an accuracy of about 3m was used. Contour plots were made using WinSurf software based on the values of concentration of particulate matter obtained at each sampling site with values of the latitude and longitude as the coordinates.

## RESULTS AND ANALYSIS

### Mass of Particulate Matter Sampled in the Jos Metropolis

The masses of particulate matter collected for 2 hours at different locations of the Jos metropolis are presented in Table 1. The masses varied from 0.008g to 0.036g with a mean value of  $(0.023 \pm 0.008)$  g.

### Mean Concentration of Particulate Matter in the Jos Metropolis

The concentration of particulate matter at each location of the metropolis was determined by dividing the mass of particulate matter sampled at the site with the volume of air drawn by the pump for two hours of the sampling process. The volume of air drawn for two hours at each of the sampling site was obtained as  $1.866\text{m}^3$ . The mean concentration of particulate matter in all sampling sites i.e. the concentration of particulate matter in the Jos metropolis are in Table 2.

### Contour Plots of Particulate Matter Distribution Trends in the Jos Metropolis

The contour map of particulate matter concentration distribution in the Jos metropolis are presented in Figure 1.

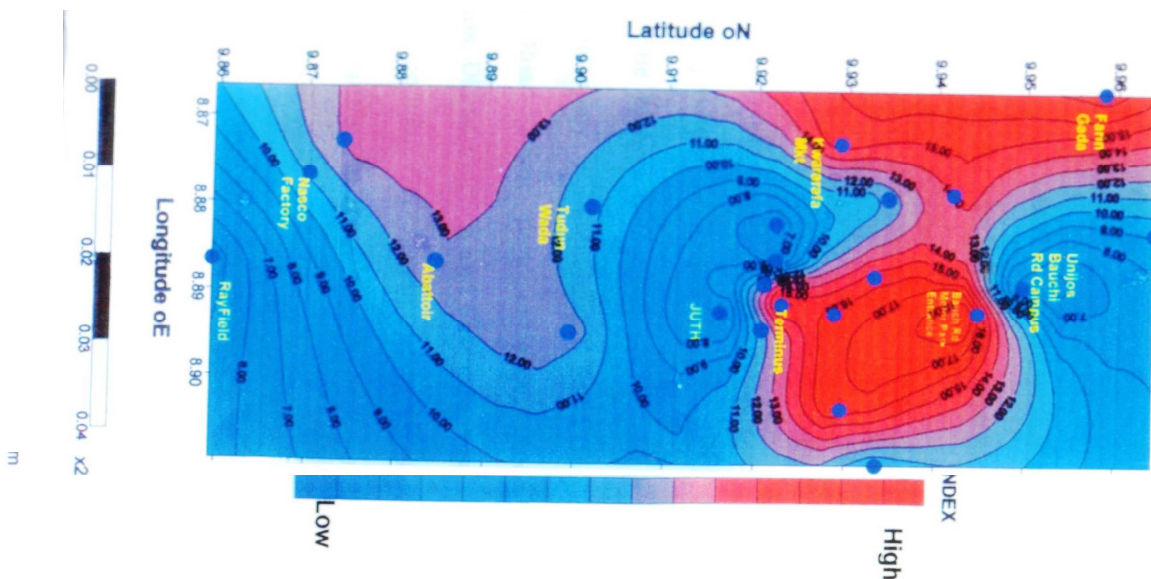


Figure 1: Particulate Matter Concentration Distribution Trend in the Jos Metropolis.

The longitude °E is used as the abscissa while the latitude °N is used at the ordinate. Colours are used to differentiate areas of high concentration of PM from areas of low concentration on the contour plot. The red coloured areas represent locations with high concentration of PM, pink coloured areas for locations with moderate PM concentration and blue coloured areas for locations with low PM concentration.

Table 1: Mass of particulate matter sampled in the Jos metropolis

S/N	Location (Sampling Site)	Coordinates		Elevation (m)	Mass (g)
		Latitude <sup>0</sup> N	Longitude <sup>0</sup> E		
1	Bauchi road motor park entrance	9 <sup>0</sup> 56'40.9"	8 <sup>0</sup> 52'.521	1172	0.035
2	Zololo Junction	9 <sup>0</sup> 56' 40.9"	8 <sup>0</sup> 53' 31.3''	1183	0.030
3	Dilimi Junction	9 <sup>0</sup> 55' 22.4	8 <sup>0</sup> 53' 31.3''	1198	0.033
4	Terminus	9° 55' 12.0"	8° 53' 28.2''	1195	0.031
5	Tudun Wada	9° 55' 12.0"	8° 53' 26.2''	1250	0.021
6	Kwararafa Market	9° 55' 59.2"	8 <sup>0</sup> 53' 16.2''	1190	0.029
7	Nasco factory	9 <sup>0</sup> 52' 26.3''	8 <sup>0</sup> 52''22.1''	1288	0.025
8	Abattoir	9° 53' 3.8"	8 <sup>0</sup> 53' 11.7''	1270	0.024
9	Katako	9° 56' 30.7"	8 <sup>0</sup> 52' 42.1''	1155	0.028
10	Gada Biu	9° 55' 40.2"	8 <sup>0</sup> 52' 21.3''	1155	0.030
11	Farin Gada	9 <sup>0</sup> 57' 30.9''	8° 51' 59.5''	1123	0.033
12	Plateau riders motor park	9° 55' 19.7''	8° 53' 9.8''	1191	0.012
13	Anguwa Rukuba	9 <sup>0</sup> 56' 0.7''	8 <sup>0</sup> 54'34.6''	1190	0.018
14	West of Mines	9 <sup>0</sup> 55' 19.8''	8 <sup>0</sup> 52' 54.9''	1180	0.011
15	Rwang Pam	9 <sup>0</sup> 55'15.4''	8 <sup>0</sup> 53'19.6''	1199	0.029
16	Dilimi	9 <sup>0</sup> 55'14.4''	8 <sup>0</sup> 53'38.9''	1190	0.020
17	Permanent Site Unijos	9 <sup>0</sup> 57'51.3''	8 <sup>0</sup> 52'57.9''	11.35	0.017
18	Unijos Bauchi Road campus	9 <sup>0</sup> 56'59.0''	8 <sup>0</sup> 53' 20.11''	1164	0.008
19	Nasarawa Gwom	9° 55' 46.4"	8 <sup>0</sup> 54' 11.4''	1198	0.033
20	JUTH	9 <sup>0</sup> 54' 57.6''	8 <sup>0</sup> 53' 31.5''	1196	0.011
21	Apata	9 <sup>0</sup> 56' 4.2''	8° 52' 44.0''	1160	0.019
22	Bauchi Ring Road	9 <sup>0</sup> 53' 57.7''	8° 53' 40.6''	1196	0.024
23	Rayfield	9 <sup>0</sup> 51' 33.8''	8° 53' 11.7''	1270	0.008
24	J.I.B entrance	9 <sup>0</sup> 52' 12.48''	8° 53' 36.18''		0.021
	TOTAL				0.551
	Mean				0.023±.008

## DISCUSSION

### Mass of Particulate in Jos Metropolis

The highest masses of particulate matter about 0.030g and above, were obtained in Farin Gada, Gada Biu, Bauchi Road Motor park entrance, Zololo Junction, Terminus, Dilimi Junction and Nassarawa Gwom. The areas identified with high level of traffic, small scale industries, markets and commercial activities. These areas are mostly congested with vehicles raising dust from the road and particulate matter from poorly maintained engines' exhaust into the city air. Next to the above areas are, Katako, Kwararafa Market, NASCO Factory, Tudun Wada, Abattoir and Rwang Pam. The lowest masses of particulate matter were obtained in Rayfield, a low – density residential area, the inside of UNIJOS Bauchi Road Campus and Jos University Teaching Hospital, compound.

Table 2: Concentration of Particulate Matter in the Jos Metropolis

S/N	Location (Sampling Site)	Coordinates		Elevation (m)	Concentration mgm <sup>-3</sup>
		Latitude <sup>0</sup> N	Longitude <sup>0</sup> E		
1	Bauchi road motor park entrance	9°56'40.9"	8°52'52.1"	1172	19.29
2	Zololo Junction	9°56' 40.9"	8°53' 31.3''	1183	16.08
3	Dilimi Junction	9°55' 22.4"	8°53' 31.3''	1198	17.08
4	Terminus	9° 55' 12.0"	8° 53' 28.2''	1195	16.61
5	Tudun Wada	9° 55' 12.0"	8° 53' 26.2''	1250	11.25
6	Kwararafa Market	9° 55' 59.2"	8°53' 16.2''	1190	15.54
7	Nasco factory	9°52' 26.3''	8°52''22.1''	1288	13.9
8	Abattoir	9° 53' 3.8"	8°53' 11.7''	1270	12.86
9	Katako	9° 56' 30.7"	8°52' 42.1''	1155	15.01
10	Gada Biu	9° 55' 40.2"	8°52' 21.3''	1155	16.08
11	Farin Gada	9° 57' 30.9''	8° 51' 59.5''	1123	17.68
12	Plateau riders motor park	9° 55' 19.7''	8° 53' 9.8''	1191	6.43
13	Anguwa Rukuba	9°56' 0.7''	8°54'34.6''	1190	9.60
14	West of Mines	9°55' 19.8''	8°52' 54.9''	1180	5.80
15	Rwang Pam	9°55'15.4''	8°53'19.6''	1199	14.50
16	Dilimi	9°55'14.4''	8°53'38.9''	1190	10.70
17	Permanent Site Unijos	9°57'51.3''	8°52'57.9''	1135	9.10
18	Unijos Bauchi Road campus	9°56'59.0''	8°53' 20.11''	1164	4.29
19	Nasarawa Gwom	9° 55' 46.4"	8°54' 11.4''	1198	17.68
20	JUTH	9°54' 57.6''	8°53' 31.5''	1196	5.80
21	Apata	9°56' 4.2''	8° 52' 44.0''	1160	10.18
22	Bauchi Ring Road	9°53' 57.7''	8° 53' 40.6''	1196	12.90
23	Rayfield	9°51' 33.8''	8° 53' 11.7''	1270	4.29
24	J.I.B entrance	9°52' 12.48''	8° 53' 6.18''		11.25
	Mean				12.22
					±4.40

### Concentration of particulate matter in Jos City

The average taken over all the concentration of PM obtained at the twenty-four sampling sites gave the concentration of particulate matter in the Jos Metropolis to be  $12.2 \pm 4.4 \text{mgm}^{-3}$ . This represents the Total Suspended Particles (TSP) in the air resulting from the harmattan dust, aerosols emanating from nearby markets, road side motor mechanic workshops, commercial and industrial activities. Compared with the Nigerian Ambient Air Quality Standard Value of  $250 \mu\text{gm}^{-3}$  daily average and maximum of  $600 \mu\text{gm}^{-3}$  not to be exceeded for not more than once a year (FEPA, 1991) the value of  $12.2 \text{mgm}^{-3}$ . (Utah et al 2005) obtained PM concentration at isolated sites in Jos City as  $1.6 \text{mgm}^{-3}$ . These differences in values when compared to the results obtained in this work of 2007/2008 harmattan season, could be attributed to many factors, for instance, increased small scale industrial and commercial activities, and influx of vehicles with poorly maintained engines and poor quality of fuel, which release substantial amounts of particulate matter into the city air. Moreover in this work, industrial, congested and usually known polluted areas were targeted as sampling sites. It is therefore expected that the mass concentration of particulate matter at these sites should be higher than those previously reported for isolated sites. In related measurements of TSP along some Nigerian motorways, (Ogunsola et al. 1993) obtained values as high as  $2000 \mu\text{gm}^{-3}$  for Lagos and  $720 \mu\text{gm}_3$  for Ile-Ife.

### Contour Plot of PM Concentration Distribution in the Jos Metropolis

A contour map showing how particulate matter is distributed in different locations of the city is presented in Figure 1. The contour map generally presents the trend of distribution of PM concentration in the city such that at a glance, a concerned environmentalist can know the areas

of focus. Figure 1 gives a general outlook of the concentration distribution and uses colours to differentiate areas of high concentration of PM from areas of low concentrations of PM. The red coloured areas are areas with very high concentration of PM, about  $13.00\text{mgm}^{-3}$  and above. Such areas like Farin Gada, notified with the vegetable market and the mechanics village with heavy vehicular traffic throughout the working day. Areas with moderate concentrations, the pink coloured areas, have concentration of PM between  $10\text{mgm}^{-3}$  and  $13\text{mgm}^{-3}$ , like the Abattoir. The blue colored areas are areas with low concentrations of PM, of about  $10\text{mgm}^{-3}$  and below. Such areas include UNIJOS Main Campus, the Jos University Teaching Hospital and Rayfield. While the University environment is composed of offices and class room blocks, the Rayfield area is purely a low density residential settlement of the Jos metropolis. This accounts for the low concentration of PM obtained in these places which are recommended for residential purposes. It is known that inhaled PM of diameter less than  $10\mu\text{m}$ , depending on duration of exposure, cause respiratory and cardiovascular ailment leading to death (WHO, 2000). It is therefore recommended that people with such ailments should avoid those areas with high concentration of PM especially between the hours of 12 noon and 5pm.

### CONCLUSION

Particulate matter was sampled in twenty-four different locations within the Jos Metropolis during the harmattan season of December 2007 through March 2008. The average concentration of particulate matter obtained for the city was  $12.2\pm 4.4\text{mgm}^{-3}$ . High concentrations of PM were obtained in areas with high levels of traffic and commercial activities. Contour plots which depict at a glance the particulate matter concentration distribution for the city were also obtained. The PM concentration of  $12.2\text{mgm}^{-3}$  in Jos city is relatively high when compared to FEPA Standards. People with respiratory and cardiovascular ailments living in the areas with high PM concentration in the city should avoid outdoor activities between the hours of 12noon -5pm; which is the peak period of PM concentration.

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