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Research Article

LOAD OF HEAVY METALS AND PAH PRESENCE IN THE AIRBORNE DUST PARTICULATES OF NAGPUR CITY

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ABSTRACT

The heavy metals heavy metals characterization and pahs presence in the airborne dust particulates have been studied in different representative areas of nagpur city. This report presents the profile of pah, monitored in the particle bound ambient air of nagpur city in Maharashtra. Respirable dust and fine particulate sampler collected the ambient air particulate on the filter paper. Extracted samples were analyzed by atomic absorption spectrophometer (aas) for heavy metals viz. Cr, ni, cu, zn and pb respectively and same extract sample analyzed by capillary gas chromatography using fid for various pahs. The occurrence of metal concentration were generally in order to industrial > commercial > residential are in Nagpur city. The result analysis show the existence of toxic metal concentration in the order zn > pb > ni > cr > cu in nagpur city. These large levels of metals pollutants have been also correlated with some meteorological parameters like temperature, relative humidity and wind velocity. Further also during study period it was observed that b(a)a concentration ranging from 0.0 to 1.56 ng/m3, b(b)f concentration ranging 0.0 to 1.28 ng/m3 and b(a)p was ranged from 0.0 to 1,01 ng/m3. During the winter season the concentration of pah's recorded higher as compare to monsoon & summer seasons. This might be due to foggy conditions in winter.

Key Words: *Air Pollution, Metal Pollutants, PAHs, Meteorological Parameters, Source Identification*

INTRODUCTION

Heavy Metal Concentration

The emission pathways of metal pollutants in to the atmosphere are of very diverse type *viz*. volcanic activity, emission through vegetation, soil erosion and man-made. In other words, pollutants are emitted from natural sources and anthropogenic sources. An accurate assessment of natural source strength is quite difficult but also important, as for many elements, natural emissions exceed those from anthropogenic sources (Harrison and Grieken 1998; Pacyna *et al.*, 1998). Among the natural sources of trace metals, the windblown dust and volcanic eruptions are considered the most important. Some Saharan dusts are known to contain high levels of Cr i.e. up to 3000 ppm. Long-range transport of such soils was expected to contribute significantly to Cr release, even in Europe, together with Cr condensation on airborne soil dust. The anthropogenic source processes are mainly related to the volatility of elements at high temperature of fossil fuel combustion, and many other high-temperature industrial processes, particularly the extraction of non-ferrous metal from sulfide (Ottley and Harrison, 1993). Metal pollutants are emitted into the atmosphere from numerous sources including combustion of fossil fuels, metal smelters and alloy refineries, cement manufacturing plant and municipal incinerator. Metals and metallic compounds exist in the atmosphere in three distinct physical forms: solid particulate matter, liquid droplets (mists) and vapors. The size range of airborne particulates matter is broad (Baeyens *et al*., 1990). Toxic elements occur in very small quantities in earth's crust (less than 1000 ppm) and hence called trace metals. These are further arbitrarily sub-divided on the basis of their densities; those having densities below 5 g cm^{-3} are called 'light metals' and those with densities above 5 g cm^{-3} are designated as 'heavy metals'. Thus, metals like Pb, Cu, Zn and Ni etc. are generally 'known as toxic heavy metals'. Surprisingly, even metalloids, As and Sb are also generally considered under this category, thus making it appear as if the term 'heavy metals' is misnomer. Although the toxic heavy metals are present in the earth's crust in trace levels, anthropogenic activities such as industrial processing and use of metals, alloys and metallic compounds disperse them into the environment, thus adding up to their natural background levels (Moore and Rama moorthy, 1984; Natusch and Wallace, 1974). Many previous studies have documented the air borne concentrations of several metallic elements in the fall. Others have also attempted to estimate the associated atmospheric loading. This pointed out the difficulties encountered in the quantification of different modes of atmospheric inputs, i.e. wet, dry and total inputs. Christophe *et al*. (1997) have reported some metal in air-borne dust particulates and reported 0.18, 0.35, 6.0, 3.7 and 220 $\mu g\ m^{-2}\ d^{-1}$ total fluxes were measured for Cd, Co, Cu, Ni and Zn, respectively. High heavy metal concentrations around Aliage Industrial Site in Turkey, especially near to iron smelters and steel mills have been reported due to industrial activities. Metals such Zn, Cr, Ni, Cd and Hg etc. are known for toxic effect on human health. The entry of these elements into the environment through industrial or other anthropogenic means needs to be monitored with concern source of these elements (Pacyna, 1987; Pacyna and Nriagu, 1988). Verma *et al*. (1989) have reviewed the introduction into the environment of these metal pollutants in an industrial area. The concentrations ($mg\ kg^{-1}$) of large number of toxic elements in the dust fall-out matter collected from areas of highest fall-out rates in the vicinity of an integrated steel plant have been reported as follows: Ni 190.0, Zn 120.0, Cu 50.0, Cr 140.0 and Mn 142.0. Investigation on metal concentration in particulate matter in the ambient air of Steel City, Rourkela in eastern India has shown the existence of tremendous contamination in air. Sandhu and Gehlan (1992) have estimated some metal pollutant in Amritsar in northern India by employing flame (air-acetylene) AAS. The dust fall samples collected from different locations in Agra were analyzed for Zn, Cu, Ni and Cr by atomic absorption spectroscopy.

They reported that the concentration of all metals were highest at the industrial site followed by residential and sub-urban site in general concentration pattern of metal in decreased order Cu > Zn > Ni > Cr> at all sites. With regard to season, all metals were present at higher level during winter compared to summer at all sites.

The aim of the present work was to determine the concentration of some of the toxic metals (Cr, Ni, Cu and Zn) in air-borne dust particulates in different representative areas of Nagpur City, an urban city of central India, i.e. industrial, commercial and residential

Poly aromatic Hydrocarbon

One of the adverse effects of the profuse use of fossil fuels by man now-a- days is ubiquitous presence of Polycyclic aromatic hydrocarbons (PAHs) in the environment in relatively high concentrations. There is no indication that the input of these compounds into the environment as a result of human activities will decrease sustainably in the next decades. Polycyclic aromatic hydrocarbons (PAHs) constitute a large class of compounds and hundreds of individual substances may be released during incomplete combustion or pyrolysis of organic matter which is an important source of human exposure. Studies on various environmentally relevant matrices, such as coal, combusted effluent, motor vehicle expects, used motor fabricating oil and tobacco smoke have

Shown that the presence of PAHs in these mixtures is mainly responsible for the carcinogenic potential. Numerous paper and review have been published on the occurrence, distribution and transformation of PAHs in the environment and its ecotoxicological and toxicological effects.

In general, any organic compound containing two or more aromatic rings may be considered to be a more aromatic matter. The term “Poly cyclic aromatic hydrocarbon” commonly refers to a large class of organic compound containing two or more fused aromatic rings made up of carbon and hydrogen atoms. At ambient temperature, PAHs is solids. The general characteristics common to the class of high melting and boiling points, low vapor pressure and very low water solubility which tends to decrease with increase molecular mass. PAHs are soluble in many organic solvents and are highly lipophilic. They are chemically rather inert.

Temperature has a significant influence on the solubility’s of PAHs. In the presence of light and oxygen PAHs readily undergo photo-oxidation. Reactions that are of interest with respect to their environmental fate and possible sources of loss during atmospheric sampling are photodecomposition and reaction with nitrogen oxides, nitric acid, sulfur oxides, sulphuric acid, ozone and hydroxyl radicals(Mukherjee and Chakraborty et.al. 1989)

The PAHs principally are used as intermediate in the production of PVC's and plasticizers (Nathalie) Pigments (acenapthelene, pyrene), dyes (anthracene, flouranthene), and pesticides (Phenentherene). The largest emissions of organic materials during industrial processes and other human activities including –

- Processing of coal, crude oil and natural gas, petroleum refining and production of carbonblacks, creosol and coal tar.
- Aluminum, iron and steel production in plants and foundries.
- Heating in power plants and residence and cooking.
- Combustion of refuse
- Motor vehicle and
- Environmental tobacco smoke

PAHs are highly lipid soluble showing less tendency towards bioaccumulation in the fatty tissue; the lungs and gut of mammals to metabolize rapidly absorb them. The increase in pollution level of these compounds will increase the possibility of cancer patients (Thakur *et al.*, 1977). In biota uptake process for PAHs are related to their hydrophilic character. Due to above environmental significance, ambient PAHs concentration scenario has been elaborated and include entire Nagpur region for PAHs study from April 2010 to March 2011which is one of the most growing city of Central India.

MATERIALS AND METHODS

Study Area: Nagpur has been an important city of India, since the 18th century, but it came into prominence only after 1956 being the second capital city of Maharashtra and due to its geographical location and progress in industrial, educational and cultural sectors. The development in various avenues like two major rail link junctions, chamber of commerce, Rastra Sant Tukdoji Maharaj Nagpur University, Nagpur Improvement Trust, Winter assembly session of the Government of Maharashtra, Textile mills, Air force Command, Ambajari Ordnance Factory, Central Reserve Police Force camp, Maharashtra Industrial Development Corporation and MIHAN are just a few of Nagpur achievements.

The total area of the city was only 217.56 Sq. Km. at the time of the establishment of Nagpur Municipal Corporation in 1951. At that time only 42 wards were demarked. However, in 1968, the city was re-divided into 75 wards due to rapid growth in its population. According to Census 2011, population of the Nagpur district was 23, 98,165 (Table 1 and Figure 1). In addition to this, the city has grown in length and breadth and today the total vehicle population in the city has grown to more than 10 lakhs indicating the progress and improvement in the living standard along with the problems of environmental concerned

Table 1: Population of Nagpur city

Year	Population
1961	6,43,659
1971	8,66,076
1981	12,19,461
1991	16,24,752
2001	20,52,066
2011	23,98.165

In the present study, samples were collected from different areas of Nagpur City, India. These areas included, Sakkaradara Square (busy traffic area with high commercial activity), which was selected for

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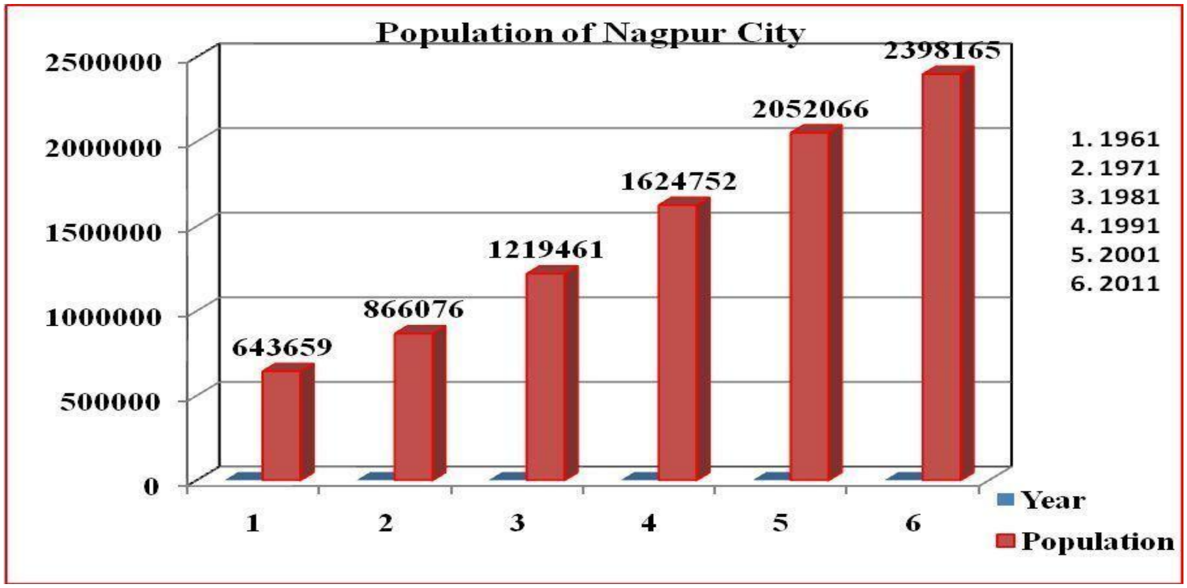

. **Figure 1: Population Growth in Nagpur City**

monitoring the levels of particulate matter (PM10). Civil lines and Ramdeobaba Kamla Nehru Engineering College (RKNEC), campus areas were selected as representatives of residential zone as they are surrounded by residential area. MIDC, which is the industrial area, was selected as industrial site **(Plate 1)**. The particulate matter (PM_{10}) sampler was operated at a height of approximately 5-15mts above the ground level. The details of monitoring sites are presented in **Table 2**. To assess the heavy metals from the particles obtained during the air sampling, the Whatman EPM 200 filter paper was placed in the sample bottles with 200ml extraction fluid (GBC Manual 1989). The bottles were kept over the reciprocating shaker for shaking for about 20-48 Hrs. Afterwards, the samples were filtered through Whatman filter paper No. 42. Heavy metal characterization of particulates was carried out by using Atomic Absorption Spectrophotometer (AAS Model No AA 6300). The characterization of particulates obtained from various locations (Industrial, Residential and Commercial zones) of Nagpur city during summer 2008-09 and winter 2008-2009 was thus carried out and the data is presented hereunder. **(Plate.2).** The month wise measurements of ambient air quality, concentration and flux of Cr, Fe and Zn were made for the pre- and post-monsoon seasons only in the whole year in each sampling site.

Out of sixteen PAHs compounds B (a)A, B(b) F and B(a) P which are known to be potentially weak, moderate and strong carcinogenic respectively (Hoffmann and Wynder et.al. 1968) were selected for this study. *Sampling:*

The samplings of suspended particulate matter were collected on 24 hourly basis in the following shifts:

6.00 am to 2.00 pm
2.00 am to 10.00 pm
10.00am to 6.00 pm

By a Respirable Dust Sampler (RDS) and Fine Particulate Sampler (FPS) at a average rate of 1.5 m^3/min once in week at each location from April 2010 to March 2011.The dust collected was used as the basis material for extraction of organic fraction and its enrichment for the PAHs was performed by using soxhlet extraction, rotary evaporator as discussed in PAHs standard method for air sampling **(Plate-3).**

*Sample Preparation***:** Suspended and fine particulate matter of diameter >10µm and <10 µm were collected Respirable Dust Sampler (RDS) and Fine Particulate Sampler (FPS) respectively on pre -weighed glass fiber filter paper. The filter papers were in kept in desicator and then weighed. Extraction of PAHs was performed by soxhlet extraction method. Full exposed filter paper was cut in to small pieces with care to avoid loss of dust and put in to 30 ml distillation vessels for 6 hrs using 100 ml cyclohexane in evaporating flask. After extraction; extract was reduced up to 5 ml. If the extract was clear, cleanup was not necessary. Extracted sample was

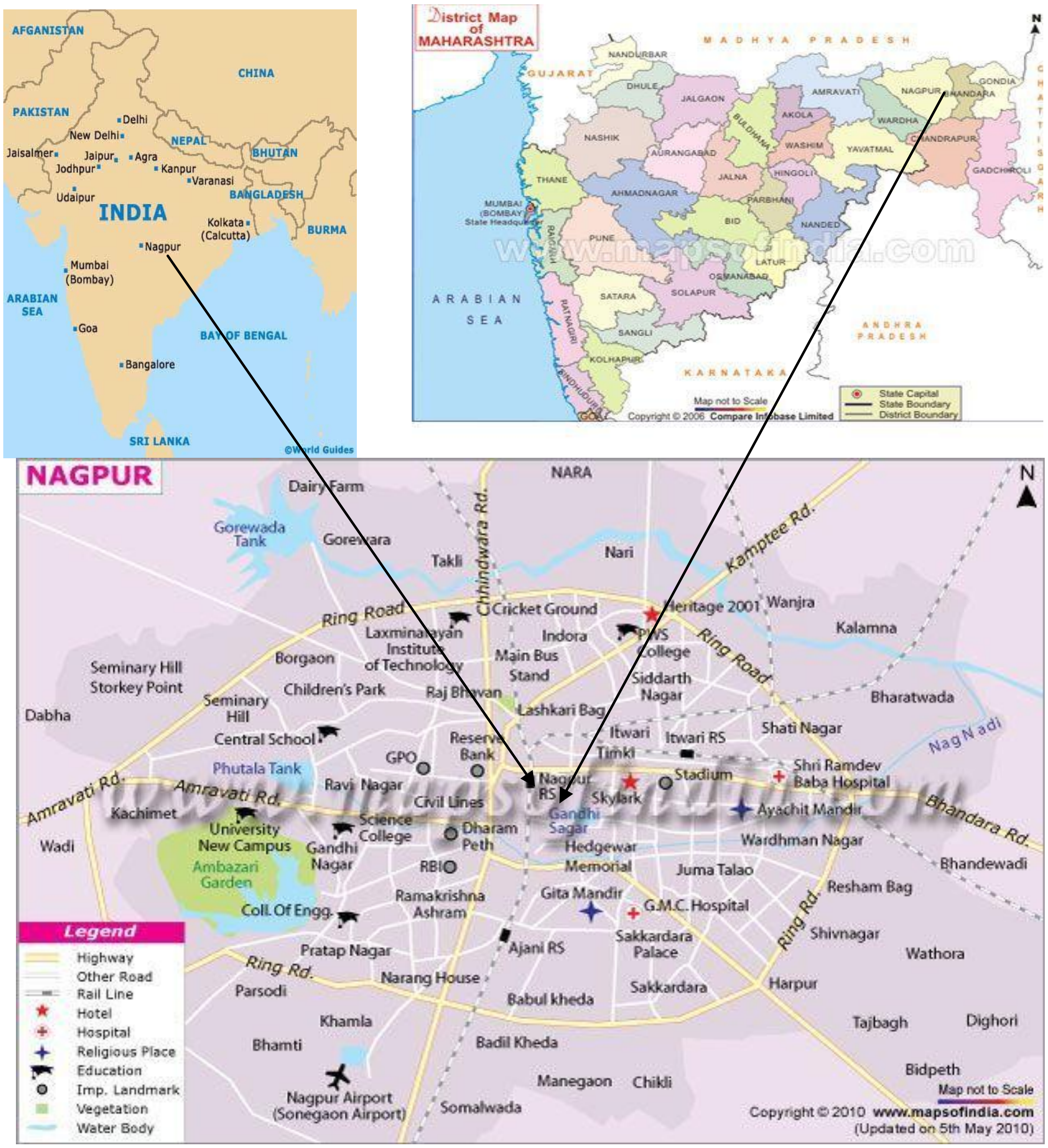

Plate 1. Map Showing Ambient air monitoring stations, Nagpur (MS), India *(Courtesy: www.mapsofindia.com)*

ready for Gas Chromatographic analysis by the method described by Lodge (Lodge et.al.1989)

*Capillary Gas Chromatography***:** Analysis of PAHs compounds has been performed by capillary Gas Chromatogram (Liberty, Cartoni and Cantuni et.al. 1962). For PAHs analysis, sigma 2000 (Shimadzu make) Gas Chromatograph with flame ionization detector (FID) was used. The analysis was carried out under the following experimental conditions.

- Column: Recktex, 30 mtrs x 0.25 ID, film thickness 0.50 um (DB-5 ms)
- Carrier Flow: Nitrogen 22 psi

- Column Temp: 65^o C for 1 min. @ 25^o C up to 140^o C for 0 min. @ 10^o C up to 290 ^{o}C for 15 min
- Detector Temperature : 300 ^{o}C
- Injector Temperature : 275 ^{o}C

Table 2: Details of sampling stations

Site	**Location**	**Activity**	**Height above the Ground level (meters)**
MIDC, Higna	Wadi Naka	Industrial, Vehicular	5
Sakkardara Square	Near Sevaldal Mahavidhalaya	Commercial, Residential, vehicular	15
Civil Lines	Residential Quarters	Residential, Government offices, green belt	5
Katol Road	Near RKNEC	Highway, Residential	5

Plate 2: Respirable Dust Sample at Hingna Site

Instrument analysis: Standardization was done using USA Made Poly science standards. Volume of injection was 2 µl and split open after 1 minute of injection .The identification and quantification of sample chromatograms with standards chromatograms were performed by Gas Chromatogram –Mass Spectrometer (GC-MS) {Shimadzu Make) integrator ; chromatograms were also checked manually by overlapping the standards and sample chromatogram (Plate-4).

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Plate 3: Atomic Absorption Spectrophotometer (AAS) Make- Shimadzu, Model –AA6300

RESULTS AND DISCUSSION

Heavy Metal Analysis

The study on seasonal variation of meteorological parameters *viz*. temperature, wind velocity, humidity and rainfall of the study area during one hydrological year (April 2010 to May 2011) has been studied. The city has extreme climate; the monthly average day temperature varies from minimum of 23.9 $^{\circ}$C in winter (January) to maximum of 42.4 $^{\circ}$C in summer (May). The minimum temperature recorded in a day is 4.5 $^{\circ}$C in January and the maximum temperature recorded in a day is 47.5 $^{\circ}$C in the month of May. The annual rainfall recorded is about 126.4 cm. In summer, the monthly average relative humidity (RH) lowers down up to 40.5% (May). Annually it ranges between 40.5% (May) – 90% (November and January). The monthly average wind speed varies from 1.4 (November) to 8.0 (January) km hr^{-1}

The characterization of particulates was carried out for the samples collected from all three locations i.e. Industrial, Residential and Commercial zones of Nagpur city during the study period (2008 and 2009).

Plate 4: Gas Chromatograph- Mass Spectrophotometer (Shimadzu Make)

The heavy metal analysis for particulates was carried out by using Atomic Absorption Spectrophotometer (AAS Model No AA 6300 Make-Shimadzu)

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The list of heavy metals analyzed is as under:

1. Cadmium as Cd
2. Chromium as Cr
3. Copper as Cu
4. Lead as Pb
5. Nickel as Ni
6. Zinc as Zn

Seasonal variations of heavy metals present in dust particulates was showing in bar chart. From the data, it was observed that copper and zinc were the most prevalent heavy metals present in the ambient air of commercial area (Table 3, Table 4, Table 5 and Table 6). *The seasonal variation and distribution of metal pollutants:*

Chromium: The average value of chromium at site 1 (Commercial area) has been found to be 0.773 mg/lit. The concentration of chromium at this site (site 1, commercial area) ranges between 0.540- 1.007 mg/lit and at site 2 (Residential area) it was found the below detectable limit (BDL). The chromium concentrations for site Industrial area are in ranges 0.032-0.694 mg/lit of air borne dust particulate. These are higher than the chromium concentrations found in commercial area. Due to maximum precipitation of airborne particulates as well as highest concentration of chromium in commercial area the flux of chromium is also maximum in this zone. The next higher flux of chromium is at Industrial area and then at residential area. The occurrence of chromium levels was found in different areas in the order: commercial > industrial > residential. The trends obtained for the Cr level in particulate samples was in accordance with the earlier work (Savant and Pandey, 1993). The trend obtained for the Cr level in particulate samples was in accordance with the earlier work (Savant and Pandey, 1993). The average of chromium levels in commercial and industrial area is quite comparable. This indicates the similar nature of the source of heavy metals in both areas (commercial and industrial).

Nickel (Ni) The concentration of Ni in the dust particulates in mg/lit, in different representative sites (Commercial, industrial and residential) ranges between at commercial area; 0.0018 – 0.054, at Industrial area; 0.0018 – 0.018 and at residential area; 0.0 to 0.009. It can be seen from the data obtained that the maximum precipitation of Ni along with the dust particulates is in the winter season than the summer. The concentration of Ni gradually increases from November to February and then starts falling in the summer.

Table 3: Heavy metals characterization for the Year Summer 2008

Sr. No	**Name of Area**	**Name of the Location**	**Values in ppm**					
	Heavy Metals		**Cu**	**Cd**	**Cr**	**Ni**	**Zn**	**Pb**
1	Commercial	Sakkardara Square	1.230	0.034	0.704	0.054	7.906	0.015
2	Residential	Civil Lines	0.766	BDL	BDL	BDL	3.461	BDL
3	Industrial	Wadi Naka	0.278	0.003	0.654	0.012	3.281	0.0012

Table 4: Heavy metals characterization for the Year Winter 2008

Sr. No	**Name of Area**	**Name of the Location**	**Values in ppm**					
	Heavy Metals		**Cu**	**Cd**	**Cr**	**Ni**	**Zn**	**Pb**
1	Commercial	Sakkardara Square	1.357	0.056	0.840	0.0018	2.457	0.009
2	Residential	Civil Lines	0.9870	0.0025	BDL	0.009	1.487	BDL
3	Industrial	Wadi Naka	0.0024	0.021	0.694	0.018	4.250	0.0020

Table 5: Heavy metals characterization for the Year Summer 2009

Sr. No	Name of Area	Name of the Location	Values in ppm					
	Heavy Metals		Cu	Cd	Cr	Ni	Zn	Pb
1	Commercial	Sakkardara Square	0.5132	0.032	1.007	0.066	0.092	BDL
2	Residential	Civil Lines	0.098	BDL	BDL	BDL	0.012	BDL
3	Industrial	Wadi Naka	1.098	0.012	0.032	0.010	0.065	0.0019

Table 6: Heavy metals characterization for the Year Winter 2009

Sr. No	Name of Area	Name of the Location	Values in ppm					
	Heavy Metals		Cu	Cd	Cr	Ni	Zn	Pb
1	Commercial	Sakkardara Square	0.092	0.029	0.540	0.0024	0.934	0.008
2	Residential	Civil Lines	0.054	0.0018	BDL	BDL	0.108	BDL
3	Industrial	Wadi Naka	0.068	0.320	0.148	0.0018	0.740	0.002

Abbreviation's*-Copper, Cd- Cadmium, Cr-Chromium, Ni-Nickel, Zn-Zinc and Pb-Lead*

Note: BDL- Below Detectable Limit

Copper (Cu): Copper has been found to be present in the dust particulate at different sampling sites in the range: commercial area, 0.092- 1.357 mg/lit; at Industrial area, 0.0024 – 1.098 mg/lit; at residential area, 0.054 – 0.9870 mg/lit.

Zinc (Zn): Zn has been found in various sites of Nagpur City. The highest concentration of Zn was observed at commercial area; 0.092 – 7.906 mg/lit, zinc concentration observed at industrial area is ranges between 0.065 – 4.250 mg/lit and at residential area, zinc concentration is ranges between 0.012 – 3.461 mg/lit.

Zinc also is found to be present at maximum concentration in summer season than the other season.

The occurrence of Zn was found in different areas in the order: commercial > industrial > residential.

Poly aromatic Hydrocarbon:

Trend of analysis of criteria pollutant (Suspended Particulate Matter) of Nagpur city was projected in (**Table-7 and Table 8**).

Table 7: Minimum-Maximum Ranges of SPM in Nagpur City (2009-2010)

Sr. No	Area	Location	Minimum	Maximum
1	Industrial	Wadi Naka	110.5	323.0
2	Commercial	Sakkardara Square	106.6	245.5
3	Residential	Campus of RKNEC Civil Lines	81.0	202.0

• *All results in µg/m^3*

Air quality status of Suspended Particulate Matter (SPM) in Nagpur city shows that average concentration of SPM is higher in Commercial area followed by Industrial area in 2007-2008. The SPM concentration levels in ambient air are reported minimum value 81.0 µg/m^3 at Residential area and maximum value 323.0 µg/m^3 at Industrial area of Nagpur city. PAHs trend of Nagpur city that all the Monitored Polyaromatic Hydrocarbons (PAH's) are present in ambient air during 2007-2008. Out of three PAH compound B(a)A show highest concentration ranging from 0 to 1.56 ng/m^3 followed by B(α)F The

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seasonal variation of ambient PAHs level shows that the concentration of B(α)A [Benzo Alpha Anthracene] , B(α)F [Benzo Alpha Florescence] and B(α)P[Benzo Alpha Pyrene] was higher in winter as compared to other seasons (Table 10). During summer season, the PAHs compounds are comparatively at low concentration level than winter seasons. This is attributed due to high temperature in summer, which is responsible in an enhancement in the rate of disintegration of organic compound leading to lowPAHs concentration. Secondly, the PAHs compounds are adsorbed/absorbed specially on <10 μ size particles. During summers, heavy dust storms is a climatic characteristic of Nagpur city which help to increase the Suspended Particulate Matter (SPM, >10μ size) concentration due to natural process. Varying from 0 to 1.28 ng/$m^3$and B (a) P from 0.0 to 1.01 ng/m^3 (Table 9). Low value of PAHs in monsoon may be due to the less particle density during rainy reason hence chances for particle bound PAHs are also leThe results obtained during the study course reveal the presence of PAHs compounds in the ambient air of Nagpur city. Higher concentration observed in winter at commercial areas & minimum at residential area. This may be due to enhancement in the rate of disintegration of organic compound in summer. In summer heavy dust storm results in increase of SPM

Table 8: Seasonal Concentration profile of SPM in Nagpur City (2009-2010)

Sr.No	Area	Winter	Summer	Post Monsoon
1	Industrial	142.0 – 345.0	154.0 – 458.0	94.0 – 108.0
2	Commercial	115.0 – 516.0	108.0 – 492.0	87.0 – 218.0
3	Residential	116.0 – 201.0	72.0 – 188.0	92.0 – 198.0

All results in μg/m^3

Table 9: Minimum-Maximum Concentration of PAH's in Ambient Air of Nagpur Region (2009-2010)

Sr. No	PAHs	Minimum	Maximum	Remarks
1	B (α) A	BDL	1.56	At Sakkardara Square (C/W)
2	B (α) F	BDL	1.28	At Sakkardara Square (C/W)
3	B (α) P	BDL	1.01	At Sakkardara Square (C/W)

- *All results in ng/m^3*
- *C/W: Commercial/ winter*
- *BDL- Below Detectable Limit*

Table 10: Seasonal Concentration profile of PAH’s in Nagpur city (2009-2010)

Sr.No	PAH’s	Winter	Summer	Monsoon
1	B (α) A	0- 1.56	0-1.02	0-0.98
2	B (α) F	0-1.28	0-0.96	0-0.72
3	B (α) P	0-1.01	0- 0.36	0- 0.19

**All results in ng/m^3,*

(10 μ size) but PAHs adsorbed specially on particle size less than 10μ which may also responsible for low PAHs concentration in summer. The presence of PAHs in ambient air of Nagpur city necessitates the

continuous/regular monitoring of ambient air in the urban sector with respect to PAHs as this compound recognized as a very important factor in field of air pollution problem because of its carcinogenic nature.

Conclusion

Heavy Metal Analysis: Although information on monitoring and analysis reported for the suspended particulate matter (SPM) are extensive yet the literatures available on dust particulate analysis are scanty. Most of the work carried out so far in India relates to south-western part of India including metropolitan cities only. Thus the comparison amongst the results becomes a tough job. The present work is an earnest effort in this respect as to provide a common picture on the current load of pollutants in the form of dust in a rapidly growing urban city. When compared between the present data and the results of the studies carried out in the recent past years in India and other parts of the world, it is quite obvious that Nagpur air is surprisingly a polluted one.

Their results are more in values than ours because their analysis is related to only in the vicinity of industrial areas. Based on the main characteristics of land use and intensification of human activities, the city can be loosely categorized in to four areas, industrial, heavy traffic, commercial and residential. Mean and standard deviations of samples within each area were calculated. In industrial area metal content, except those of Cu, Ni and Zn, in dust fall-out were higher than in other areas (Christophe et al. 1997). Average metal concentrations in residential areas were always the lowest among the four. The elemental composition of particulate matter shows high level of, Zn, Pb, Ni, Cr and Cu. The maximum concentration of Zn, Pb in the airborne dust particulates of industrial area could be due to its source as emission through stack of Cu and Pb etc. bearing alloys industries and other industries (Savant and Pandey, 1983 &1984). The higher Pb and Ni level in the particulates of heavy traffic area is quite obvious and is due to the vehicular emission, apart from the other contributing sources. Anthropogenic activities, wind velocity and wind directions are the major contributing sources of air pollution.

The meteorological parameters *viz.* temperature, relative humidity, wind velocity and rain fall have shown positive correlation with the quantum of dust fall in a particular site as well as in a particular seasons. Overall, the occurrence of metal concentration was found in the order industrial area > heavy traffic area > commercial area > residential area.

It is, thus, obvious now that much more stress should be given to measure the amount of metal pollutant in particulate matter. Regular basis monitoring and analysis of toxic trace elements in particulate matters is of great importance for the toxicological, environmental and occupational health viewpoint. Compared to the vast efforts made all round the world, very few work have been reported for characterization of trace metals in dry depositions in Indian subcontinent.

Seasonal variations of heavy metals present in dust particulates was showing in bar chart. From the data, it was observed that copper and zinc were the most prevalent heavy metals present in the ambient air of commercial area.

Figure 2, 3 and 4 has been observed that the concentration of Chromium and Lead was found more as compare to other heavy metals. Most probable sources of these heavy metals i.e. Cr^{+} and Pb^{++} for commercial zone was automobile body workshops and vehicular activities while the probable sources for industrial zone was electroplating and small scale of galvanizing industries. In the industrial area has also been observed the Concentration of Chromium and Lead but comparative low i.e. almost half of the commercial and industrial zone. The sequences of the concentration variation of heavy metals are as under: Commercial< Industrial < Residential area

Poly aromatic Hydrocarbon : As per the qualitative and quantitative analysis of PAHs in air samples, it may be concluded that qualitatively, the PAHs, such as B(α)A [Benzo Alpha Anthracene], B(α)F [Benzo Alpha Florescence] and B(α)P[Benzo Alpha Pyrene] were present in

the air environment of study area i.e. Nagpur City (Table 7). Furthermore, on the basis of data regarding seasonal variation of PAHs concentration in air, it may be concluded that a significantly ($P<0.05$) higher concentration of all the PAHs was prevalent during the winter season (Figure 5 and Figure 6).

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Anthracene by far the most abundant PAH in the whole ecosystem Most PAHs derived from biomass or fossil fuel combustion and is distributed in the atmosphere. Numerous local biological sources of PAHs are present; more research is needed in the area. Similarity in patterns to temperate regions

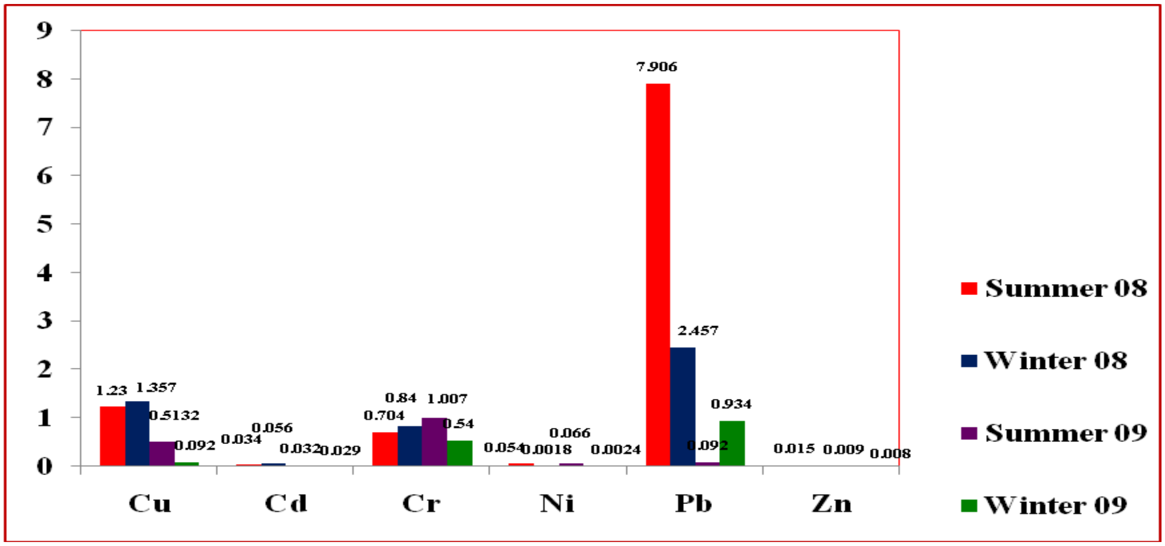

Figure 2 : Seasonal variation in Heavy metals concentration at Commercial zone

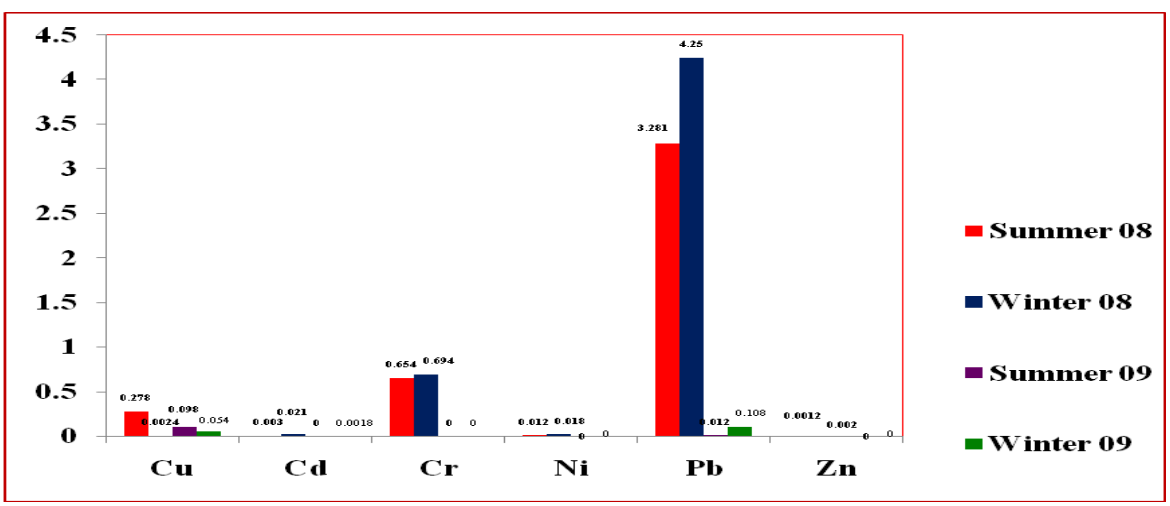

Figure 3: Seasonal variation in heavy metal concentration at Industrial zone

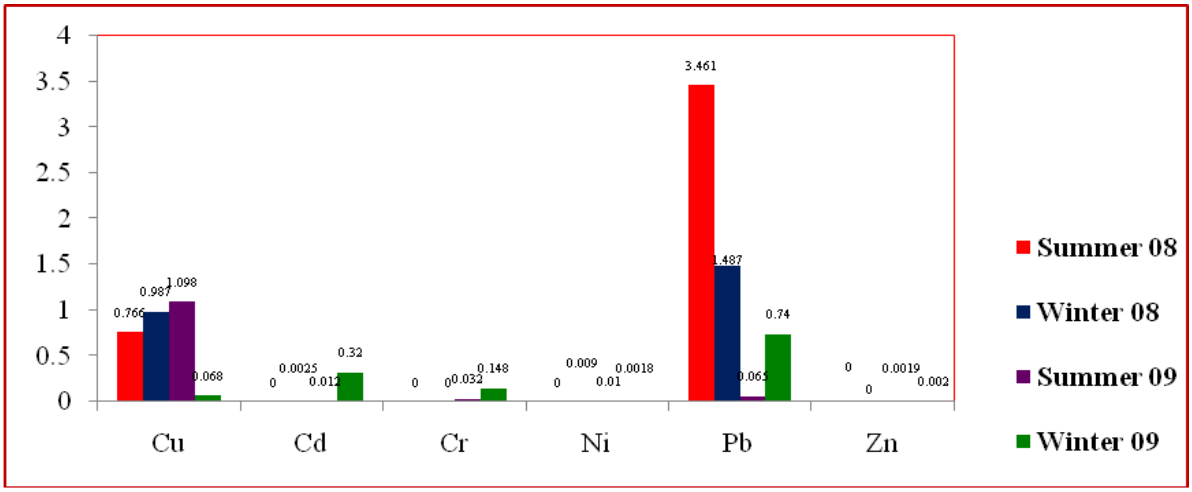

Figure 4: Seasonal variation in heavy metal concentration at residential zone

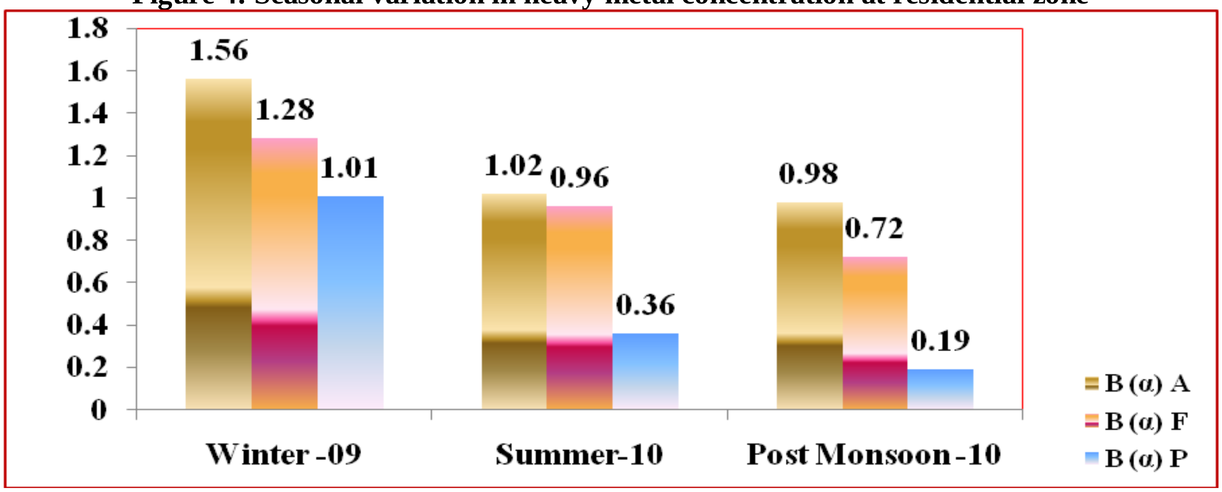

Figure 5: Seasonal variation in PAHs concentration during session 2009-2010

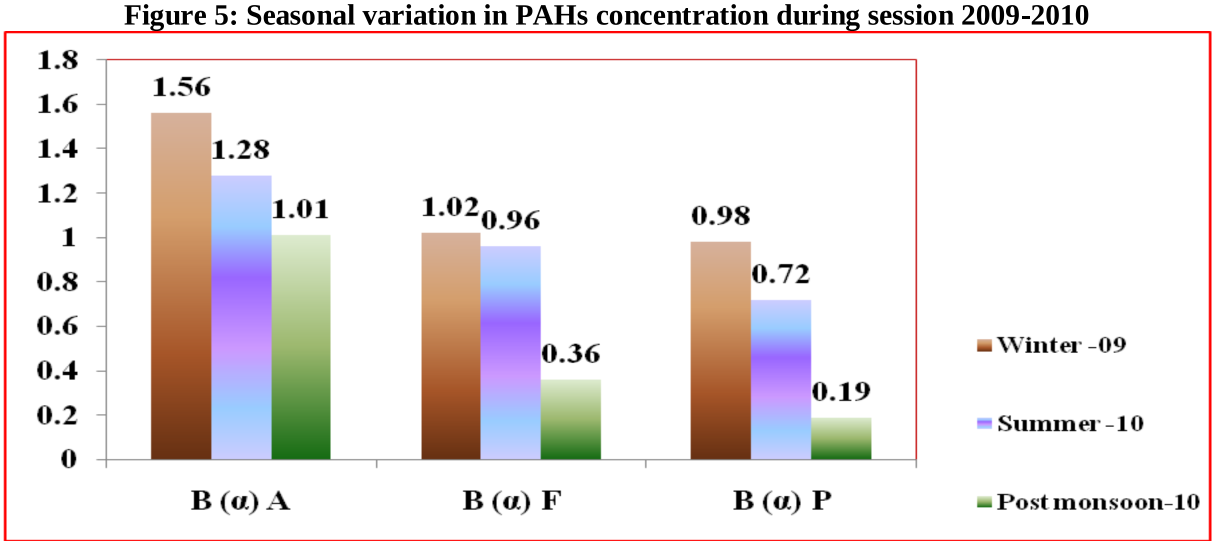

Figure 6: Seasonal variation in PAHs concentration during session 2009-2010

Table 11: Different International Standard Limit for Poly Nuclear Aromatic Hydrocarbon.

OSHA	Occupational Safety &Health Administration	0.2 mg/m^3	For Ambient Air
NIOSH	National Institute for Occupational Safety & Health	0.1 mg/m^3	For Human Exposure
EU	Europe	5.0 ng/m^3	Benzo (α) Pyrene
GER	Germany	1.3 ng/m^3	Benzo (α) Pyrene
USA	United State of America	03-07 ng/m^3	Benzo (α) Pyrene

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