RESEARCH ARTICLE

ASSESSMENT OF METAL CONCENTRATIONS IN THE STREET DUSTS OF DELHI

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ABSTRACT

Heavy metal concentrations play an important role in affecting the health of people by an overall activation of the haemostatic system upon chronic/acute exposure of these contaminants present in air. Present study was conducted with an objective to estimate metal concentration in the street dust of Delhi. 14 different sites were selected for the study which included industrial, commercial, bus terminals and other areas. Inductively Coupled Plasma-Optical Emission Spectrometer analysis showed that Al had the highest concentration while Cd had the lowest. Pb concentration was recorded to be high in the present study sites, but relatively low as compared to those cited in previous literatures due to an early phase-out of leaded gasoline. Industrial areas reported high concentrations of Cr & Fe, Cu &Zn, and Al &Ca. Besides anthropogenic activities, natural sources do account for heavy pollution of metals in the street dusts of Delhi (Ca and Fe), which are present in its loosely bound soil. Anthropogenic sources are major contributors to the trace metal pollution in Delhi. Residential-cum-commercial area had lowest concentration for all the metals studied. Correlation coefficient analysis indicated that industrial activities are the source of Cd, Ni & Cu, and Pb, Mn, Zn and V. Fe, Mn, Ni, V, Al are a result of dust re-suspension from traffic related sources.

Keywords : Street dust, Heavy metals, Delhi, Anthropogenic sources

INTRODUCTION

Air pollution in less developed countries like India, is one of the major concerns due to increase in urbanization. The growing population, increasing number of vehicles and industries, improper maintenance of vehicles and lack of implementation of stringent emission standards are the chief causes (Srinivas, 1999), which make the problem of air pollution still severe (Mittal & Van-Grieken, 2001). Delhi, being the capital city, the pollution is mostly contributed by the use of vehicles which is 70% (Gokhale & Patil, 2004). Atmospheric air, being the mixture of gases also contains suspended particulate matter emitted from various activities. These particulate matters, on re-suspension, gets settled on the road and become the "road dust". Of the total air pollution caused in the environment, about half of this is caused due to "road dust". It can be said from the fact that all those metals which are associated with vehicular pollution or industrial activity gets associated with the road dust during the course of time (Khemani et al., 1985; Anju and Banerjee, 2003; Monkkonen et al., 2004; Mouli et al., 2006; Srivastava and Jain, 2006).

In urban areas, sources of heavy metal pollution in road dust includes water transported material from surrounding soils and slopes, road surface wear, road paint degradation, dry and wet atmospheric deposition biological inputs, vehicle wear (tyres, body, brake lining, etc.) and vehicular fluid and particulate emissions (Sutherland and Tolosa, 2000).

The trace metals contamination in road deposited sediments is known to exert a toxic impact on the human system which may be due to biochemical activity of metals (Smith et al., 1997). The trace metals found in outdoor air may also become the source of indoor air pollution (Tong and Lam, 2000;

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Chattopadhyay et al., 2003; Srivastava and Jain (2007). Direct inhalation, ingestion and dermal contact absorption are three routes for entry of toxic metals in the human body (Ferreira- Baptista and De Miguel, 2005; Ahmed and Ishiga, 2006). Toddlers are more susceptible to ingestion of these air-borne metals (Okorie et al., 2011; Xin-Hu et al., 2011; Guitao et al., 2010) through "Pica" (defined as the mouthing of non-food objects) (Davis et al., 1990; Wijnen et al., 1990; Calabrese et al, 1997). Heavy metals are dangerous because they tend to be bio-accumulated. This focuses the light on the fact that, within a particular biological organism, the heavy metal can be found in higher concentration than that in the environment. Therefore, determination of heavy metals, with regard to its origin, distribution and its level, is possible through the study of road dust.

The present study attempts to assess the trace metal levels of street dust samples collected from the 3 main broad categorized areas- industrial, commercial and residential, of a capital city Delhi and their possible health impacts.

MATERIAL AND METHODS

1. Road dust sampling procedure- Urban street dust was collected from 14 locations of Delhi in the month of April through hand- brushing. The collected dust was transferred to self-sealing polyethene bags (with proper labeling) for transport to laboratory for analysis. Details of sampling sites are given in Table 1.

For quality maintenance, necessary precautions such as one-time usage of gloves were taken so as to avoid contamination and interference of any extraneous matters such as cigarette, etc. The samples were screened through a stainless steel of size 45 micrometer to obtain a desirable fraction of the dust sample which would be preferable for acid digestion and metal analysis in ICP-OES.

2. Microwave Acid Digestion- The samples were digested in a MARS microwave system according to the procedure described in household dust levels digestion protocol (Gautam Chattopadhyay et al., 2003). Samples solution was filtered through Whatmann filter paper no.42, and then analyzed using ICP-OES (Prodigy XP from Teledyne leemans Lab U.S.A), for heavy metal analysis.

3. QA/QC Analysis- Samples were digested in closed microwave assisted pressurized vessels. Acids of analytical grade (Nitric Acid with 70% purity of Himedia Laboratories Pvt.Ltd, Mumbai, India) were taken for maintaining purity of samples. Millipore ultra pure water was added to dilute the samples.

4. Statistical Analysis - Statistical analysis was done using SPSS 17. Mean, Median, Maximum, Minimum, Range and Standard Deviation was calculated for all the metals at different locations. Also, correlation coefficients were obtained between the metals observed at different locations in street dusts of Delhi. It was used to establish the correlation between different metals, further implicating the possible source of their concentration level. One-way ANOVA was used to determine the existence/ non-existence of variations within and between groups for all the sites.

RESULTS & DISCUSSION:

The concentrations of Cr, Fe, Al and Ca were observed to be high in samples collected from most of the sites (10 sites: Site no. 1, 2,3,4,5,6,7,8, 11 and 14). Site 9 had high concentrations of Cu and Zn along with Cr, Fe, Al and Ca. Site no. 10 and 13 showed little contamination of Zn in the range of 45.6 mg/l and 89.6 mg/l. Higher levels of Cu and Zn were observed in the samples collected from site no.12. These values are quite high in comparison to other reported studies from various countries. Lead concentration was observed to be lower in comparison to previous study from same city.

Zn contamination may be a result of its release from vehicle tyre wear and tear process as Zn metal incorporated by rubber manufacturing industry in the vulcanization process. (Smolders and Degryse, 2002).High concentrations of **Cu** in the samples collected from industrial sites, i.e. Site no.9 and 12, were observed. It can be a result of abrasion of vehicle parts. According to Al- Khashman (2004), the Cu and Zn contamination of roadside soils result from the abrasion of vehicle parts such as brake lining, oil leak sumps, and cylinder head baskets. Source of **Cr** contamination can be vehicular pollution (Balachandran et al., 2000; Khillare et al., 2004).

Table 1: Delhi samples- location with their description.

SITE	LOCATION/ AREA/DESCRIPTION	DUST COLLECTED (g/cm^2)
1	Near bus stand Dilshad Garden-Jhilmil area(residential area)	0.016
2	Near Reebok factory price shop, Govindpuri-Kalkaji (residential area)	0.008
3	Opposite Falcov industry Okhla industrial area- Phase II(slum areas)	0.033
4	Stand no.112- Anand Vihar ISBT (bus stand with heavy traffic)	0.010
5	Stand no.18- Anand Vihar ISBT (bus stand with heavy traffic)	0.011
6	Near Gurudwara Govindpuri-Kalkaji (residential-cum- commercial)	0.024
7	Airtel communication, Okhla industrial area- Phase II(industries e.g. paint)	0.128
8	Near petrol pump Way to Anand Vihar from Dilshad Garden	0.118
9	Near classic company Patparganj industrial area (commercial area)	0.055
10	Front of Radhakrishna mandir Dilshad Garden- (a marketplace)	0.06
11	Delhi Jal Board Okhla industrial area- Phase II (open road side shops)	0.010
12	Backside of Sahwney industry Jhilmil area (heavy traffic load)	0.052
13	Stand no.8- Anand Vihar ISBT (bus stand with heavy traffic)	0.038
14	Opposite Toyota showroom Patparganj (industrial area)	0.22

Table 2: Street dusts in different samples of street dusts from different cities/countries- a comparison (values in mg/kg)

City/Country & Reference	Cd	Cr	Pb	Fe	Ni	Cu	Mn	Zn	V	Al	Ca
Delhi (India), Present study	5.711[a]	4587.74[a]	179.6429[a]	18399.84[a]	83.1028[a]	1052.32[a]	413.0[a]	1504.13[a]	77.7842[a]	32425.4[a]	5786.3[a]
Calcutta (India) Chatterjee &Banerjee (1999)	3.12	-	536	-	42	44	-	159	-	-	-
Delhi (India), A.D.K.Banerjee(2003)	18.96[a]	4816.93[a]	597.63 [a]	-	574.56 [a]	721.50 [a]	-	365.92 [a]	-	-	-
USA, E.Apeagyei et al. (2011)	-	95 [a]	73 [a]	28,091 [a]	-	105 [a]	456 [a]	240 [a]	-	-	9185 [a]
China, T.Yang et al.(2010)	-	75.3 [a]	102.6 [a]	-	27.7 [a]	62.1 [a]	602.9[a]	224.2 [a]	65.6 [a]	-	-
Paris (France) Pagotto et al. (2001)	1.7	-	1450	-	25	1075	-	840	-	-	-
Kavala (Greece) Achilleas and Nikolaos (2009)	0.2	-	301	-	58	124	-	272	-	-	-
Ottawa (Canada) Rasmussen et al. (2001)	0.37	-	39.1	-	15.2	65.8	-	112.5	-	-	-
Austria, Zechmeister et al. (2005)	0.431[a]	0.81[a]	7.3[a]	259[a]	16.5 [a]	70 [a]	-	37.4[a]	1.38 [a]	136.3[a]	2192 [a]
Girona (Spain) Amato et al.(2011)	2[a]	-	128 [a]	-	191 [a]	1055	-	1760 [a]	-	-	-

[a] mean value used

All the sites excepting site no.10, 12 & 13 showed high concentrations of **Fe.** The Fe is known to be of crustal origin and is found in Delhi's loosely bound dust (Srivastava and Jain, 2007). **Cd** is released as combustion in vehicles (Al- Khashman 2007 a, b; Divrikli et al., 2005). Bone damage and kidney dysfunction results due to low levels of Cd (Alfven et al., 2002; Buchet et al., 1990). The street side of Delhi contains significant amount of **Ca** (crustal re-suspension) (Balachandran et al., 2000; Srivastava and Jain, 2007). **Pb** is ubiquitous in industrialized regions. Among the applications of lead, it can be said that paints, varnishes, pipes, storage batteries and insecticides are the major areas where Pb is used (Venugopal and Luckey, 1978). The major use of **Ni** is in plating the vehicle or its parts. It may be applied on outer part of a vehicle or on the surface of the cylinder and pistons of an engine (Hidayah and Amran, 2008).**Mn** may result as a consequence of industrial activities (V. Shridhar et al., 2010). Site no.8 is a zone near to petrol pump where heavy diesel ad petrol vehicles pass through the road. Mn- based additives in gasoline are used to increase gasoline octane, and Mn is emitted by vehicles as brake- dust (A. V. Kumar et al., 2001; A. Tandon et al., 2008).

CONCLUSION:

Al has the highest mean concentration of all the metals studied, while Mg and Cd had the least. Site no.9, which was an industrial area, had high concentration of Zn, Cu, Fe, Ca, Pb, Ni, Mn, and V. Industrial areas reported high concentrations of Cr, Fe, Al, Ca (11 sites study) along with Cu and Zn (2 sites study). The high concentrations of these metals can be a product of industrial activities and heavy movement of vehicles (accounting for vehicle wear, abrasion parts wear, re-suspension of dust). Besides anthropogenic activities, natural sources of trace metals do account for heavy pollution of metals in the street dusts of Delhi (such as Ca and Fe), which are present in loosely bound soil of Delhi. Thus, an important conclusion which can be drawn is that anthropogenic sources are the major contributors to the trace metal pollution in Delhi, an area which registers high rates of street dust metal pollution as a consequence of traffic emission and industrial establishments.

Correlation coefficient analysis indicated that industrial activities are the source of Cd, Ni &Cu, and Pb, Mn, Zn and V. Fe, Mn, Ni, V, Al are a result of dust re-suspension, while Mn, V, Al and Ca are traffic related sources. One-way ANOVA analysis clearly indicates that there exists a variation in their concentration between the metals studied within groups.

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