Heavy Metals Deposition in Urban Environment in Rewa M.P.

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Abstract:

Due to rapid industrialization and urbanization lead atmospheric deposition of heavy metals and dust load to become a global problem. The deposition of dust and seven heavy metals (Pb, Cd, Ni, Zn, Mn and Cu) at selected urban and sub – urban sites of Rewa. Dust- fall samples from different sampling location collected and selected heavy metals viz. Pb, Cd, Cr, Ni, Zn, Mn and Cu in them determined by atomic absorption spectrophotometer. Average flux of 2.88, 0.33, 2.96, 12.22, 22.27 and 2.89 g h-1 y-1 measured for Pb, Cd, Cr, Ni, Zn, Mn and Cu respectively. The result has shown that dust load significantly higher in summer and winter as compared to rainy season. The deposition rate of Ni, Pb, Mn and Cr were significantly higher during summer and that of Cd, Cu and Zn deposition rates were highest during winter.

Keywords: Heavy metal, atmospheric deposition, urban environment.

INTRODUCTION:

Atmospheric activities have dramatically raised the atmospheric concentration of pollutants and trace elements in many parts of the world. Although some developed countries such as USA have witnessed some control, atmospheric emissions of pollutants and trace elements are continue to rise in many developing countries including India.[1] reported 190.0, 120.0, 50.0, 140.0 and 142.0 mg of Ni, Zn, Cu, Cr, and Mn per Kg of atmospheric particulates in the vicinity of an integrated Cement plant in Bela in India. Reported atmospheric load of Pb – 64.5, Cr – 4.32, Cd – 0.41 and Ni – 3.15 ngm-3 in La Plata, have also reported that atmospheric load of Pb, Cr, Cd, Ni in Southeast Chicago, USA were 127.0, 11.2, <4.0 and 4.8 ngm-3.2-3 Due to rapid urban and industrial development most parts of our country are receiving increasingly high levels of gaseous and particulate pollutants. The latter contains a variety of toxic trace elements. Depending upon the size, nature and climatic variables these pollutant elements eventually deposit of ground surfaces thereby contaminating the soil, water, dietary

vegetable and crops. The last two decades have witnessed extensive data collection from all over the world on atmospheric deposition of trace elements.

An atmospheric flushing of Cu, Zn, Pb, Cd in New Brunswick, Canada were 0.10 – 49.7, 3 – 401, 0.046 – 20.1, 0.007- 313 g ha-1yr-1.4 An atmospheric deposition of Zn, Cu, Pb, Cd in Amman, Jorden were 2474, 462.8, 344.8, 12.5 μg m-2 mon-1.5 The total atmospheric flushing of Cd, Co, Cu, Ni and Zn in Aliage Industrial site,6 Turkey were 0.18, 0.35, 6.0, 3.7 and 220 μgm-2d-1. Vousta *et al*, have reported 7 – 1020, 3.2 – 24, 0.76 – 78m-3 of Pb, Cr, and Cd of atmospheric particulate in Ionia, Greece. 7In India, The substantially high input of airborne trace metals at Madhya Pradesh. Similar observation in Rewa, that atmospheric deposition of heavy metals are significantly higher and it is clearly defined that the urban and industrial activities of the city, have potential to elevate the levels of heavy metals in the atmospheric deposits, which may consequently contaminate the soil, air and water and thus posing health risk to the local population. [8]

MATERIAL AND METHOD:

The climate of the city is dry tropical with three distinct seasons i.e. summer, winter and rainy. The summer season (March – June) in Rewa is usually dry, associated with strong hot winds, high temperature during the day ranging between 28 – 46^0C, relative humidity 26 – 47% and infrequent pre – monsoon rain. Rainy season starts end of June and continues until mid-October. During rainy season, the temperature varies from 22 – 33^0C and relative humidity from 65 – 92%. Winter season starts in November and continues until February, temperature ranges between 08 – 22^0 C; relative humidity varies between 38 – 77%. Rewa city is one of the most densely populated cities of India having many small-scale industries, compact residential areas and congested narrow roadsThe numbers of vehicles plying in the city are more than 1, 00,000.

Sampling Sites: The present study carried out from November 2011 to October 2012 in urban and suburban areas of Rewa. Twelve different sampling sites based on heavy traffic, residential, commercial and sub-urban areas selected. Sampling was carried out simultaneously at all the 12 sites for one year period with deposition dust collector having 6.8 to 7.8 cm diameter of mouth area. The deposition dust collectors placed at the height of about 3 – 5 m from the earth surface at selected sites. After the collection of dust, measured the dust fall rate.

Dust fall rate = Weight of dust / mouth area of dust collector

The sampling zone location and their details given in **Table-1.**

Table- 1: Characterization of sampling sites.

S. No	Sampling Locations	Traffic load	Population load	Land uses
1	Padhra (pad)	Medium	Dense	CA, RA
2	*Chorahta (ch)*	Heavy	Dense	CA, IA, RA
3	Sirmour road (Sr)	Medium	Dense	CA, RA
4	Bajrang Nagar (Bn)	Low	Sparse	RA, CA
5	Indira Nagar (In)	Medium	Dense	CA, RA
6	Bansghat (Bg)	Medium	Sparse	CA, RA, IA
7	Saman (Sa)	Medium	Dense	CA, RA
8	Nehru Nagar (Nn)	Low	Sparse	RA
9	Bela (Be)	Heavy	Dense	IA, CA
10	Amahiya Road (Am)	Medium	Dense	CA, RA
11	Dwarika Nagar (Dn)	Low	Sparse	RA
12	Jaypee Road (jr)	Heavy	Dense	IA, CA, RA

CA = commercial area, RA = residential area, IA = industrial area

Analytical Method:

After collection of samples from each sites the atmospheric dust were analyzed by tri acid (69% high purity HNO3, 70% HClO4 and 98% H2SO4; 5: 3: 3) digestion method. Tri – acid mixture (15 ml) were added to the beaker containing 1 g atmospheric dust and heated at 800C till the solution become transparent. 9 The resulting solution cooled and filtered through Whatman no. 42 filter paper. The filtered solution was finally maintained to 50 ml using deionized water and kept at room temperature for further analysis of heavy metals. Atomic Absorption Spectrophotometer (Model 2830 Perkin – Elmer, Inc., Norwalk, CT, USA) achieved determination of the elemental composition of the filtrate. The instrument was calibrated using manually prepared standard solution of respective heavy metals. Acetylene gas used as the fuel and air as the support. An oxidizing flame used in all cases.

Statistical analysis:

Mean values supported with SE and range to justify the variability. All statistical analyses performed using the Microsoft SPSS (version-10) and all graphs e plotted through sigma plot - 8.0.

RESULTS AND DISCUSSION:

The annual dust deposition rates at 12 selected sampling locations in urban and sub-urban areas of Rewa. The seasonal variations of dust deposition rate which presented in mean ± 1SE (n=3). The seasonal variations of dust deposition rate are higher during the summer and winter seasons as compared to rainy season.10 ascribed the reason for the lowest deposition rates in rainy season to washout effects of frequent rainfall events. The result showed that BE, JR and CH, which are heavy traffic areas, receives high amount of dust load 18.36 ± 0.099, 13.77 ± 0.077 and 13.12 ± 0.132 t ha-1 yr-1 respectively in summer season. These sampling location receive high dust load in other seasons too. In winter season these sites received 17.58 ± 0.038, 11.66 ± 0.030 and 11.74 ± 0.045 and in rainy season, 11.17 ± 0.056, 7.54 ± 0.172 and 6.30 ± 0.169 t ha-1 yr-1 respectively. Minimum dust deposition were found in BN, NN and BG in summer which is 6.23 ± 0.086, 6.35 ± 0.120 and 6.32 ± 0.101 t ha-1 yr-1 respectively. But in winter season, minimum dust load was found in BN, NN and BG, which are 5.34 ± 0.066, 5.53 ± 0.034 and 6.15 ± 0.041 respectively.

In rainy season, the minimum dust deposition receiving sites are BN, DN and BG, which received 2.32 ± 0.054, 2.63 ± 0.034 and 2.92 ± 0.279 t ha-1 yr-1 respectively. The dust deposition rate varied between 18.36 t ha-1 yr-1 at BE in summer and 2.32 T ha-1 yr-1 at BN campus during the rainy season. Minimum values found during rainy and maximum in summer. During the rainy season, dust deposition rate decreases 50% as compared to summer season. During March – June, high rate of dust fall could be due to air borne dust because of frequent nor-western. During rainy season, they are washed out more or less efficiently by rain but in other season, dry deposition is predominant. According to the US researchers, dust fall rates in tropical environment, as India found to be many times higher than in temperate countries climate, like USA.[11]

Deposition of Heavy Metal:

The results showed that, deposition of Cd, Cr, Cu, Mn, Ni and Zn were significantly higher during summer and winter season as compared to rainy season. In summer, atmospheric deposition rates of Cd (g ha-1 yr-1) ranged from a minimum of 0.216 at NN to a maximum of 0.580 at JR, in winter season, Cd deposition rate ranged, from a minimum of 0.238 at NN to maximum of 0.290 g ha-1 yr-1 CH. In rainy season, deposition of Cd was lowest at DN, which was 0.059 And highest at JR, 0.290 g ha-1 yr-1. On an average, the Cd deposition found to be 0.338 g ha-1 yr-1 which is 0.04 × 10-4 % of total annual dust-fall of Indore city. The concentration of Cd in dust-fall was found to be highest at PAD 0.047 ± 0.003, which ranges between 0.042 – 0.051 and the lowest at SR 0.021 ±

0.001 which ranges between 0.019 – 0.024 mg kg-1. Most of the Cd comes from anthropogenic sources. The important sources of Cd are coal and oil combustion. Chronic exposure to Cd can result in respiratory illness, hypertension and heart enlargement resulting in premature death. In summer, Cu deposition was highest at BE, which was 5.786 g ha-1 yr-1, in winter season, deposition rates of Cu (g ha-1 yr-1) maximum at BE, which was 5.857 and minimum deposition 0.246 g ha-1 yr-1 at DN. In rainy season, Cu deposition rate ranged maximum at BE and minimum at DN, which is 3.769 – 0.448 g ha-1 yr-1. On an average the Cu deposition rate was found to be 2,907 g ha-1 yr-1, which is 0.349 × 10-4 % of the total annual dust-fall of the city. The concentration of Cu in dust-fall found highest at PAD 0.529 ± 0.0031, which ranges between 0.523 – 0.533 mg kg-1 and the lowest concentration found at DN, 0.177 ± 0.001, which ranges between 0.175 – 0.179 mg kg-1. In summer, deposition rate of Ni was highest at JR, which was 6.840 g ha-1 yr-1 and lowest 1.235 g ha-1 yr-1 at BN, in winter season, highest deposition at BE, which was 7.899 g ha-1 yr-1 and 1.745 g ha-1 yr-1 lowest deposition at AM. In rainy season, Ni deposition rate was highest at JR, where deposition rate was 4.521 g ha-1 yr-1 and lowest at DN where deposition rate was 0.631 g ha-1 yr-1.
On an average, the Ni deposition in city found to be 2.907 g ha-1 yr-1, which is 0.356 × 10-4 % of the total annual dust-fall of Rewa. The concentration of Ni in dust-fall found highest at RR 0.502 ± 0.002, which ranges between 0.500 – 0.505 mg kg-1 and the lowest concentration was found at SR 0.176 ± 0.001, which ranges between 0.175 – 0.177 mg kg-1. Ni in the atmosphere originates from the combustion of fossil fuel, smelting, crustal sources and volcano. It is also found that combustion of oil and incineration of waste contributes more than 70 % of total Ni to the atmosphere from man-made sources followed by refining process with 17 % (IPCS, 1991b). Continuous and prolonged exposure to Ni can produce dermatitis and disorders in the respiratory system.

It is also a possible carcinogen. Deposition rate of Pb (g ha-1 yr-1) was to be maximum of 9.62 at JR to minimum of 1.268 at DN in summer; in winter, maximum deposition rate of Pb was 8.53 g ha-1 yr-1 at JR and minimum deposition rate of Pb 1.47 g ha-1 yr-1 at NN. In rainy season, maximum deposition 5.07 g ha-1 yr-1 was at JR and minimum at BN, where deposition rate was 0.55 g ha-1 yr-1. On an average, the Pb deposition found to be 2.88 g ha-1 yr-1, which is 0.35 × 10-4 % of the total annual dust load of the city. The concentration of Pb in dust-fall found highest at JR, 0.707 ± 0.002, which ranges between 0.704 – 0.710 mg kg-1 and the lowest concentration, found to 0.185 ± 0.002 at SR, which ranges between 0.182 – 0.188 mg kg-1. The Pb concentration found in various environmental compartments bordering a roadway is a function of a no. of factors, including distance and meteorology. 12 It has been recorded that only 25 % of Pb emitted by vehicles are in coarse fraction and thus, deposit close to roads. The

remaining 75 % in fine fraction and so may remain air borne contaminating areas more remote from the point of its emission. 13-14 In summer, highest Cr deposition was found at BE and lowest deposition rate at NN where range of deposition was 9.635 – 1.534 g ha-1 yr-1, in winter season Cr deposition rate was highest at BE which was 10.94 g ha-1 yr-1 and lowest Cr deposition rate was found at DN, where deposition rate was 1.24 g ha-1 yr-1. In rainy season, highest deposition rate found at BE where, deposition is 7.01 g ha-1 yr-1 and lowest deposition at Orderly bazaar where deposition rate was 0.72 g ha-1 yr-1. On an average, the deposition of Cr in city found to 2.96 g ha-1 yr-1, which is 0.36 × 10-4 % of total annual dust deposition of Rewa.

The concentration of Cr in dust-fall found highest at BE 0.522 ± 0.002, which ranges between 0.51 – 0.52 mg kg-1 and the lowest concentration was found 0.178 ± 0.0006, which ranges between 0.17 – 0.172 mg kg-1. Cr originates from combustion of fossil fuel and industrial activities. Long exposure of Cr to workers and neighbors of industries can cause irritation of respiratory system; perforation of nasal passage and lung cancer, chronic exposure may also lead to liver and kidney damages. In summer, highest deposition rate of Zn was found at JR, which was 36.98 g ha-1 yr-1 and lowest 3.81 g ha-1 yr-1 at DN. In winter, highest deposition rate was found at JR and lowest at DN, which was 38.81 to 3.19 g ha-1 yr-1, and in rainy season, highest deposition rate of Zn was found at RR which 19.32 and lowest at NN which was found to 12.22 g ha-1 yr-1 which is1.47 × 10-4 % of total dust deposition per year in Rewa. The concentration of Zn in dust – fall found highest at JR, 3.634 ± 0.0645, which ranges between 3.52 - 3.74 mg kg -1 and lowest concentration was found to 0.350 ± 0.009 at BE, which ranges between 0.21 - 0.53 mg kg -1. Atmospheric deposition rate of Mn, highest at JR, which is 50.72 g ha-1 y-1 and lowest at BN, which is 13.71 g ha-1 y-1 in summer, in winter season, highest Mn deposition rate was found at CH, where, deposition rate was 45.49 g ha-1 y-1 and lowest rate was found at SR, which was 13.20 g ha-1 y-1 , in rainy season, highest deposition rate was 25.93 g ha-1 y -1 found at JR and lowest deposition rate was found at BN, which was 6.17 g h-1 y-1. On an average, the deposition of Mn in city found to 22.27 g h-1 y-1 which is 2.67×10-4% of total annual dust deposition of Rewa. The concentration of Mn in dust – fall found highest at CH 3.795 ± 0.010, which ranges between 3.59 – 3.91 mg kg-1, and lowest concentration found at SR 1.23 ± 0.031, which ranges between 1.17 – 1.28 mg kg-1. The deposition rate of Ni, Pb, Mn and Cr were significantly higher during summer and winter season as compared to rainy Cd, Cu and Zn deposition rate was significantly higher in winter and summer as to rainy season. Depositions of all heavy metals were lowest in rainy season. The results of seasonal variations in heavy metal deposition rates showed that frequent rain fall during rainy season removed the particulates containing heavy metals from the atmosphere that

resulted into least deposition rates of all ascribed the season for the lowest deposition rate in rainy season to washout effects of frequent rain fall events. During late summer season, when rain fall starts, fine particulates attached to rain droplets can also gather contaminants from wider area and from greater heights than sampling locations.10,15 These factors could lead to an increase in atmospheric deposition heavy metals in summer.

Table- 2: Concentration of heavy metals (mg kg-1) at twelve selected sampling locations in Indore. Values are mean ± 1SE (n= 3) and ranges are in parentheses.

SN	Sites	Cd	Cu	Ni	Pb	Cr	Mn	Zn
1	PAD	0.047 ± 0.003 (0.042 - 0.051)	0.53 ± 0.003 (0.523-0.533)	0.44 ± 0.001 (0.44 -0.444)	0.32 ± 0.003 (0.320 -0.330)	0.39 ± 0.001 (0.382 -0.388)	2.40 ± 0.085 (2.234 -2.516)	3.63 ± 0.065 (3.520 -3.741)
2	CH	0.043 ± 0..002 (0.041- 0.024)	0.25 ± 0.003 (0.341-0.255)	0.484 ± 0.018 (0.481-0.487)	0.368 ± 0.0033 (0.360 - 0.370)	0.322 ± 0.388 (0.320 - 0.324)	3.79 ± 0.099 (3.598 -3.912)	0.917 ± 0.142 (0.889 - 0.935)
3	SR	0.21 ± 0.001 (0.019 - 0.024)	0.35 ± 0.021 (0.341 - 0.348)	0.176 ± 0.0005 (0.175 - 0.177)	0.185±0.0017 (0.182 - 0.188)	0.179 ± 0.0014 (0.177 - 0.182)	1.23 ± 0.314 (1.179 - 1.288)	0.878 ± 0.0611 (0.757 - 0.952)
4	BN	0.041 ± 0.001 (0.039 - 0.042)	0.47 ± 0.015 (0.466 - 0.471)	0.19 ± 0.001 (0.198 - 0.199)	0.21 ± 0.001 (0.207 - 0.210)	0.30± 0.0015 (0.299 - 0.304)	2.26 ± 0.105 (2.103 - 2.459)	1.91 ± 0.025 (1.857 - 1.936)
5	IN	0.034 ± 0.001 (0.032 - 0.036)	0.22 ± 0.004 (0.219 - 0.231)	0.24 ± 0.017 (0.243 - 0.249)	0.33 ± 0.032 (0.299 - 0.396)	0.27 ± 0.0015 (0.265 - 0.270)	2.30 ± 0.122 (2.120 - 2.535)	2.31 ± 0.140 (2.042 - 2.516)
6	BG	0.045 ± 0.001 (0.044 - 0.047)	0.26 ± 0.004 (0.251 - 0.266)	0.34 ± 0.001 (0.341- 0.343)	0.42 ± 0.001 (0.418 - 0.422)	0.43 ± 0.001 (0.427 - 0.432)	2.70 ± 0.178 (2.358 - 2.956)	0.744 ± 0.067 (0.625 - 0.856)
7	SA	0.030 ± 0.001 (0.028 - 0.032)	0.48 ± 0.001 (0.481- 0.485)	0.41 ± 0.001 (0.410 - 0.413)	0.32 ± 0.001 (0.319 - 0.322)	0.44 ± 0.001 (0.440 - 0.444)	2.78 ± 0.042 (2.699 - 2.829)	2.44 ± 3.11 (2.233 - 2.594)
8	NN	0.033 ± 0.001 (0.031 - 0.035)	0.22 ± 0.003 (0.211 - 0.222)	0.43 ± 0.002 (0.422 - 0.429)	0.21 ± 0.002 (0.207 - 0.215)	0.235 ± 0.001 (0.232 - 0.237)	2.78 ± 0.073 (2.648 - 2.900)	0.69 ± 0.056 (0.588 - 0.782)
9	BE	0.027 ± 0.001 (0.025 - 0.028)	0.31 ± 0.001 (0.311 - 0.317)	0.25 ± 0.001 (0.244 - 0.249)	0.34 ± 0.001 (0.340 - 0.344)	0.52 ± 0.002 (0.519 - 0.526)	2.18 ± 0.052 (2.113 - 2.283)	0.35 ± 0.094 (0.211 - 0.530)
10	AM	0.04 ± 0.001 (0.039 - 0.041)	0.32 ± 0.001 (0.316 - 0.321)	0.22 ± 0.009 (0.215 - 0.218)	0.29 ± 0.001 (0284 - 0.290)	0.19 ± 0.001 (0.177 - 0.179)	3.18 ± 0.030 (3.120 - 3.225)	0.53 ± 0.075 (0.379 - 0.628)
11	DN	0.03 ± 0.001 (0.035 - 0.038)	0.18 ± 0.001 (0.175 - 0.179)	0.22 ± 0.001 (0.222 - 0.226)	0.38 ± 0.001 (0.377 - 0.381)	0.22 ± 0.002 (0.217 - 0.223)	2.29 ± 0.118 (2.056 - 2.433)	0.78 ± 0.086 (0.682 - 0.952)
12	JR	0.04 ± 0.001 (0.041 - 0.044)	0.38 ± 0.003 (0.370 - 0.381)	0.50 ± 0.001 (0.500 - 0.505)	0.71 ± 0.002 (0.704 - 0.710)	0.41 ± 0.001 (0.410 - 0.414)	3.73 ± 0.137 (3.486 - 3.961)	3.23 ± 0.085 (3.093 - 3.385)

CONCLUSION:

The present study showed that atmospheric deposition rate of metals and dust load in urban areas of Rewa were significantly elevated reflecting strong anthropogenic inputs through urban, vehicular and industrial activities. In urban areas of the city normally dust deposition and metal deposition (Mn, Cr, Pb, Ni, Zn, Cu and Cd) are higher in compression to sub – urban areas. The elemental composition of deposit dust shows highest level for Mn and lowest for Cd. The seasonal variation had shown that deposition of dust and mostly metals significantly higher in summer and lowest during rainy.

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