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Soil as a Source Contributor in Mineral Dust Fallout at Urban Industrial Residential Area

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Abstract

The components and quantities of atmospheric dusts fallout has been reported to be the pollution indicator of large urban areas. The multiplicity and complexity of sources of atmospheric dusts in urban regions (e.g. industrial complexes composed of a variety of industrial processes, automobiles, construction activities etc.) has put forward the need of source apportionment of these sources indicating their contribution to specific environmental receptor. The study presented here is focused on investigation of source contribution estimates of dusts fallout in an urban-industrial area, Raipur, India. Six sampling sites have been identified on the basis of land use for development plan of anthropogenic activities and factors related to the transportation and dispersion pattern of atmospheric dusts. 12 samples of dusts fallout has been collected from each site (one in each month) and subjected to chemical analysis of selected chemical constituents known as markers of selected major dust emitting sources(Steel making average, Road traffic-borne dusts, construction activities, municipal waste burning, and soils). Chemical profiles alongwith SPECIATE of USEPA has been used for the preparation of source profiles. Source apportionment has been done using Chemical Mass Balance (CMB 8). Good fit parameters and relative source contribution has been analyzed and documented. Variations in source contribution estimates of selected indicator species has been occurred and justify the significant contribution of local area and line sources of dusts emission in various parts of the study region. Soil has shown different contribution for different radical.

Keywords: *Soil, Mineral Dust fallout, Urban industrial residential area.*

Introduction

Multiplicity and complexity of dusts emission and transportation has justified the need to determine relative contribution of coarse dusts from specific source [1, 2 & 3]. It is possible to use statistical techniques to derive source category signatures, identify indoor-outdoor source category signatures, and estimation of their contribution to dusts of receptors [4, 5 & 6]. The effective variance weighed chemical mass can be used for source apportionment of air pollution studies [7, 8 & 9]. A chemical mass balance model (CMB 8, EPA) consisting a set of solution of linear equations to express each receptor chemical concentration as a linear sum of products of source profile abundances and source contributions has been defined [10, 11, 12, 13, 14, 15 &16]. The presented work has been focused on source apportionment of dust fallout in selected classified urban residential receptor of Raipur City, District Raipur, India which located in global scale of: 21°14’22.7” N latitude and 81°38’30.1” E longitudes. Regression analysis between various longitudinal measurements of selected and defined dust deposit regions has been utilized to identify possible sources/routes of dust transport to a receptor region.

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Chemical mass balance (CMB8, EPA) has been executed to investigate source contribution estimates of dust fallout in a specific ambient-outdoor receptor located in a residential area.

Increasing severity of dispersion and fallout of fugitive dusts in urban areas of India has shown spontaneous linkage with higher degree of health disorders especially bronchial ailments [17, 18, 19, 20, 21 & 22]. Due to higher settling tendency of bigger particles of dust near emission sources on a regional scale, researchers have made classification of its reception pattern as ambient-outdoor, street-outdoor and indoor dust fallout [23, 24, 25 & 26]. Due to presence of a variety of point, line and area sources of dusts emission along with higher degree of variation in meteorological parameters, a non-uniform distribution of dusts in various environmental media has been reported earlier [25]. Close deposition pattern and higher degree of relative contribution from local sources, especially temporary dust formation sources, compared to suspended fine particulates has been reported in earlier investigations [28, 29, 30, 31, 32, 33, 34 & 35] have characterize the street dusts to investigate Zn as tire dust indicator in Japan using reference work done in the field of chemical apportionment of road-traffic settleable dusts earlier [36 & 37]. Atmospheric deposition of vanadium, lead, chromium, copper, zinc and nickel has been described earlier [38, 39, 40, 41, 42 & 43]. Large size particles of

dusts fallout in urban regions has been reported to be the major cause of prevalence of asthma (occur at upper nasal area) compared to association of fine particulates with inner respiratory disorders [44, 45, 46 & 24].

2. Materials and method (study design, sampling plan and data analysis)

2.1 Study Design

The study was undertaken in urban areas. The goal of the study is to evaluate relative source contribution estimates of various routes of dust fallout in urban residential environment. The objectives here are: (1) To measure and characterize dust fallout at identified sources (2) to analyze statistically, the relationship between dust fall measurements of source-routes and residential receptors and (3) to carryout apportionment of dust fall at residential-receptors, taking identified atmospheric routes as possible sources using Chemical mass balance Model (CMB8). A residential area (Birgaon) located in close proximity to a major industrial area (Siltara) has been selected for the study. Apart from two major industrial sources of dusts emission, local soils, paved road dusts and automobile exhaust emissions along with construction activities have also been identified to cluster of source profiles for source apportionment. The details of location of residential colony (receptor), major industrial complexes, windrose and wind channels have been shown in Fig 1

2.2 Sampling Design

A comprehensive study about source contribution estimates of major possible and observable sources of dusts emission to dust fallout of urban areas (residential, commercial and sensitive regions) was started from yr 2007. Source apportionment study of dust fallout of a specific urban-residential region has been presented here. A non-probability based longitudinal stratified random sampling design in space-time frame work has been chosen to achieve the objectives [47 & 24]. Ambient-outdoor has been decided as atmospheric measurement levels at identified sources of dust emissions and residential-receptor, respectively (Table 1).

2.3 Sampling Method of Dust Fallout:

Dust emission sources were identified using layout map, anthropogenic activity patterns and urban-industrial development plan of the study area. The identified sources (Table 1) were classified in point, line and regional sources of dust emission [18]. Dust collection Jars (Dimension: dia-23" ht- 45") with standard specifications [48 & 49] has been placed for a month at a height of 10 ft (ambient-outdoor), at both source and receptor sites, 5 ft (local street-outdoor) and 1 ft (indoor-house) at receptor sites. Sampling at local-outdoor (5 ft height) has been chosen for measurement at construction activity site. In case of sampling at paved road source (S-3), sampler was installed at the height of 5 ft at major cross road passing near to the residential colony. About a liter of double distilled water was placed in each Jar and a net sheet (size: 20 mesh) was placed on mouth of the Jars. Water soluble and insoluble fraction of dust fallout has been measured separately and by adding them, total dust fallout was measured. Five replicate measurements were done to minimize weighing error (Table 2).

As far as soil chemical profile (S-6) is concern, samples of soils (1 kg) have been collected from open land of residential colony. Soil samples were collected after removing surface soils up to 6 cm (to avoid plant and animal organic, inorganic and microbial contamination on the surface soil) depth and sent to laboratory. Soil has been smashed in a milling machine and blown in a closed glass chamber (size 1.5 m^3) using a pressure fan. The dust collecting jars has been placed in the chamber and collected dust during dispersion of soil dusts in the chamber [50]. Black smoky dust emitted and deposited in automobile exhaust silencers of diesel fuel based heavy duty trucks and petrol based cars have been collected and scum were mixed together for development of chemical profile of automobile source (S-5). Vehicles have been selected randomly which mostly passes through that road junction. About 5-10 g of exhaust emitted black smoky dust has been collected. Frequency of sampling was 12 (one in each month) at each source-receptor site throughout the sampling-period (December 2007 to November 2008).

The dust fall rate was calculated for each site using the following equation [52]:

$$R = 1{:}273(W/D)^{2} \times (30/N) \times 10^{4}$$

Where,

R = Dust fall rate (metric tonne (mt) km^{-2} $month^{-1}$);

W = the total weight of dust fall-out in the collecting container (g);

D = the diameter of the dust collecting container (cm);

N = the number of days of collection of sample.

2.4 Chemical Analysis of Dust Fallout

Specialized cleaning and sampling techniques were used during all stages of sample collection to prevent contamination. All containers and equipment used for sampling were cleaned using a dilute liquid soap followed by a hydrochloric acid solution and multiple rinses in ultra pure, deionized (DI) water, following standard protocols. The dust fallout after the sampling immediately transferred to the laboratory. The samplers were washed with double distilled water and filtered by using wattman filter paper no.42 in pre-washed polyethylene bottles. The bottles were filled up

to neck and then added few drops of acid mixture (Sulfuric acid H_2SO_4 and Hydrochloric acid HCl, 1:1) to maintain the pH about1-2. The dust fall which is collected on filter paper was stored in zippered polyethylene. All collected samples stored at 5·C or less until chemical analysis. The samples were taken for digestion in the Teflon digestion bomb and added nitric acid (HNO_3) and hydrogen peroxide (H_2O_2) (3:1). The Teflon bomb was then kept in an electric oven at 60º C for five hour. After five hours Teflon bomb was cooled, content was filtered in a volumetric flask and washed with dilute nitric acid (HNO_3).

Table 1. Identification and grouping of defined sources and receptor in the study area

S.No.	Name of Source/receptor	Type	Classification of monitoring level	Site characteristics	Sampling Frequency
Source sites					
S-1	Siltara industrial area	Stationary point	Ambient-outdoor	Most of the industries are: casting, sponge iron, steel foundries.	**12** samples throughout the sampling year(One in each month)
S-2	Urla Industrial, area	Stationary point	Ambient-outdoor	Most of the industries are: casting, chemical, oil production, glass and plastics.	
S-3	Paved road	Line	outdoor	Re-suspended dusts of road side runoff measured at 3ft height	
S-4	Civil construction	Area	Ambient-outdoor	Dusts emitted from handling of raw materials used in civil construction site	
S-5	Automobile	Point	Emission outlet	Mixed dust fraction emitted from silencer of truck, cars and two wheelers	
S-6	Local soils	Area source	-	Re-suspension of soil dusts	
R-1		Birgaon, Raipur	Residential area	Residential area located northeasterly and downwind to industrial complexes	**12** samples throughout the sampling year(One in each month)

Table 2. Yearly average dust fallout ($mt.km^{-2}.month^{-1}$) monitored in selected classified receptor and source sites.

Yearly average of Dust fall at source and receptor sites						
S.No	**Site No**	**Minimum**	**Max**	**Geo.mean**	**STDV**	**R^2**
01.	S-1	131.51	391	181.186	77.974	43.03%
02.	S-2	178.54	245.29	217.429	24.414	11.23%
03.	S-3	122.73	186.25	141.435	18.324	12.96%
04.	S-4	67.71	116.54	87.845	16.366	18.63%
05.	S-5	ND	ND	ND	ND	ND
06.	S-6	ND	ND	ND	ND	ND
07.	R-1	51.784	119.64	77.592	25.488	32.85%
08.	R-2	12.342	18.923	14.314	2.388	16.68%
09.	R-3	61.56	143.56	84.291	22.355	26.52%

Final volume of the digested sample was made to 25 ml using distilled water. Digested samples and soluble fraction of dust fallout measured during field sampling were analyzed for Mn, Fe, Ni and Pb content using inductive coupled plasma-atomic emission spectrophotometer (ICP-AES) (JOBIN-YVON HORIBA ICP Spectrometer Version 3.0). Calibration of instrument was done using Merck standard ICP solution of concentration range 0.1-10 ppm. The power used for analysis is 1200W; plasma gas flow rate is 12L/min.

2.5 Data Analysis

Measurement data of dust fallout has been documented as geometrical mean and standard deviation of twelve measurements at each monitoring site and presented in Table 2. Regression analysis between annual mean of dust fallout measured at defined receptor site (local-outdoor, indoor and street of Birgaon residential region) and selected source sites (Siltara Industrial complex, Urla Industrial complex, paved road and construction sites) has been conducted and presented in Fig. 2.

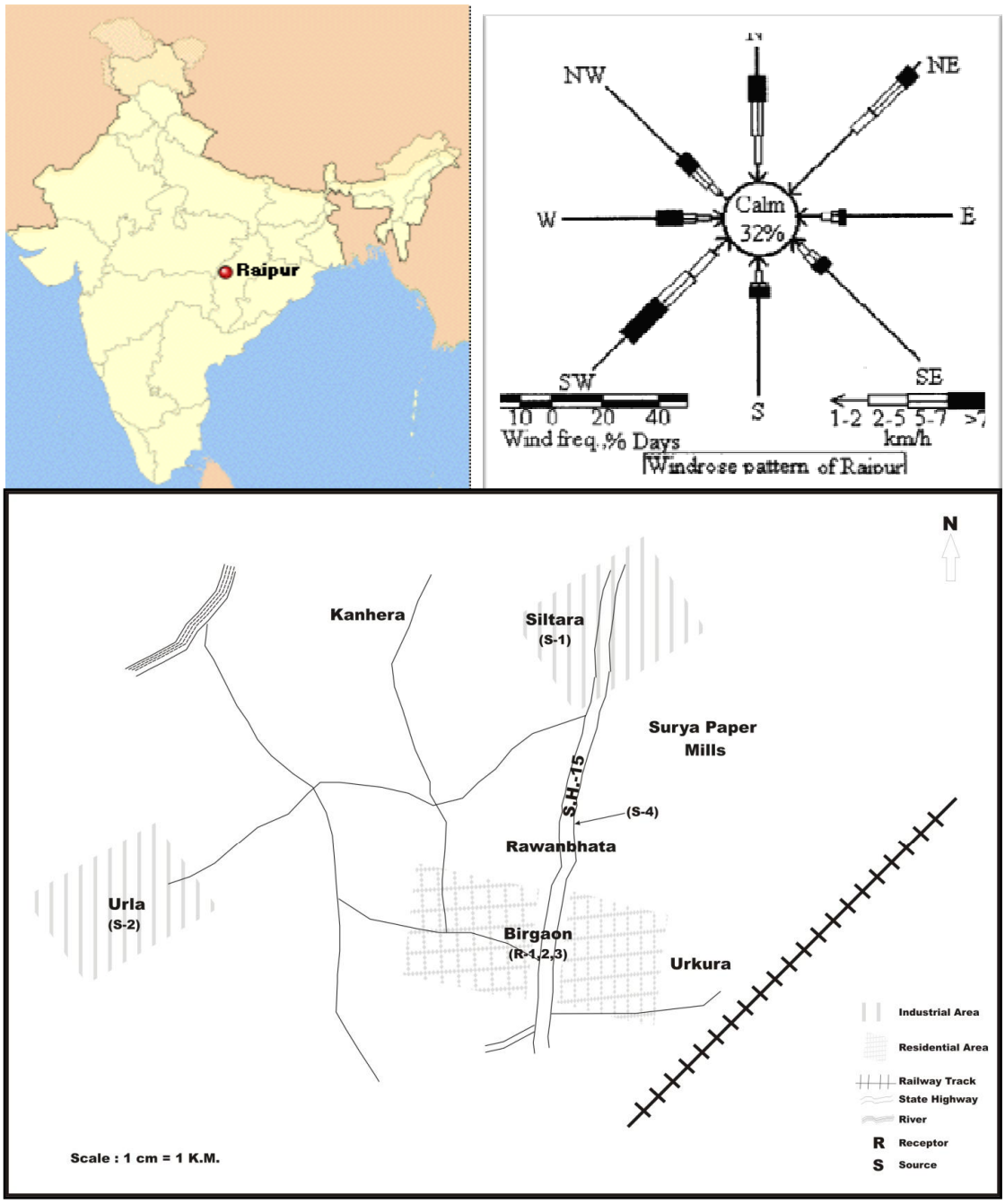

Fig. 1. Local map of source and receptor sites in Raipur City along with windrose of the region

The source profile abundances (mass fraction of chemicals in the emissions from each source type) and the receptor concentrations, with appropriate uncertainty estimates, serve as input data to the CMB model. The output consists of the amount contributed by each source type represented by a profile to the total mass and each chemical species. The CMB calculates values for the contributions from each source and the uncertainties of those values. The CMB is applicable to multi-species data sets. The CMB modeling procedure requires: (1) Identification of the contributing source type; (2) selection of chemical species or other properties to be included in the calculation; (3) estimation of the fraction of each of the chemical species which is contained in each source type (source profile); (4) estimation of the uncertainty in both receptor concentrations and source profiles; and (5) solution of the chemical mass balance equations. The CMB is implicit in all factor analysis and multiple linear regression models that intend to quantitatively estimate source contributions [13]. The chemical mass balance consists of a least squares solution to a set of linear equations which expresses each receptor concentration of a chemical species as a linear sum of products of source profile species and source contribution.

Exact knowledge of dispersion factor of emissions is not necessary in receptor models [13]. Geometric mean and standard deviation values of chemical parameters have been utilized for the concentration and uncertainties of corresponding species of specific site for development of source/receptor profiles. All prepared source and receptor profiles has been introduced in CMB model using an INFRA control file to execute source apportionment program [7 & 8]. Results of CMB execution have been presented in Figs. 3, 4 and 5.

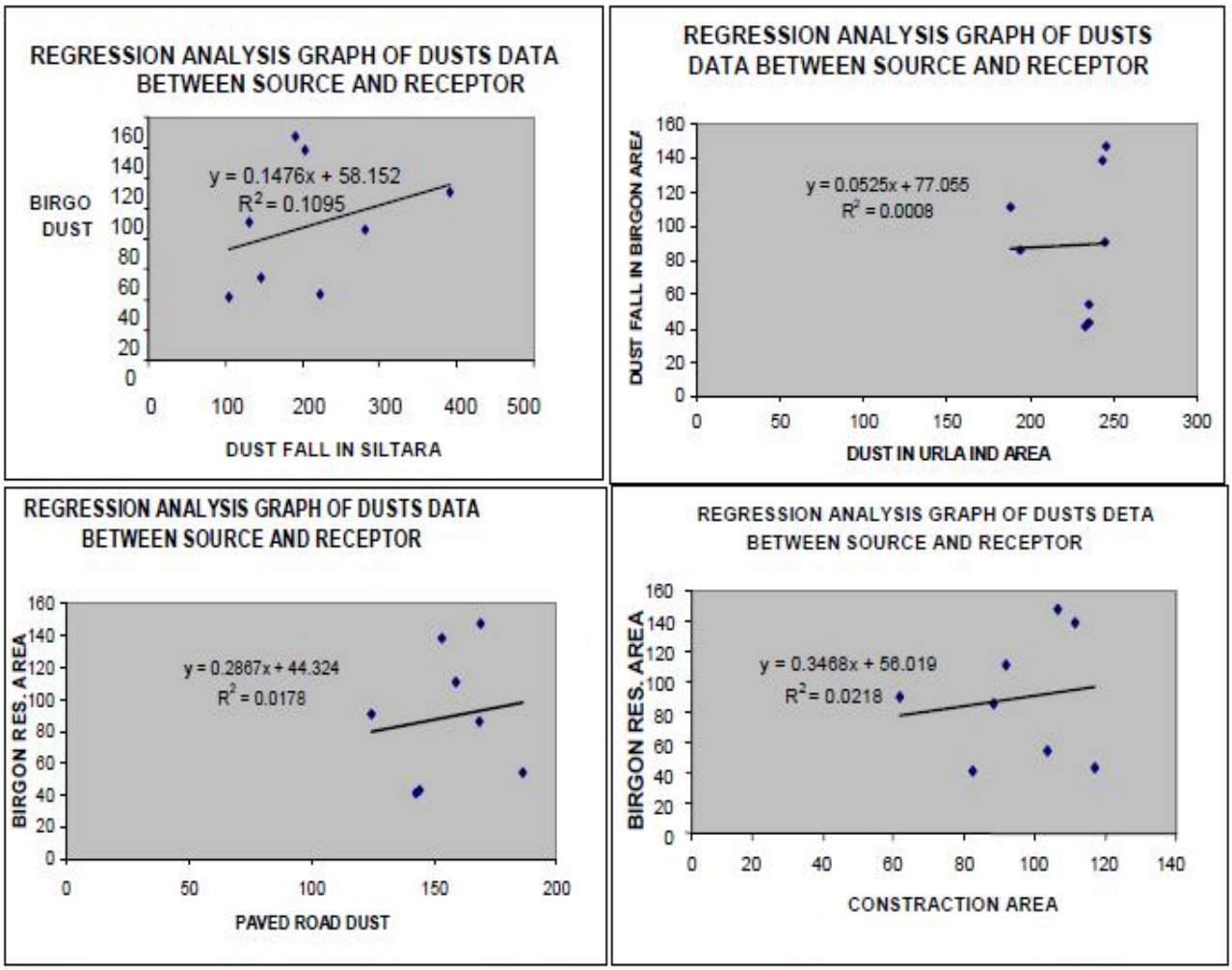

Fig. 2. Regression analysis of selected source dust fallout measurement with its component measured at receptor site.

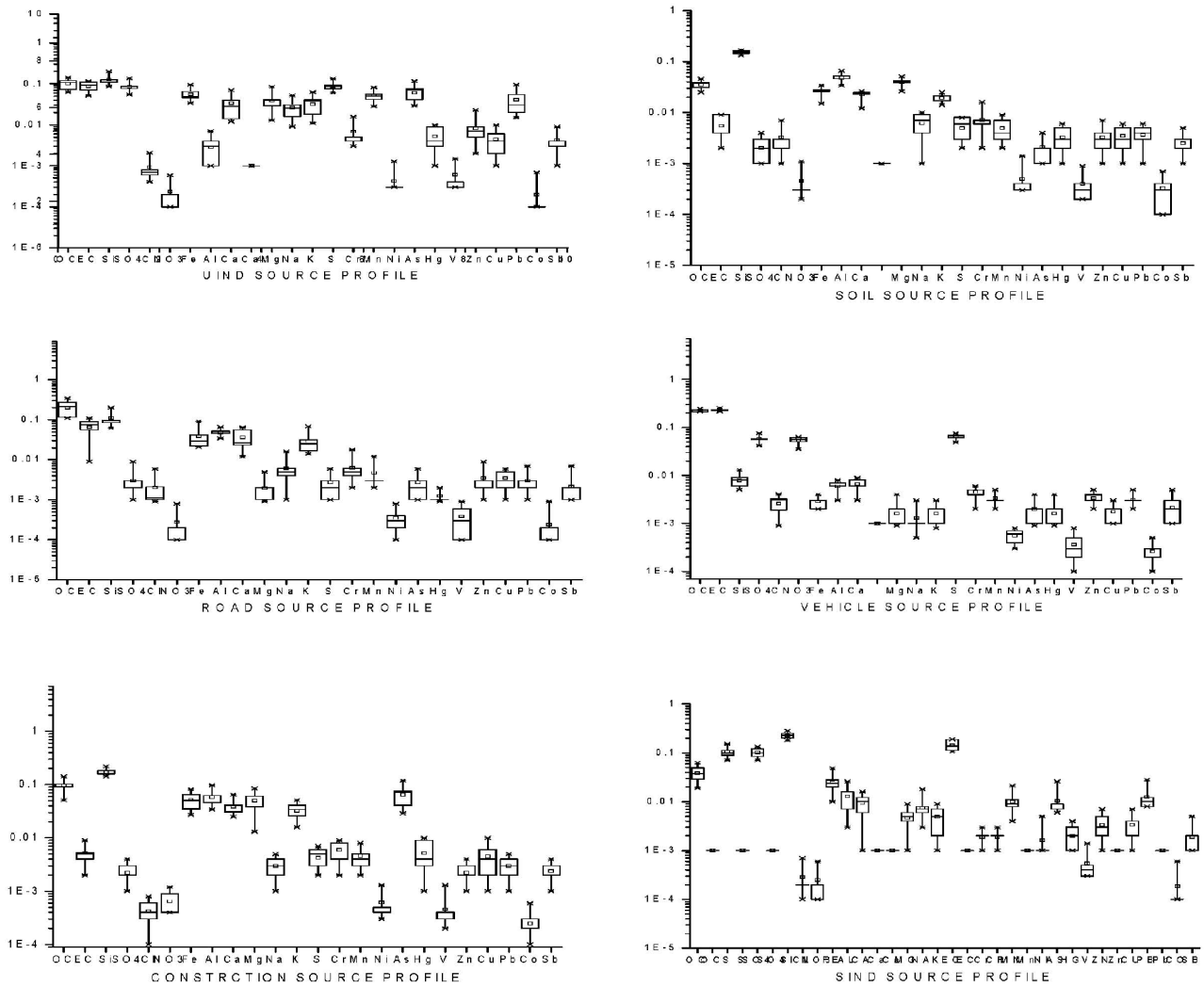

Fig. 3. Profiles of identified sources developed by Chemical Mass Balance Model (CMB 8).

Table 3. Good fit parameters of CMB execution output results for selected receptors

	TSTAT							
SUB	R^2	CHI SQUARE	S-1	S-2	S-3	S-4	S-5	S-6
AMBIENT	0.79	0.34	1.6924	1.0201	0.8417	-	1.6504	0.9738
STREET	0.51	3.75	3.8964	1.672	0.207	-	2.414	0.141
INDOOR	0.73	1.63	2.235	2.084	0.425	-	3.529	0.301

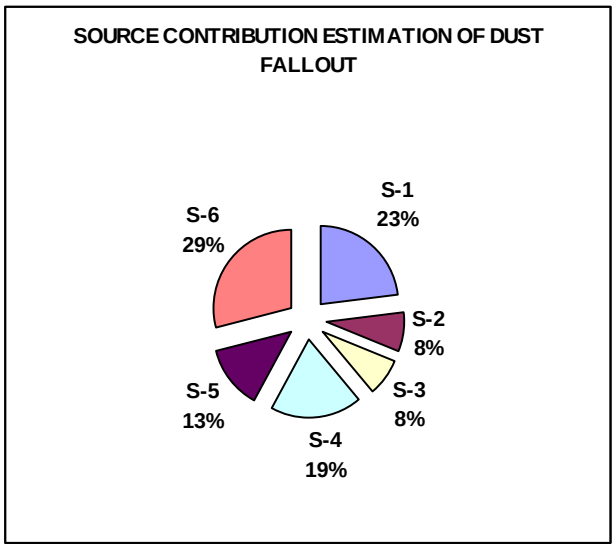

Fig. 4. Relative source contribution estimates of atmospheric dust fallout (Annual average) at Birgaon-residential area of Raipur, India.

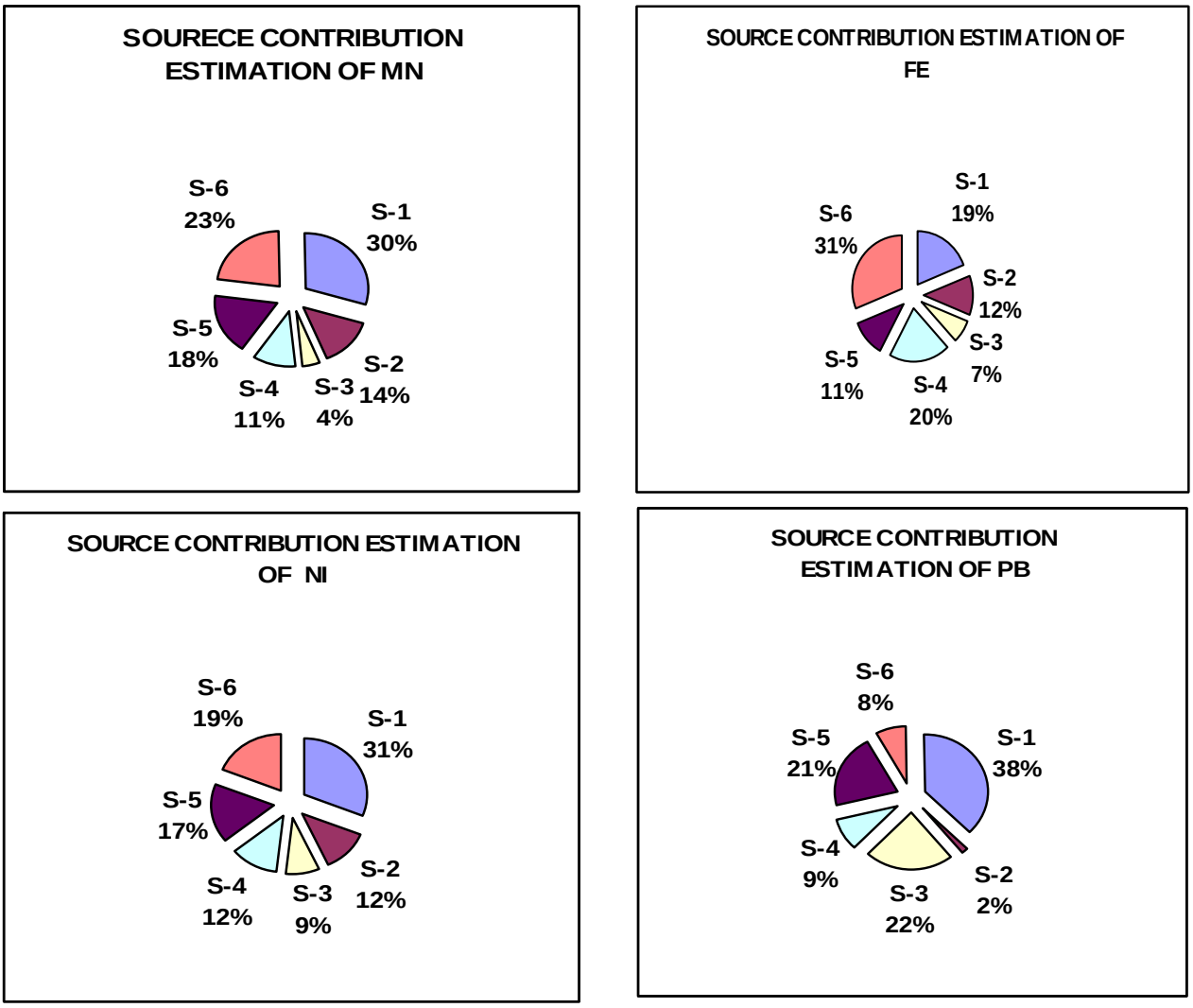

Fig. 5. Relative source contribution estimates of selected parameters at receptor.

3. Results and Discussion

Profuse and highly skewed dust fallout at outdoor receptor of Birgaon residential area has been observed. It has been observed that geometrical mean level of dust fallout at residential outdoor receptor is thousand times higher than maximum permissible limits (0.01 metric tonn/km2/month) developed in Australia [51] and also shown significant increase within a decade [49]. Dust fallout levels in Siltara industrial area has shown higher deviation pattern in annual geometrical mean compared to that in Urla Industrial area. Soil has shown dominating contribution in annual mean of dust fallout in all monitoring locations. Annual mean of dust fallout at civil construction source site has shown thousand times higher level compared to maximum permissible limits. Annual mean of selected chemical species measured in dust fallout of S-1 to S-4 has been utilized as source profile for the source apportionment of dust fallout at Birgaon residential outdoor (R-1). Besides, chemical profiles of vehicle exhaust (S-5) and local soils (S-6) have also been prepared and used for source apportionment modeling. Output of CMB8 with good fit parameters has been presented (Fig. 4 and 5). Model calculated source profiles have also been presented (Fig. 3). Multiple source contribution has been observed with dominance of soil (S-6). Lower contribution of Urla Industrial source (S-2) compared to Siltara Industrial source (S-1) has been observed. In contrast to international scenario, vehicle exhaust has shown lower contribution due to predominance of soil dust source. Iron has shown different pattern of occurrence at the residential outdoor site. Natural soil (S-6) has shown dominance in iron compared to industrial sites due to high deposition of industrial waste in soil near to receptor site. In case of manganese contribution, S-1, and 6 have shown similar share with dominance on other source(S-2, 3, 4 and 5). Nickel has shown major contribution from industrial source (S-1) followed by soil. S-1 has shown dominance on lead contributor (38%) to receptor dust fallout (R-1) and soil has shows low contribution relatively to other sources. Local construction, paved road and vehicle exhaust have shown significant relative contributions. In conclusion, dust fallout at outdoor atmospheric level in Birgaon residential area (R-1) is not only affected by a single source but soil (S-6) has shows significant contribution remaining all sources. Siltara Industrial area (S-1) has also shows good contribution in dust fall at receptor site (R-1). Except Lead all other elements (Fe, Mn and Ni) shows good emission from soil (S-6) at urban industrial residential area Birgaon (R-1) due to highly precipitation of industrial waste in the soil of the residential area.

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References

[1] Begum, A.B.; Biswas, S.K., and Hopke, P.K., 2007. Source Apportionment of Air Particulate Matter by Chemical Mass Balance (CMB) and Comparison with Positive Matrix Factorization (PMF) Model. Aerosol Air Qual. Res. 7: 446-468.

[2] Kothai, P., Saradhil, I.V., Prathibha, P., Hopke P.K., Pandit, G.G. and Puranik, V.D. 2008. Source Apportionment of Coarse and Fine Particulate Matter at Navi Mumbai, India. Aerosol Air Qual. Res. 8: 423-436.

[3] Zhang, Y., Quraishi, T., and Schauer, J.J., 2008. Daily Variations in Sources of Carbonaceous Aerosol in Lahore, Pakistan during a High Pollution Spring Episode. Aerosol Air Qual. Res. 8: 130-146.

[4] Yakovleva, E., Hopke, P.K., and Wallace, L., 1999. Receptor Modeling Assessment of Particle Total Exposure Assessment Methodology Data. Environ. Sci. Technol. 33: 3645-3652.

[5] Anderson, M.J., Daly, E.P., Miller, S.L. and Milford, J.B. 2002. Source Apportionment of Exposures to Volatile Organic Compounds II. Application of Receptor Models to TEAM Study Data. *Atmos. Environ.* 36:3643-3658.

[6] Chowdhury, Z., Zheng, M., and Russell, A.G., 2004. Source Apportionment and Characterization of Ambient Fine Particles in Delhi, Mumbai, Kolkata, and Chandigarh. Draft Final Report to the World Bank. Prepared by Georgia Institute of Technology, Atlanta, GA.

[7] Watson, J.G., Robinson, N.F., Lewis, C., and Coulter, T., 1997. Chemical Mass Balance Receptor Model Version 8 (CMB8): Users Manual. Document Number 1808-1D1, Desert Research Institute, US Environment Protection Agency (USEPA).

[8] Watson, J.G., Robinson, N.F., Fujita, E.M., Chow, J.C., Pace,D.G., Lewis, C., and Counter, T., 1998. CMB8 Application and Validation Protocol for PM2.5 and VOCs. Document Number 1808-2 D1, Desert Research Institute, US Environment Protection Agency (USEPA).

[9] Aditi Kulshresta, P._Gursumeeran Satsangi, Jamson Masih and Ajay Taneja. 2009. Metal concentration of $PM_{2.5}$ and PM_{10} particles and seasonal variations in urban and rural environment of Agra, India**.** Sci. of tot. environ. 407,6196-6204, 2009.

[10] Friedlander, S.K., 1973. Chemical Element Balances and Identification of Air Pollution Sources. Environ. Sci. Technol. 7: 235-240.

[11] Cooper, J.A., and Watson, J.G., (1980). Receptor Oriented Methods of Air Particulate Source Apportionment. J. Air Pollut. Contr. Assoc. 30: 1116-1125.

[12] Gordon, G.E., 1980. Receptor models. Environ. Sci. Technol. 14: 792-800.

[13] Watson, J.G., 1984. Overview of Receptor Model Principles. J. Air Pollut. Contr. Assoc. 34: 619-23.

[14] Watson, J.G., Cooper, J.A. and Huntzicker, J.J. 1984. The Effective Variance Weighting for Least Squares Calculations Applied to the Mass Balance Model. Atmos. Environ. 18: 1347-1355.

[15] Gordon, G.E., 1988. Receptor models. Environ. Sci. Technol. 22: 1132-1142.

[16] Hidy, G.M., and Venkataraman, C., 1996. The Chemical Mass Balance Model for Estimating Atmospheric Particle Sources in Southern California. Chem. Eng. Commun. 151: 187-209.

[17] Quraishi, Y. F., and Pandey, G.S., 1995. Bronchial Contamination with Toxic Metals in Mineral Based Industrial Areas of India. Environ. Geochem. Health. 17: 25-28.
[18] Goel, P.K., and Trivedi, R.K. 1998. An Introduction to Air Pollution. Techno Science, Jaipur.
[19] Bohm, G.M., and Saldiva, H.N., 2000. Urban Air Pollution and Health Effect: A Summary of Evidences Collected in SaoPaulo, BRAZIL. Iniciativa De Aire Limpio, School of Medicine, University of Sao Paulo, Brazil.
[20] Sharma, R.K., and Pervez, S., 2003. Enrichment and Exposure of Particulate Lead in a Traffic Environment in India. Environ. Geochem. Health. 25: 297-306.
[21] Sharma, R.K., and Pervez, S., 2005. Toxic Metals Status in Human Blood and Breast Milk Samples in an Integrated Steel Plant Environment in Central India. Environ. Geochem. Health. 27:39-45.
[22] Saxena, D.K., Singh, S., and Srivastava, K., 2008. Atmospheric Heavy Metal Deposition in Garhwali Hill Area (India): Estimation Based on Native Moss Analysis. Aerosol Air Qual. Res. 8: 94-111.
[23] Quraishi, Y. F., and Pandey, G.S., 1993. Exposure of Steel Plant Related Dusts in Domestic Environments in Bhilai Residential Areas. Indian J. Environ. Prot. 13: 580-583.
[24] USEPA, 2003. Fourth External Review Draft of Air Quality Criteria for Particulate Matter (June 2003). EPA/400/3- 91/003Ad, Environmental Protection Agency, Research Triangle Park A.C.
[25] Sharma, R.K., and Pervez, S., 2004. A Case Study of Spatial Variation and Enrichment of Selected Elements in Ambient Particulate Matter around a Large Coal-Fired Power Station in Central India. Environ. Geochem. Health. 26: 373-381.
[26] Gadkari, N., and Pervez, S., 2007. Source Investigation of Personal Particulates in Relation to Identify Major Routes of Exposure among Urban Residentials. Atmos. Environ. 41: 7951-7963.
[27] Dubey, N., and Pervez, S., 2008. Investigation of Variation in Ambient PM10 Levels within an Urban-Industrial Environment. Aerosol Air Qual. Res. 8: 54-64.
[28] Sartor, J.D., and Boyd, G.B., 1972. Water Pollution Aspects of Street Surface Contaminants. EPA-R2-72-081. Environmental Protection Agency, Washington.
[29] Pitt, R. E., and Amy, G., 1973. Toxic Materials Analysis of Street Surface Contaminants. EPA-R2-73-283. Environmental Protection Agency. Washington, DC.
[30] Pitt, R.E., 1979. Demonstration of Nonpoint Pollution Abatement through Improved Street Cleaning Practices. EPA- 600/2-79-161. Environmental Protection Agency. Cincinnati, USA EPA.
[31] Mustard, M.H., Ellis, S.R., and Gibbs, J.W., 1985. Runoff Characteristics and Washoff Loads from Rainfall-Simulation Experiments on a Street Surface and a Native Pasture in the Denver Metropolitan Area, Colorado. U.S. Geological Survey, Open File Report, p. 84-820.
[32] Schroder, L.J., and Hedley, A.G., 1986. Variation in Precipitation Quality during a 40-hour Snowstorm in an Urban Environment—Denver, CO. Int. J. Environ. Stud. 28: 131-138.
[33] Schroder, L.J., Brooks, M.H., Garbarino, J.R., and Willoughby, T.C., 1987. The Influence of an Urban Environment in the Chemical Composition of Precipitation, Chemical Quality of Water and the Hydrologic Cycle, Lewis Publishers, Chelsea, MI.
[34] Illinois State Water Survey 2003. National Atmospheric Deposition Program 2002 Annual Summary. NADP Data Report 2003-01. Illinois State Water Survey. Champaign, IL.
[35] Adachi, K., and Tainosho, Y. 2004. Characterization of Heavy Metal Particles Embedded in Tire Dust. Environ. Int. 30: 1009-1017.
[36] Smolders, E., and Degryse, F., 2002. Fate and Effect of Zinc from Tire Debris in Soil. Environ. Sci. Technol. 36: 3706-3710.
[37] Davis, A.P., Shokouhian, M., and Ni, S., 2001. Loading Estimates of Lead, Copper, Cadmium, and Zinc in Urban Runoff from Specific Sources. Chemosphere. 44: 997-1009.
[38] Barceloux, D.G., 1999. Vanadium. Clin. Toxicol. 37: 265-278.
[39] Arslan, H., 2001. Heavy Metals in Street Dust in Bursa, Turkey. J. Trace Microprobe Tech. 19: 439-445.
[40] Dundar, M.S., and Altundag, H., 2002. Heavy Metal Determination of House Dust in Adapazari, Turkey, after Earthquake. Trace Elem. Electrolytes 19: 55-58.
[41] Dundar, M.S., and Pala, M.F., 2003. Monitoring of Lead, Zinc, Cadmium, Nickel, Chromium and Copper in Street Dust Samples in Adapazari, Turkey, after Earthquake. Trace Elem. Electrolytes. 20: 104-107.
[42] Dundar, M.S., and Deryaoglu, N., 2005, Heavy Metal Determinations in Outdoor Atmospheric Dust Depositions. Fresenius Environ. Bull. 14: 185-188.
[43] Dundar, M.S., 2006. Vanadium Concentrations in Selected Outdoor Dust Particles. Environ. Monit. Assess. 123: 345-350.
[44] Wieringa, M.H., Weyler, J.J., Van Bastelaer, F.J., Nelen, V.J., Van Sprundel, M.P., and Vermeire, P.A., 1997. Higher. Asthma Occurrence in an Urban than a Suburban Area: Role of House Dust Mite Skin Allergy. Eur. Respir. J. 10: 1460-1466.
[45] Sax, I.N., and Richard, J.L., 1984. Dangerous Properties of Industrial Materials (7th Ed.), Vol-I, Van Nostrand Reinhold, New York.
[46] Roosli, M., 2001. Spatial Variability of Air Pollutants in the Basel Area and Carcinogenic and Non-carcenogenic Health Risk. Ph.D. Thesis, University of Basel, Basel, Switzerland.
[47] Gilbert, R.O., 1987. Statistical Methods for Environmental Pollution Monitoring, John Wiley, New York.
[48] Katz, M., 1977. Methods of Air Sampling and Analysis, American Public Health Association, Washington, D.C.
[49] Thakur, M., and Deb, M.K., 1999. Lead Levels in the Airborne Dusts Particulates of an Urban City of Central India. Environ. Monit. Assess. 62: 305-316.
[50] Gadkari, N. and Pervez, S., 2008. Source Apportionment of Personal Exposure of Fine Particulates among School Communities in India. Environ. Monit. Assess. 142: 227-241.
[51] Ferrari, L., 2000. Dust Nuisance: An Australian Perspective. http://www.mfe.govt.nz/publications/air/workshop-presentatio ns/l-ferrari-dust-may00.pdf.
[52] Kikuo, Oikawa: 1977, Trace analysis of atmospheric samples. Halsted Press Book Kdanahsa Ltd., Tokyo.