Lead Environmental Pollution in Central India

Khageshwar Singh Patel[1*], Balram Ambade[1], Saroj Sharma[1], Dhananjay Sahu[1], Nitin Kumar Jaiswal[1], Sapana Gupta[1], Rakesh Kumar Dewangan[2], Silvia Nava[3], Franco Lucarelli[4], Borislav Blazhev[5], Rositsa Stefanova[5] and Jan Hoinkis[6]
[1]*School of Studies in Chemistry, Pt. Ravishankar Shukla University, Raipur-492010, India*
[2]*Central Ground Water Board, Dhamtari Chauk, Raipur, CG, India*
[3]*Department of Physics, National Institute of Nuclear Physics, Florence, Italy*
[4]*Department of Physics, National Institute of Nuclear Physics, Geneva, Italy*
[5]*Central Laboratory for Chemical Testing and control, 1330-Sofia, Bulgaria*
[6]*Karlsruhe University of Applied Sciences, Moltkestr.30, 76133 Karlsruhe, Germany*

1. Introduction

Lead is a well known non-biodegradable toxic metal in the environment and now, it has become a global health issue (1-5). More than 15 million children in developing countries are suffering permanent neurological damage due to Pb poisoning (6). Lead toxicity in children causes serious health hazards i.e. permanent brain damage, causing learning disabilities, hearing loss, and behavioural abnormalities and in adults causes hypertension, blood pressure problems, heart disease, etc. (7-9). The elevated levels of Pb in blood of children (200 µg l^{-1}) and dogs (250 µg l^{-1}) of Indian megacities were reported (10-11). Sources of Pb pollution in India may be divided into two major categories: industrial and domestic. The industrial Pb exposures are mainly due to the particulates generated by coal burning and roasting of minerals i.e. iron pyrite, dolomite, alumina, etc. The domestic Pb exposures come mainly from cooking by use of the solid fuels (i.e. coal, biomass, agricultural waste, etc.), paints, ceramic glazes, cosmetic and folk remedies, drinking water, food, etc. The most of minerals and coal in Indian subcontinent are reserved in the central states i.e. Chhattisgarh, Jharkhand, Madhya Pradesh, Orissa, etc. Raipur city is capital of Chhattisgarh state and the environment (soil, rain, etc.) of this region is found to be contaminated with Pb and other heavy metals at elevated levels (12-13). The aim of this work is to highlight the lead levels in the various environmental compartments (i.e. air, rain, runoff water, surface soil, sludge and plants of the central India) and to discuss its sources, exposures and toxicities.

2. Method and Materials

2.1 Study area

The lead contamination levels were investigated in the environment of five cities: Raipur, Bhilai, Kaudikasa, Mandla and Korba, Figure 1. Their geography and environment are shown in Table 1. The population of Raipur city is ≈ 2.0 million, and being exposed to high levels of air pollution due to rapid industrialization and urbanization. Raipur city and its neighbourhood are now becoming an important regional commercial and industrial destination for the coal, power, steel and aluminium industries. Raipur is the biggest iron markets in the country. Bhilai is the second-largest city in Chhattisgarh state, and it is located 20 km away in the north-western part of Raipur. The town is famous for running of one of the largest World Steel Plant. Korba is another city famous for power supply and located in the NE direction ≈ 150 km away from Raipur. The Kaudikasa is a remote area, situated in Rajnandgaon district, Chhattisgarh and severely suffering with geogenic arsenic toxicity problem (14). The Mandla town is situated in a loop of the Narmada river in the Madhya Pradesh state and severely affected with the flourosis problem (15).

2.2 Collection and analysis

The respirable aerosol particles, fine and coarse particulate matter ($PM_{2.5}$ and PM_{10}) were collected at residential site (i.e. Dagania) of Raipur city during period, June, 2005 – May, 2006 to know Pb-

Fig. 1. Representation of sampling sites in India

City	Location	Population million	Type	Remark
Raipur	21°24′N & 81°63′E	2	Urban & Industrial	Several steel, ferro-alloy and cement plants are running
Bhilai	21° 13′ N & 81° 25′ E	0.5	Industrial	The Asia biggest steel plant is in the operation
Korba	22° 21′ N & 82° 40′ E	0.5	Industrial	Thermal power plants of capacity, 40000 MW Yr^{-1} are in operation
Koudikasa		0.01	Rural	Suffering with geogenic arsenic problem
Mandala	22°60′ N & 80°38′E	0.1	Semi-urban	Suffering with severe fluorosis problem

Table 1. Geography and environment of sampling sites

contamination in the air. The Partisol Model 2300 sequential speciation air sampler (Thermo Scientific, USA) was used for collection of the PM_{10} and $PM_{2.5}$ over the teflon PTVC filter (Whatmann, 47-mm diameter). The sampler was installed at the roof of the building, 10-m above from the ground level. The weighted filters were housed in the sampler and run for duration of 24-hrs duration from 6.00 am - 6.00 am. The loaded filters were dismounted, brought to laboratory, transferred into the desicator, and finally weighted to record the particulate contents. Each loaded filter was kept in a petri dish, and dispatched to (Department of Physics, National Institute Nuclear Physics, Florence) Italy for the analysis of the total lead content by technique i.e. proton induced X-ray emission spectroscopy (PIXE).

The rain water samples were collected by using automatic collector in year 2008. Whereas, the runoff water samples were collected manually. The pH and conductivity values were measured immediately. The rain water sample was transferred into 50-ml plastic bottle and acidified with few drops of ultra pure nitric acid.

The surface soil, sludge and plant samples were collected in dry season from three industrial city i.e. Raipur, Bhilai, Korba, Mandla and Koudikasa. The sample was dried, crushed, sieved out (< 0.5 mm) and digested in the microwave digestion system "MARS 5 with the aqua regia.

A VARIAN "SpectrAA 220Z" model graphite furnace atomic absorption spectrometer (GF-AAS) equipped with a longitudinal Zeeman Effect background corrector and THGA tube, auto sampler and automatic data processor was used for analysis of Pb at wavelength and slit width of 283.3 and 0.5 nm, respectively. The drying, ashing and atomization was carried out at 110-130, 975 and 2400 ^{o}C, respectively. The reference materials were used for the quality control.

3. Results and Discussion

3.1 Raw material

Two natural resourced raw materials such as iron pyrite and coal are widely used for production of steel and generation of energy, respectively. They were found to be contaminated with the toxic metals at the trace levels. The estimated Pb levels in the iron pyrite and coal were > 10 and >30 mg kg^{-1}, respectively. The combustion of 10 MT each of pyrite and coal may emit > 400 T Pb in the air.

3.2 Air

Lead in the air is emitted as aerosol predominately by burning of solid fuel (i.e. coal and biomass) and roasting of pyrite minerals in this region. The annual concentration of PM_{10} and $PM_{2.5}$ in the air (n = 44) was ranged from 37 -501 and 27 – 293 µg m^{-3} with arithmetic mean value of 209 ±38 and 95 ±18 µg m^{-3}, respectively (16). The Pb concentration associated with the $PM_{2.5}$ and PM_{10} are summarized in Table 2.

PM	Range	A. Mean	G. Mean	Median	STD, ±
$PM_{2.5}$	13 - 5234	730	230	258	1092
PM_{10}	21 - 5582	909	287	294	1251

Table 2. Concentration of Pb in air associated to PM, Raipur city, ng m^{-3}

The highest concentration of the $PM_{10}Pb$ and $PM_{2.5}Pb$ in the air was seen in the month of January and December of a year, respectively mainly due to the lowest wind speed, Figure 2. Meteorologically, the whole hydrological year was classified into four seasons: rainy (July - September), autumn (October - December), winter (January - March) and summer (April - June). The concentration of Pb in the rainy season was remarkably decreased, may be due to removal with the rain, Figure 3. The $PM_{10}Pb$ (r^2 = 0.40) and $PM_{2.5}Pb$ (r^2 = 0.17) concentration have poor correlation with the PM concentration, showing dissimilarity in their origin. While the $PM_{10}Pb$ and $PM_{2.5}Pb$ have good correlation value (r^2 = 0.91), indicating similarity in their origin in the both fractions, Figure 4.
The annual concentration of Pb in the PM_{10} and $PM_{2.5}$ was ranged from 0.01 – 1.52 and 0.01 – 2.56% with mean value of 0.34 and 0.66%, respectively. The highest and lowest concentration of Pb in the PM was seen in the autumn and rainy season, respectively, Table 3.

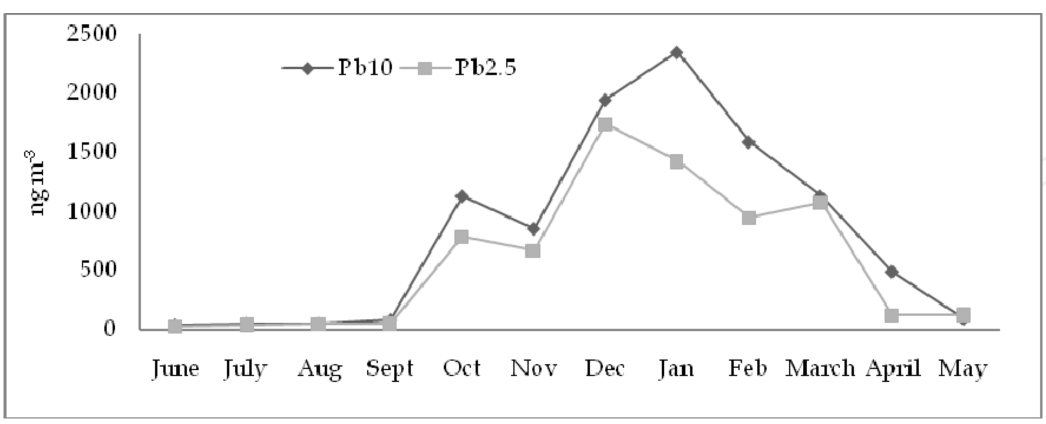

Fig. 2. Monthly mass distribution of Pb in air

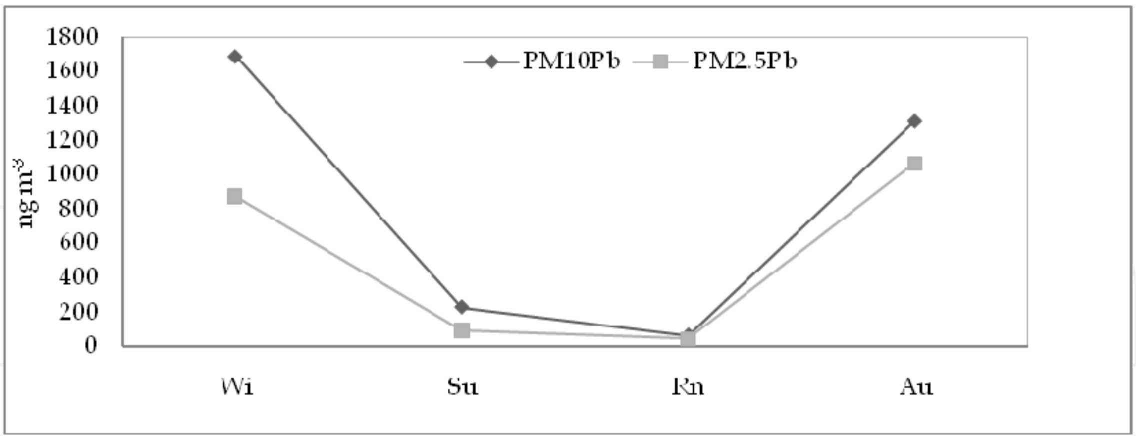

Fig. 3. Seasonal mass distribution of Pb in air

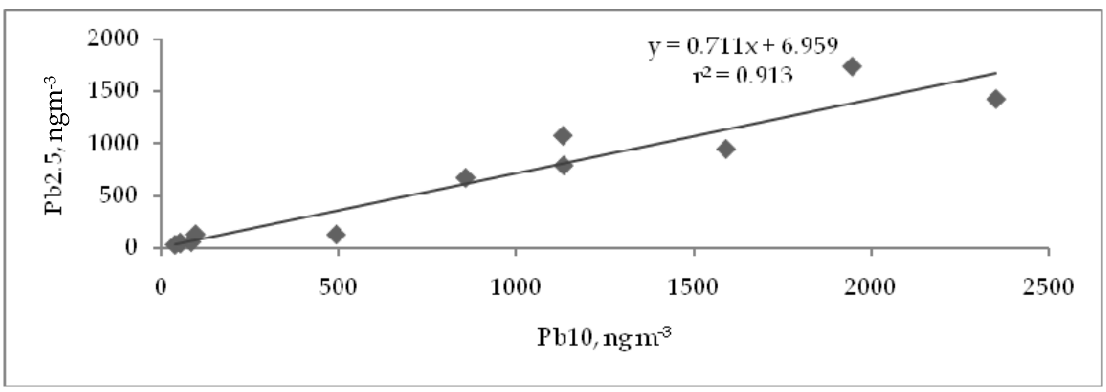

Fig. 4. Correlation of $PM_{10}Pb$ with $PM_{2.5}Pb$

The monthly mean meteorological parameters i.e. rain fall (RF), temperature(T), humidity(H), vapour pressure(VP), wind speed(WS) and sunshine(SS) in Raipur city during period, June, 2005 – May, 2006 are summarized in Figure 5. The lowest values of the RF, T, VP and WS were observed in the winter season. The particulate Pb has poor to fare negative correlation with meteorological parameters i.e. RF, T, H, VP and WS except SS, Table 4. The concentration of Pb in the air was decreased when the value of RF, T, H, VP and WS was increased. A reverse trend was observed in the case of sunshine. The WD of the air also influenced the concentration of Pb in the air, and found to be increased remarkably due to coming of industrial effluents from north to east directions. In industrial site, the

PM	Annual	Winter	Summer	Rainy	Autumn
PM2.5	0.56	0.83	0.23	0.16	1.06
PM10	0.34	0.50	0.07	0.07	0.59

Table 3. Concentration of Pb in PM, Raipur city, %

Species	RF	T	H	VP	WS	SS
PM10Pb	0.25	0.71	0.03	0.16	0.78	0.38
PM2.5Pb	0.1	0.63	0.16	0.04	0.45	0.11

Table 4. Correlation (r^2) of the Pb content with meteorology

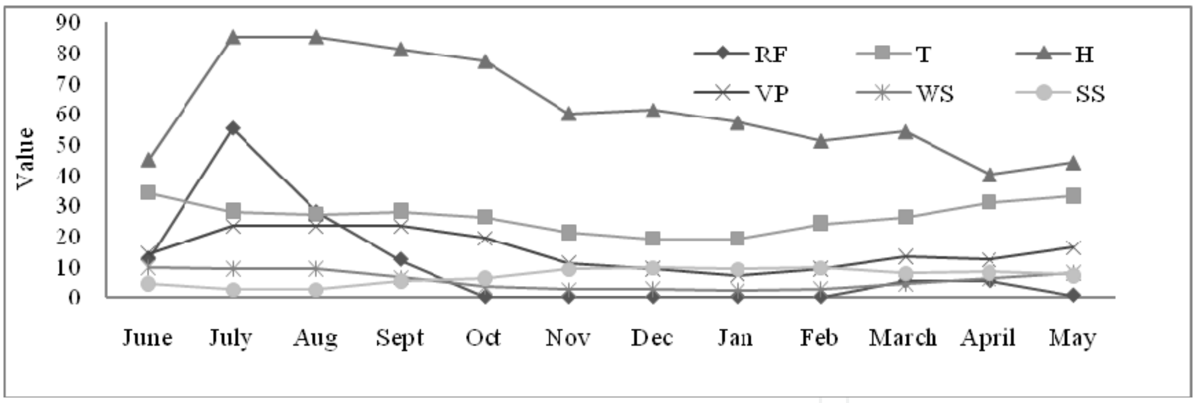

Fig. 5. Meteorology of Raipur city

Pb concentration in the air was tremendously increased (> 2-folds) due to the anthropogenic emissions, Figure 6.

The annual mean ratio of [$PM_{2.5}$Pb]/[PM_{10}Pb] was found to be 0.80, indicating the accumulation of 80% Pb in the aerodynamic mode. The Pb concentration in the air has good correlation with the elements i.e. S (r^2 = 0. 71), Cl (r^2 = 0. 80), Mn (r^2 = 0. 82) and Zn (r^2 = 0.78) in the fine fraction. The enrichment factor of Pb (concentration ratio of the aerosol to the soil of the element to the reference crustal element such as Al) in the $PM_{2.5}$ mode was 166, and can be considered as an element of the anthropogenic origin. Lead concentration in the ambient air of Raipur city during the dry season was found to be much more higher than other part of the country (17-18).

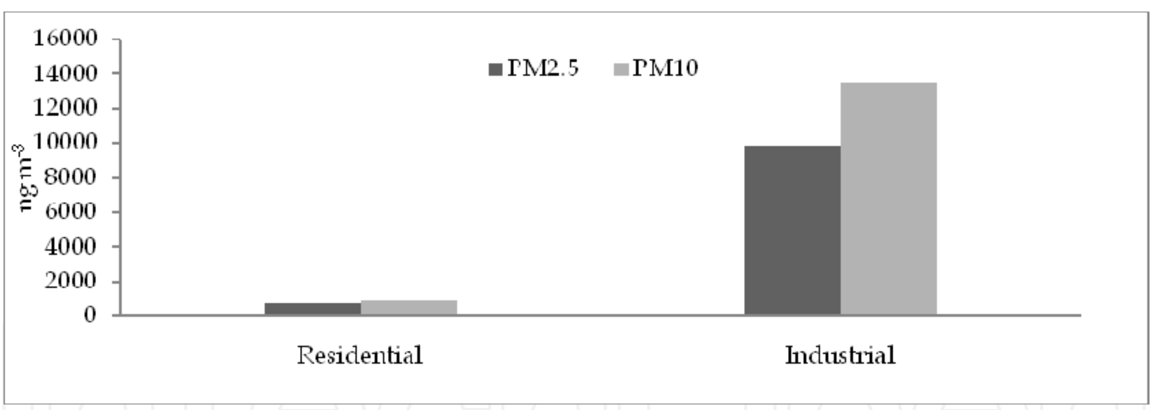

Fig. 6. Spatial distribution of Pb in PM during Feb.,2006

3.3 Rain and runoff water

The atmospheric and geospheric pollutants were washed out with precipitates (i.e. rain, fog, snow, etc.) and runoff water, respectively. The Pb contents in rain of three industrial cities i.e. Raipur, Bhilai and Korba were ranged from 28 – 849 µg l^{-1} with mean value of 291±130 µg l^{-1}, respectively (19). The highest Pb level was detected in the samples of Korba city due to higher coal burning, Figure 7. Similarly, Pb-content in the runoff water was ranged from 131 - 3157 µg l^{-1} with mean value of 659±232 µg l^{-1}, respectively. Almost similar spatial variation of Pb-content in the runoff water was observed, Figure 7. The Pb content in the rain of this region was found to be much higher than reported for other regions of the World (20-24).

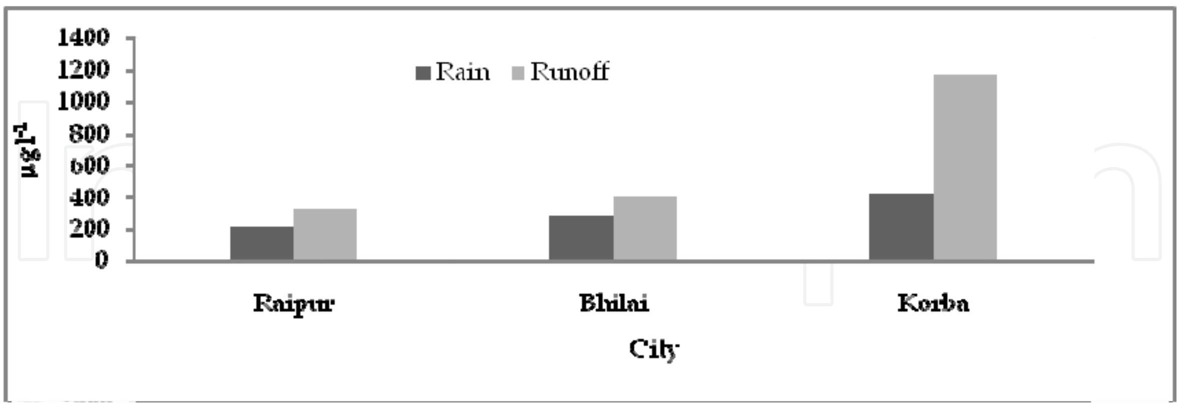

Fig. 7. Spatial distribution of Pb in rain and runoff water

3.4 Soil and sludge

The Pb content in the surface soil of remote, urban and industrial cities (i.e. Kaudikasa, Mandla, Raipur, Bhilai and Korba) is summarized in Table 5. The highest Pb content in the surface soil of coal burning site, Korba city (over area ≈ 5000 km^2) was observed, may be due to huge coal utilization (25). Similarly, high Pb- content in the soil and sludge of other industrial city: Bhilai and Raipur was measured (26). The presence of high Pb and other heavy metal contents in the Mandla city was reported (27). The most of soils were found to be associated with high heavy metal (i.e. Mn, Fe, Cu, Zn and As) contents, Table 5. Among them, Fe showed the highest fraction (1-16%) followed by Mn (3030 – 12820 mg kg^{-1}). The higher content of As was observed in the soil of sites i.e. Korba, Mandla and Kaudikasa. The origin of As in Mandla and Kaudikasa was expected due to geogenic contamination unlikely to Korba city. The Pb contents in the soil and sludge of this region was found to be higher than reported in other parts of the World (28-31).

Location	Metal, mg kg^{-1}							
	Pb	As	Hg	Fe, %	Mn	Cu	Ni	Zn
Raipur (n=5)	276	15	0.1	16	12820	566	60	348
Bhilai (n=3)	545	13	4.3	2.7	1440	1240	110	61
Korba (n=9)	1930	45	1.4	21	3400	218	42	230
Mandala (n=3)	390	53	4.8	1.0	1830	740	670	150
Kaudikasa (n=10)	25	71				49		
Bhilai (n=8)	115	17	1.1	16	3030	49	28	240

Table 5. Lead and other heavy metals in surface soil and sludge

4. Accumulation of Pb

The accumulation of Pb in the food grain, vegetables, spices, medicinal and wild species were investigated (26-27, 32-33). The Pb-content in 10 different rice (grown in 10 different fields) was ranged from 0.21 - 1.51 mg kg^{-1} with mean value of 0.64 mg kg^{-1}, Figure 8. The Pb-content in the respective husk was ranged from 0.56 - 6.28 mg kg^{-1} with mean value of 1.5 mg kg^{-1}. Among 10 rice tested, the high yield variety rice, IR-64 was found to be as good phytoextractant for Pb. The Pb-content in the leafy vegetables, medicinal, spices and wild plants was ranged from 4.6 – 54.3 mg kg^{-1}, Figure 9. Among them, Methi was found to be as good phytoextractant. The various parts of medicinal plant: sweet Basil (*Ocimum basilicum*), commonly used in medicine and for culinary purposes in India were tested for Pb-contamination, and found to be ranged from 11.7 – 18.5 mg kg^{-1}. Among them, the basil leaf showed the highest Pb levels, Figure 10. The Pb levels in the wild plants i.e. parthenium hysterophorus (PH), datura alba (DA) and lantana camara (LC) grown everywhere in India were ranged from 0.3 – 5.0 mg kg^{-1}, Figure 11. Among them, the poisonous plant i.e. datura alba was observed to be as good phytoremediating agent for Pb to remove from the contaminated soil. The Pb contents in the plants of this region were found to be comparable to the Pb values reported in other parts of the World (34-42).

5. Lead toxicity

The permissible limits for Pb in the air, drinking water, soil and food reported are 0.10 – 0.30 µg m^{-3}, 5 µg l^{-1}, 300 µg kg^{-1} and 1.1 mg kg^{-1}, respectively (43-46). The ambient air of the central India in the winter season was contaminated with the Pb at level of ≈1 µg m^{-3}, being several folds higher than the permissible limit. The rain and runoff water of the industrial cities of central India are contaminated with several folds higher Pb than permissible limit of 5 µg l^{-1}. The medicinal plants, species and leafy vegetables grown in the contaminated soil were found to be loaded with Pb beyond permissible limit of 1.1 mg kg^{-1}. The humans and other animals in the industrial cities of the central India are exposed with Pb and other heavy metals via air, water, soil and food.

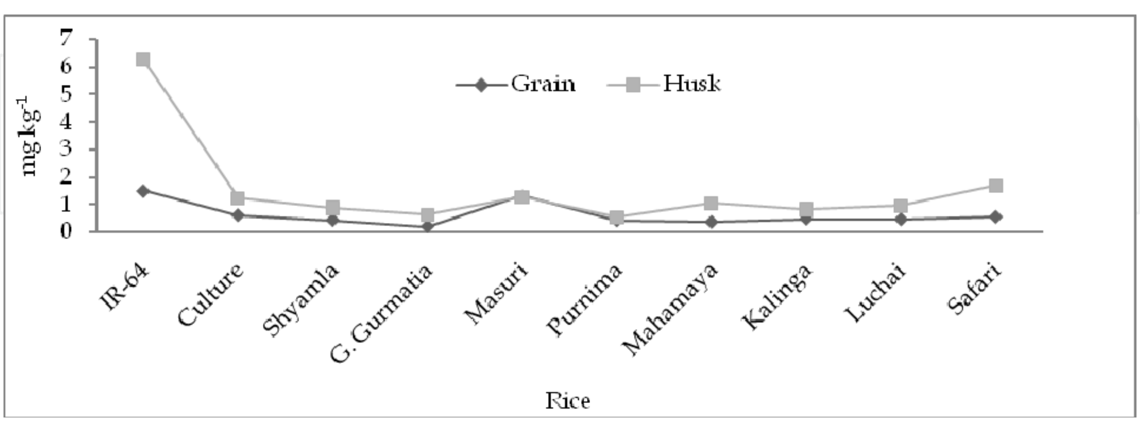

Fig. 8. Accumulation of Pb in various rice

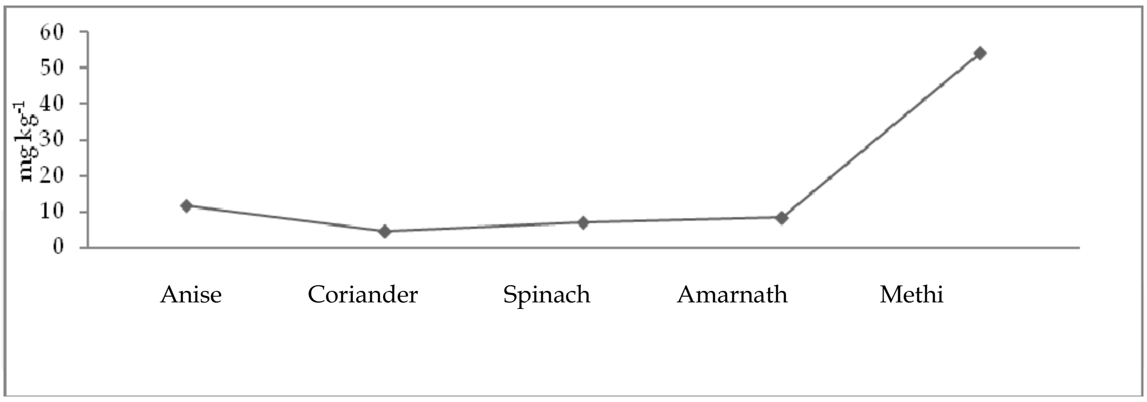

Fig. 9. Accumulation of Pb in spices and leaves

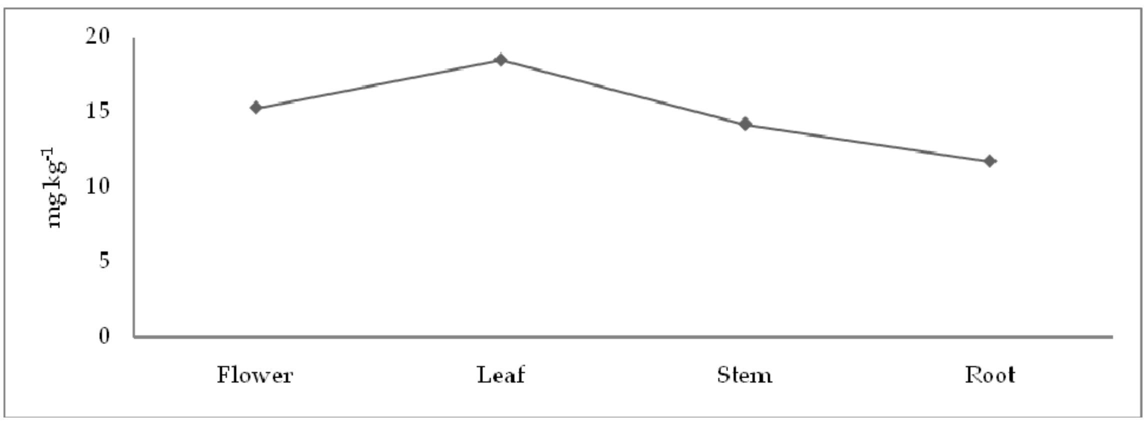

Fig. 10. Accumulation of Pb in Basil plant parts

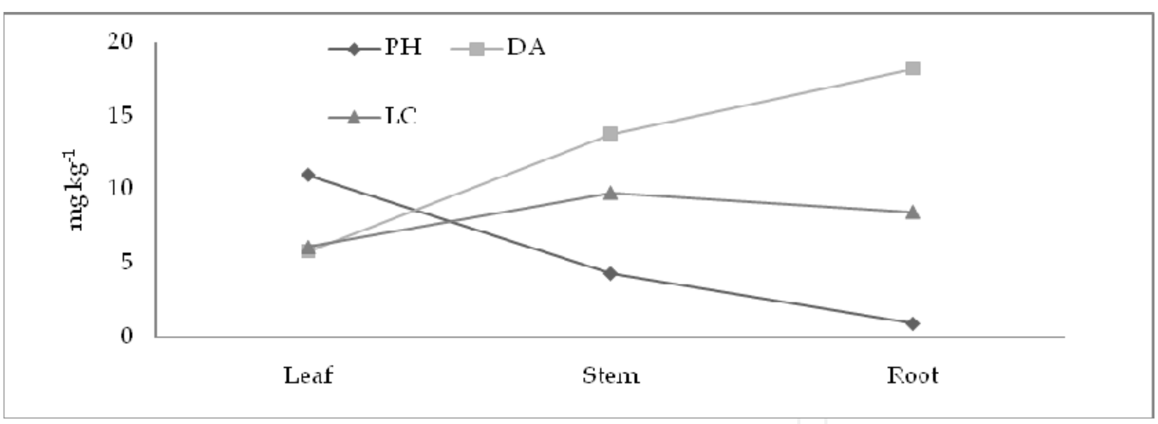

Fig. 11. Accumulation of Pb in the wild plant parts

6. Conclusion

The Pb-contamination of the central India is expected due to both geogenic and anthropogenic pollution. The coal burning is assumed as a major anthropogenic inventory for the Pb contamination in the environment. The various environmental compartments i.e. air, rain, runoff water, surface soil and sludge of the Industrial cities are contaminated with the Pb and other heavy metals at elevated levels. The leafy and medicinal plants phytoextract Pb and other heavy metals significantly, and expected one of the major entry path way route in human and other animals.

Acknowledgements

The Karlsruhe University of Applied Sciences, Karlsruhe, Germany is greatly acknowledged for providing the printing charge. We are sincerely thankful to Department of Science & Technology (DST), Government of India, New Delhi for support of this work from the project grant. no. ES/48/ICRP/008/2002. One of the authors, K. S. Patel is also thankful to the Alexander von Humboldt Foundation, Bonn for granting support for presentation of this work in the WASET conference, Heidelberg, 2008.

7. References

[1] M.C. McCarthy, H.R. Hafner, and S.A. Montzka, “Background concentrations of 18 air toxics for North America”, J. Air Waste Manage. Assoc., vol. 56, pp. 3–11, 2006.
[2] A. Peters, D.W. Dockery, J.E. Muller, and M.A. Mittleman, “Increased particulate air pollution and the triggering of myocardial infarction”, Circulation, vol. 103, pp. 2810-2815, 2001.
[3] N. Englert, “Fine particles and human health—a review of epidemiological studies,” Toxicology Lett., vol. 149, pp. 235–242, 2004.
[4] R. C. Gracia, and W. R. Snodgrass, “ Lead toxicity and chelation therapy, Am. J. Health-System Pharm., vol. 64, pp. 45-53, 2007.
[5] L. Patrick, Lead Toxicity, A Review of the Literature, Part I: Exposure”, Evaluation, and Treatment, Altern. Med. Rev., vol. 11, pp. 2-22, 2006.
[6] HEI, Special Report 15, “Health Effects of outdoor air pollution in developing countries of Asia: A Literature Review”, Health Effects Institute, Cambridge, MA, 2004.
[7] D.C. Bellinger, “Lead, Pediatrics”, vol. 113, pp.1016–22, 2004.
[8] C.A. Pope, R.T. Burnett, M.J. Thun, E.E. Calle, D. Krewski, K. Ito, and G.D. Thurston, “Lung cancer, cardiopulmonary mortality and long-term exposure to fine particulate air pollution,” J. Am. Med. Assoc., vol. 287, pp.1132-1141, 2002.
[9] M. Ahamed, S. Verma, A. Kumar, and M. K. J. Siddiqui, “Environmental exposure to lead and its correlation with biochemical indices in children”, Sci. Total Environ., vol. 346, pp. 48–55, 2005.
[10] P.P. Kaul, S. Shyam, R. Srivastava, D. Misra, P.R. Salve, and S.P. Srivastava, “Lead levels in ambient air and blood of pregnant mothers from the general population of Lucknow (U.P.), India,” Bull. Environ. Cont. Toxicol., vol.71, pp.1239–1243, 2003.
[11] M. Balagangatharathilagar, D. Swarup, R. C. Patra, and S. K. Dwivedi, “Blood lead level in dogs from urban and rural areas of India and its relation to animal and environmental variables, Sci. Total Environ., vol. 359, pp. 130-134, 2006.
[12] K. S. Patel, K. Shrivas, P. Hoffmann, and N. Jakubowski, “Lead pollution in central India”, Environ. Geochem. Health, 28, pp. 11 – 17, 2006.
[13] K. S. Patel, A. Shukla, A.N. Tripathi, and P. Hoffmann, “Precipitation of heavy metals in central India”, Inter. J. Water, Air Soil, vol. 130, pp. 463-468, 2001.

[14] K.S. Patel, K. Shrivas, R. Brandt, N. Jakubowski, W. Corns, and Hoffmann, P. (2005). Arsenic contamination in water, soil, sediment and rice of central India, Environ. Geochem. Health, Vol. 27, pp. 131-145, 2005.
[15] M. Dubey, "Toxic effect of fluorosis among school children in village of Mandla district, Madhya Pradesh". J. Ecophysio. Occup. Health, Vol. 4, pp. 73-81, 2004.
[16] K. S. Patel, S. Gupta, S. Nava, and F. Lucarelli, "Lead particulate pollution in Central India", Proceeding of World Academy of Science, Engineering & Technology, Vol. 33, pp. 2070-3740, 2008.
[17] A.K. Singh, and M. Singh, "Lead decline in the Indian environment resulting from the petrol-lead phase-out programme," Sci. Total Environ., vol. 368, pp. 686–694, 2006.
[18] D.G. Gaghate, and M.Z. Hasan, "Ambient Lead Levels in Urban Areas," Bull. Environ. Contam. Toxicol., vol. 62, pp. 403-408, 1999.
[19] K.S. Patel, B. Ambade, R.K. Devangan, J. F. N. Aguilera, and E. Y. Funes, "Acid rain in central India", Atmos. Environ., to be submitted.
[20] Z. Polkowska, M. Grynkiewicz, T. Górecki, and J. Namieśnik, "Levels of lead in atmospheric deposition in a large urban agglomeration in Poland", J. Environ. Monit., vol. 3, pp.146-149, 2001.
[21] E. Steinnes, G. Åberg, and H. Hjelmseth, "Atmospheric deposition of lead in Norway: spatial and temporal variation in isotopic composition", Sci. Total Environ., vol. 368, pp. 3-9, 2006.
[22] C. Ridame, C. Guieu, and M.D. Loÿe-Pilot, "Trend in total atmospheric deposition fluxes of aluminium, iron, and trace metals in the northwestern Mediterranean over the past decade (1985–1997)", J. Geophys. Res., vol. 30, pp. 127–130, 1999.
[23] L.D. Lacerda, and M.G. Ribeiro, "Changes in lead and mercury atmospheric deposition due to industrial emissions in Southeastern Brazil", J. Braz. Chem. Soc., vol. 15, pp. 931-937, 2004.
[24] B.P. Jackson, P.V. Winger, and P.J. Lasier, "Atmospheric lead deposition to Okefenokee Swamp, Georgia, USA", Environ. Pollu., vol. 130, pp. 445-451, 2004.
[25] K.S. Patel, D. Sahu, and J. Hoinkis, Fluoride and lead pollution in Korba, J. Geochem. Explo., to be submitted.
[26] K. S. Patel, V.K. Jena, S. C. Patel, B. Blazhev, R. Stefanova, Steel sludge pollution in India, Soil Sediment Conta., submitted,
[27] K.S. Patel, V.K. Jena, S. Sharma, and S.C. Patel, "Accumulation of heavy metals with spices and vegetables leaves grown in contaminated soil", Toxico. Environ. Chem., submitted.
[28] X. Li , C. Poon, and P.S. Liu, "Heavy metal contamination of urban soils and street dusts in Hong Kong", Appl. Geochem., vol. 16, pp. 1361-1368, 2001.
[29] C.S.C. Wong, and X. D. Li, "Pb contamination and isotopic composition of urban soils in Hong Kong", Sci. Total Environ., vol. 319, pp. 185-195, 2004.
[30] D.S. Manta, M. Angelone, A. Bellanca, R. Neri, and M. Sprovieri, "Heavy metals in urban soils: a case study from the city of Palermo (Sicily), Italy", Sci. Total Environ., vol. 300, pp. 229-243, 2002.
[31] C. Kabala, and B. R. Singh, "Fractionation and mobility of copper, lead, and zinc in soil profiles in the vicinity of a copper smelter", J. Environ. Qual., vol. 30, pp. 485-492, 2001.

[32] K.S. Patel, K. Shrivas, R. Brandt and N. Jakubowski, "Arsenic, copper and lead contamination of paddy soil, rice and husk of central India", J. Food Comp. Analysis, submitted.
[33] K. S. Patel, V. K. Jena, S. Sharma, and S. C. Patel, Contamination of medicinal plant (Basil) with heavy metals, Commu. Soil Sci. Plant Analy., submitted
[34] J.P. Bennetta, E. Chiribogab, J. Colemanb, D.M. Waller, "Heavy metals in wild rice from northern Wisconsin", Sci. Total Environ., vol. 246, pp. 261-269, 2000.
[35] S. D'Illio, M. Alessandrelli, R. Cresti, G. Forte, and S. Caroli, "Arsenic contents of various types of rice as determined by plasma-based techniques", Microchem. J., vol. 73, pp. 195-201, 2000.
[36] M.M. Nasralla, and E.A. Ali, "Lead accumulation in edible portions of crops grown near Egyptian traffic roads", Agri. Ecosyst. Environ., vol. 13, pp. 73-82, 1985.
[37] L. De Temmerman, and M. Hoenig, "Vegetable Crops for Biomonitoring Lead and Cadmium Deposition", J. Atmos. Chem., vol. 49, pp. 121-135, 2005.
[38] J. Bacsó, M. Kis-Varga, P. Kovács and G. Kalinka, "Investigation on the accumulation of lead and other metals in plants caused by motor-traffic and smelting" , J. Radioanal. Nucl. Chem., vol. 81, pp. 59-65, 1984.
[39] J. Barthwal, S. Nair, and P. Kakkar, "Heavy Metal Accumulation in Medicinal Plants Collected from Environmentally Different Sites", Biomedical. Environ. Sci., vol. 21, pp. 319-324, 2008.
[40] A.A.K. Abou-Arab, M.S. Kawther, M.E. El Tantawy, R.I. Badeaa, and N. Khayria, "Quantity estimation of some contaminants in commonly used medicinal plants in the Egyptian market", Food Chem., vol. 67, pp. 357-363, 1999.
[41] A.A.K. Abou-Arab, and M.A. Abou Donia, "Heavy metals in Egyptian spices and medicinal plants and the effect of processing on their levels", J. Agric. Food Chem., vol. 48, pp 2300–2304, 2000.
[42] A. Grejtovský, K. Markušová, and L. Nováková , "Lead uptake by Matricaria chamomilla L.", Plant Soil Environ., vol. 54, pp. 47-54, 2008.
[43] M.L. Wald, "EPA, Proposes New Limits on Lead in the Air, the First Revision in 30 Years, " 2008, http://www.nytimes.com /2008/05/02/Washington/02epa.html
[44] EPA, "Drinking water regulations and health advisories", Office of drinking water. USEPA, Washington D.C., 1994.
[45] S. Dudka, and W. P. Miller, "Permissible concentrations of arsenic and lead in soils based on risk assessment", Water Air Soil Pollu. vol. 113, pp. 127-132, 1999.
[46] E. J. Underwood, "Trace elements and health: An overview", Phil. Trans. R. Soc. Lond., vol. 288, pp. 5-14, 1979.

New Trends in Technologies
Edited by Blandna ramov

ISBN 978-953-7619-62-6
Hard cover, 242 pages
Publisher InTech
Published online 01, January, 2010
Published in print edition January, 2010

This book provides an overview of subjects in various fields of life. Authors solve current topics that present high methodical level. This book consists of 13 chapters and collects original and innovative research studies.