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JEB
Journal of Environmental Biology

ISSN: 0254-8704
CODEN: JEBIDP

Analysis of heavy metals concentration in ambient air and in human population of Rohtak, India

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Publication Info

Paper received:
19 August 2011

Revised received:
09 February 2012

Re-revised received:
06 July 2012

Accepted:
08 August 2012

Abstract

The samples of ambient air collected from six different sites of the city during three different seasons on glass fibre filter papers were estimated for selected metals. The maximum value of Pb (0.191 μg m^{-3}), Cd (0.015 μg m^{-3}), Zn (0.198 μg m^{-3}), Ni (0.582 μg m^{-3}) and Cu (0.396 μg m^{-3}) was observed at Hissar road during winter season. The minimum value of Pb (0.006 μg m^{-3}), Cd (not detected), Zn (0.002 μg m^{-3}), Ni (0.003 μg m^{-3}) and Cu (0.002 μg m^{-3}) was observed at University Campus during monsoon season. These values were however below the permissible limits. Sample of 50 people each was taken up from both low and high polluted sites. The significant difference at $P<0.001$ was observed in Cu, Zn, Pb, Ni and Cd in blood samples of subjects residing at low and high polluted area.

Key words

Ambient air, Blood sample, Heavy metals, Human population

Introduction

Metals, a major category of globally-distributed pollutants, are natural elements that have been extracted from the earth and harnessed for industry (Bilos *et al.,* 2001). Metals are diverse substances, with different properties and characteristics, considered important in life cycle impact assessment because of their toxicity to humans and ecosystems (Pizzol *et al.,* 2010). Reports suggest that air in industrial and metropolitan areas is more heavily contaminated with heavy metals than in rural areas (Meyer *et al.,* 1999). To a small extent they enter our bodies via food, drinking water and air. Trace metals are emitted into the atmosphere mainly as a consequence of high temperature process such as combustion, roasting and metallurgical operations. Air borne toxic trace metals are found mainly in the suspended particulate matter dispersed in air (Dwivedi and Seth, 2001). Particulate matter of a diameter under 10μm (PM_{10}) is a mixture of solid and liquid particles in the air and major source of these fine particles are diesel engine exhaust, food cooking operations, and dust from wood burning (Zheng *et al.,* 2002).

Motor vehicles fueled with lead gasoline are the main source of lead in ambient air. Inorganic lead in ambient air also originates from emissions from coal combustion and various lead-based industries such as lead smelters and lead battery plants. Although lead in gasoline accounts for less than 10 % of all refined lead production, about 80 to 90 % of lead in global air originates from combustion of leaded gasoline (GEMS, 1988).

Several metals, such as Pb, Cd, Cr and Co are considered hazardous contaminants that can accumulate in the human body, with a relatively long half-life (Onder and Dursun, 2006). Arsenic metal is known to cause skin lesions and cancer of the brain, liver, kidneys, and stomach (Yoon *et al.,* 2010).

Air pollution has long been recognized as a potentially lethal form of pollution. Entry of pollutants into the atmosphere occurs in the form of gases or particles. Continuous mixing, transformation and trans-bound transportation of air pollutants make air quality of a locality unpredictable. The growth of population, industry and number of vehicles and improper implementation of stringent emission standards make the problem of air pollution still worse (Ravindra *et al.,* 2001). India has 23 major cities of over 1 million people and ambient air pollution levels exceed the WHO standards in many of them (Gupta *et al.,* 2002). The single most important factor responsible for deterioration of air quality in cities is the exponential increase in number of vehicles. Vehicular pollution contributes to 70% of total pollution in Delhi, 52% in Mumbai and 30% in Calcutta (C.P.C.B., 2003; Gokhale and Patil, 2004). In the developing countries, air quality crisis in cities is attributed to vehicular emission which contributes to 40-80% of total air pollution (Ghose *et al.,* 2005). Vehicular traffic is the main source of particulate air pollution in Lucknow city (Sharma *et al.,* 2006).

In the present study, an attempt was made to assess the prevailing concentration of heavy metals in the ambient air and in human population of Rohtak city.

Materials and Methods

Rohtak city is located 70 kms from Delhi towards west covers an area of 441100 ha. The present study was carried out at six sites of Rohtak city: University Campus (Low traffic density and low populated), Delhi By pass (High traffic density and low populated), Medical Mor (Moderate traffic density and thickly populated), New Bus Stand (High traffic density having light and heavy vehicles and thickly populated) Bhiwani Stand (High traffic density and thickly populated) and Hissar Road (Industrial area with high traffic density and thickly populated).

Detection of heavy metals in air : Air samples from six sites were collected using 'High Volume Sampler' (Envirotech APM 415-411) 8 hr per day once a week in winter (November, December, 2007 and January, 2008), summer (April, May and June, 2008) and monsoon (July, August and September, 2008) seasons. The total number of ten samples in each season was recorded. Samples collected on glass fibre filter papers were filtered through glass micro fibre filter paper GF/A (20.3 x 25.4 cm). The suspended particulate matter (SPM) thus got deposited on the surface of filter paper. Half of this filter paper was subjected to digestion using 3% nitric acid and 8% hydrochloric acid and evaporated to near dryness. After cooling to room temperature, the residue was dissolved in 10ml of distilled water. A blank filter paper was similarly processed as reference sample (Katz, 1977). Estimation of selected metals-lead, zinc, nickel, copper and cadmium was carried out in residue by employing double beam flame atomic absorption spectrophotometer (ECI AAS-4129). The concentrations used in the analysis were calculated as the ratio of the metal amount in each particulate matter sample to the air volume collected during the sampling.

Detection of heavy metals in human blood : The blood samples of 50 subjects were taken from low and high polluted site. The University Human Ethics Committee approved the study design and protocol. Ten ml of venous blood from antecubital vein was collected from each subject into vacutainer tubes containing EDTA using disposable pyrogen-free needle and syringes. The blood samples were kept frozen at -70°C until analyzed.

The inclusion criterion was that the person (age 15-45 years) should be a non–smoker, living and working in the selected areas for more than one year. The exposure levels in the study population were measured by the duration of stay of subjects in the study area as 1-2 year, 2-5 years and above 5 years.Informed consent was taken from the persons before the study. Peoples were excluded if they had a history of smoking, presence of previous lesions or history of pulmonary tuberculosis or any other disorder, any other chronic systemic disease that may affect quality of life such as diabetes, hypertension, coronary artery disease and arthritis etc

Acid digestion method was used to detect the heavy metals. Blood was centrifuged and transferred 1 ml of the plasma to a 10ml glass-stoppered Pyrex-glass test tube (Ivar *et al.,* 1978).A mixture of 2ml of nitric, perchloric and sulfuric acids (6:1:1) was added to the plasma. It was evaporated to near dryness on a hot plate and thereafter cooled to room temperature. The residue was dissolved in 10ml of distilled water. Estimation of heavy metals was carried out by employing double beam flame atomic absorption spectrophotometer (ECI AAS-4129). The data of two sites subjects were compared using 't'test.

Results and Discussion

The mean concentration of Pb at all the sites was found below the permissible limit (1.5 µg m^{-3}) of National Ambient Air Quality Standard (NAAQS, 1994) during all the three seasons. The lead free fuel in vehicles may be responsible for the lower concentration of Pb at all the sites. The maximum mean concentration of Pb was found at Hissar road (0.191 µg m^{-3}) during winter season and minimum at University Campus (0.006 µg m^{-3}) during monsoon season (Fig1a). The mean concentration of Cd was found below the permissible limit (0.015 µg m^{-3}) at all the sites during all the three seasons. At Hissar Road mean concentration of Cd was equal to the permissible limit (0.015 µg m^{-3}) during winter season. The maximum concentration of Cd was found at Hissar Road during winter season while it was

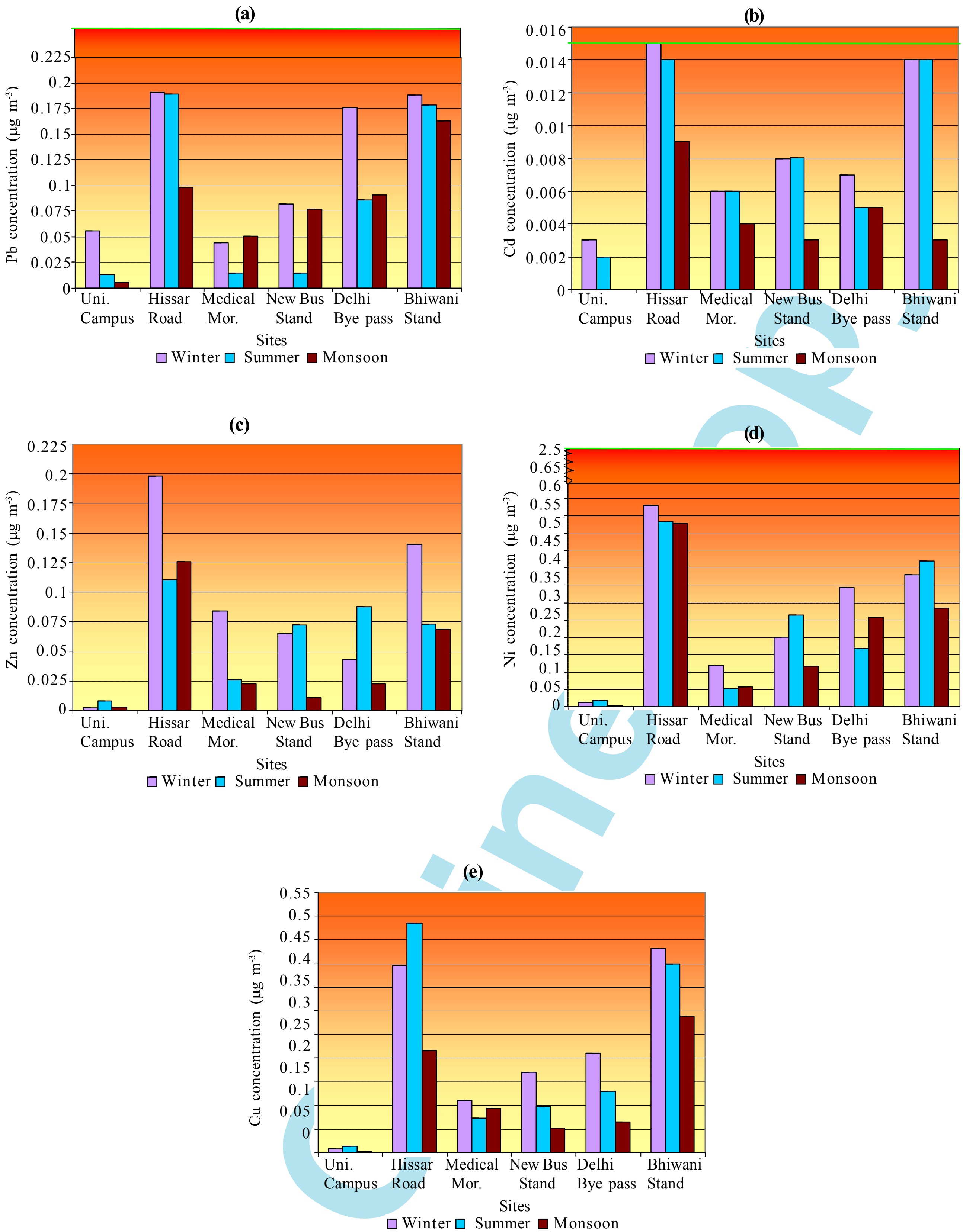

Fig. 1 : Concentration of heavy metals (a) Pb (b) Cd (c) Zn (d) Ni (e) Cu at different sites of Rohtak city during three seasons

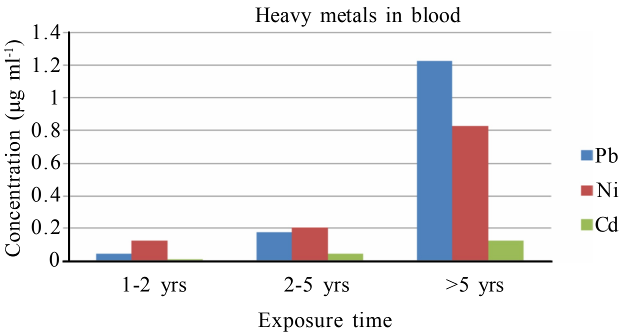

Fig. 2 : Concentration of heavy metals in different exposure groups of Highly polluted area

Table 1 : Mean concentration (µg ml^{-1}) of heavy metals in the blood samples

Heavy metals	High polluted area at Hissar Road	Low polluted area at University Campus	P values
Cu	112.30 ± 46.18	52.63 ± 34.75	p<0.001
Zn	8.26 ± 4.50	3.52 ± 4.36	p<0.001
Pb	1.44 ± 0.68	0.55 ± 0.49	p<0.001
Ni	1.15 ± 1.54	0.20 ± 0.17	p<0.001
Cd	0.16 ± 0.17	0.03 ± 0.02	p<0.001

Values are mean of 50 samples ± SD

not detected at University Campus during monsoon season (Fig1b). The maximum concentration of Zn was found at Hissar Road (0.198 µg m^{-3}) and minimum at University Campus (0.002 µg m^{-3}) during winter season (Fig. 1c). The mean concentration of Ni was found below the permissible limit (2.5 µg m^{-3}) at all the sites during all the three seasons. The maximum concentration of Ni was found at Hissar Road (0.582 µg m^{-3}) during winter season and the minimum concentration of Ni was found at University Campus (0.003 µg m^{-3}) in monsoon season (Fig. 1d). The maximum concentration of Cu was found at Hissar Road (0.486 µg m^{-3}) during summer season and the minimum concentration of Cu was found at University Campus (0.002 µg m^{-3}) during monsoon season (Fig. 1e). Next to Hissar Road, Bhiwani Stand also showed appreciable amount of metals during all seasons. It was due to the fact that Bhiwani Stand being old market area of Rohtak, is thickly populated and congested, which in turn is responsible for frequent traffic jam. Three nearby petrol pumps further aggravate the situation. Delhi Bypass have also petrol pumps and considerable traffic. But unlike Bhiwani Stand, here congestion was not a problem. So the concentration of heavy metals were found to be considerably lower than Bhiwani Stand. It was interesting to note that not much variation was found in the concentration of heavy metals during the three seasons. Similar findings were reported by Gajghate and Hasan (1999) that not much variation was found in the heavy metals levels in summer, winter and monsoon season. It was observed that the concentrations of heavy metals was higher at Hissar Road than University Campus. Polluting sources like burning solid fuels, power battery manufacturing units, crude oil processing, petrol pumps, chemical and metallargical industries and traffic dominance at Hissar Road had contributed to the higher concentration of metals.

Bender and Lange (2001) attributed the presence of Zn metal in ambient air to the traffic as it originates from engine oils, brake, exhaust systems and tire wear. Particularly ultrafine particles have been found capable of inducing harmful cellular changes in toxicological studies (Brown *et al.,* 2001). A study on concentration and distribution of heavy metals in urban airborne particulate matter in Frankfurt, Germany revealed that the highest values occurred at the main street with traffic (Zereini *et al.,* 2005).

Compared with other particle fractions, ultrafine particles have better deposition efficiency and higher number and area concentration (Frampton, 2001). They also have ability to enter directly from lungs into systemic circulation (Nemmar *et al.,* 2002).

Table 1 shows the mean concentration of heavy metals in the blood of the subjects of highly polluted area (Hissar road) and less polluted area (University Campus). The significant difference (P<0.001 was observed in Cu, Zn, Pb, Ni and Cd in blood samples of subjects residing at University Campus and Hissar Road. The mean value of Cu was observed higher in the blood samples of the subjects of high polluted area (112.30 µg ml^{-1}) as compared to the samples of low polluted area (52.63 µg ml^{-1}). The blood Cu level of Hissar Road subjects ranged between 5.37-209 µg ml^{-1} and 0.3-112.7 µg ml^{-1} in the subjects of University Campus. The level of Zn in the blood samples of Hissar road subjects ranged between 0.025-15.7 µg ml^{-1}, with a mean value of 8.26µg ml^{-1}, while that of University campus subjects ranged between 0.007-10.07 µg ml^{-1}, with a mean value of 3.52µg ml^{-1}. The level of Pb in Hissar Road subjects ranged between 0.008-2.78 µg ml^{-1}, with a mean value of 1.44 µg ml^{-1}, while level of Pb in University Campus subjects ranged between 0.003-1.5 µg ml^{-1}, with a mean value of 0.55 µg ml^{-1}. The level of Ni in the blood of Hissar Road subjects ranged between 0.1-5.6 µg ml^{-1}, with a mean value of 1.15 µg ml^{-1}, while in University Campus subjects it ranged between 0.008-0.71 µg ml^{-1}, with a mean value of 0.20µg ml^{-1}. The Cd level in blood of Hissar Road subjects ranged between 0.007-0.94 µg ml^{-1}, with a mean value of 0.16µg ml^{-1}, while in University campus subjects it ranged between 0.0016-0.1 µg ml^{-1}, with a mean value of 0.03 µg ml^{-1}, respectively.

Hissar Road being an industrial area with highly polluted area leads to exposure to people residing and working in that area against the University campus which is clean and full of greenery. So it was observed from the study that the subjects belonging to Hissar Road had 2-3 times higher concentration of Pb,Zn,Cu and 5-6 times Ni and Cd in their blood as compared to the subjects residing at University campus. The subjects residing at Hissar Road for more than five years were found to have much higer concentration of heavy metals in their blood (Fig 2).This may be due to high traffic and factories of batteries and metallurgy present at Hissar Road.

The inorganic components constitute a small portion by mass of the particulates; however, it contains some trace elements such as As, Cd, Co, Cr, Ni, Pb and Se which are human or animal carcinogens even in trace amounts (Wang *et al.,* 2006).

The concentrations of heavy metals in air were maximum at Hissar Road than other sites because of many factories of batteries, smelter operations and metallurgy industry. The subjects belonging to Hissar Road had 2-3 times higher concentration of heavy metals in their blood.

Acknowledgments

I extend my heartfelt feelings of gratitude to Mr. Gurnam Singh (Head, Air pollution Board), Dr. S.K. Tyagi (Senior Scientist) and all the members of Ministry of Pollution Board for their advice and help.

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