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Speciation of carcinogenic and non-carcinogenic metals in respirable suspended particulate matter (PM_{10}) in Varanasi, India

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ABSTRACT

Present study deals with the speciation of carcinogenic and non-carcinogenic metal (Cr, Mn, Fe, Co, Ni, Cu, Zn, Cd and Pb) in respirable suspended particulate matter (RSPM) using sequential extraction procedure (SEP) in ambient air of Varanasi, India. Higher concentration of Fe, Zn and Cu followed by Cr, Mn, Co, Cd and Pb was found in RSPM. Exchangeable fraction was highly significant in all metals except Fe which was dominant in residual fractions. Scanning Electron Microscope-Energy Dispersive X-ray Spectroscopy (SEM-EDX) was conducted to assess weight percentage of elements. EDX results revealed that particulate matter collected at Banaras Hindu University (BHU) contain Boron (55.39 wt%) which was absent at other two sites. Cu, Zn, Cd and Pb were present in significant wt% at BHU and Chandpur Industrial Estate. Metals released from anthropogenic activities may cause respiratory and dermal diseases as immediate symptoms. In long term, bioaccumulation and biomagnifications of metals may lead to serious life threatening diseases like cancer.

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1. Introduction

Rapid industrialization and urbanization has adversely affected the ambient air quality. Increase in concentration of gaseous and particulate pollutants is a serious cause of concern (Police et al., 2016). Suspended particulate matter (SPM) (mixtures of solid and liquid particles) is both natural (sea salt, pollen grains, volcanism etc.) and anthropogenic (fuels, vehicles, industries etc.) in origin, which may have inorganic or organic composition (Smichowski et al., 2005). SPM play important role in biogeochemical cycle of the environment (Soriano et al., 2012). The radiative, optical and electrical effects caused by SPM depend upon size and chemical nature of SPM (Venkataraman et al., 2002) and may affect global climate change scenario (Ali et al., 2012). The labile fractions of metals attached onto the SPM are one of the important metal contamination sources and are dispersed over a long distance by wind. It may cause severe health consequences like respiratory, dermal, cancer and neural diseases by inhalation and ingestion (Kumar and Attri, 2016; Pant et al., 2016; Taner et al., 2013; Azimi et al., 2004; Kappos et al., 2004). It may get deposited on water and soil and enter the food chain (Aas et al., 2009). To predict the hazardous effect on the biotic and abiotic components, it is necessary to study the chemical nature, especially metallic association of SPM. Determining the metal species attached to the SPM helps in understanding of mobility, bio-availability and toxicity of metals (Wiseman and Zereini, 2010; Kumar et al., 2008; Smichowski et al., 2005; Fernandez et al., 2000). Therefore, it becomes essential to assess different metal species in SPM.

Present study deals with the metal speciation in SPM in ambient air based on BCR (Community Bureau of Reference) modified sequential extraction procedure (SEP) (Sutherland, 2010; Rauret et al., 2001; Rauret et al., 1999; Tessier et al., 1979). Metal speciation in SPM has not been conducted in the study region. Hence it becomes important to assess the metallic behavior of SPM using SEP.

1.1. Study region

The present investigation was carried out in Varanasi (25°16′55″N, 82°57′23″E, 76 m amsl) which is regarded as cultural and religious capital of India. The study region has sub-tropical climatic conditions characterized by well-defined summer (April–June), rainy (July–September) and winter (November–February) seasons. March and October have transitional properties between the seasons. Temperature ranges from 35 to 45 °C in hot dry summer season while in warm humid rainy season, it ranges between 25 and 35 °C. Dry winter season is characterized by low temperature (10–25 °C) (Kushwaha et al., 2001). The city (land area 80 km^2 approx.) is represented by large number of temples, buildings and narrow lanes. High population

Table 1
Sampling period and concentration of RSPM.

Date	Concentration of PM10 (μgm^{-3})		
	CIE	PTL	BHU
7th November 2013	207.59	175.25	98.72
14th November 2013	222.44	170.42	113.07
21st November 2013	235.86	178.66	124.22
28th November 2013	240.21	175.11	131.54
4th December 2013	211.58	181.02	135.89
12th December 2013	242.70	182.39	130.41
19th December 2013	268.27	185.43	132.36
26th December 2013	268.61	190.85	137.60
2nd January 2014	275.08	188.47	141.25
9th January 2014	273.74	185.68	142.62
16th January 2014	265.18	185.93	147.31
23rd January 2014	249.22	178.11	147.95
30th January 2014	257.08	176.83	139.24
6th February 2014	276.64	177.05	134.51
13th February 2014	239.31	182.29	138.04
20th February 2014	232.40	172.15	137.87
27th February 2014	208.69	170.44	135.71
NAAQ Standards*	100 (Residential & Industrial)	100 (Residential)	100 (Residential)

* National Ambient Air Quality Standards (NAAQ), India - 24 h.