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Seasonal variation and sources of heavy metals in hilltop of Dongargarh, Central India

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ABSTRACT

An investigation to find out the presence of heavy metals (HMs) in aerodynamic particulate matter ($PM_{2.5}$) in hilltop of Dongargarh, Central India was carried out in year 2011. This is the first such study in this part of India. Sum totals of 80 samples were collected during 12-h sampling by a fine particulate dust sampler using micro fibre filter paper. The mean concentration of $PM_{2.5}$ was 121 ± 64.2 μg/m^3. The annual concentration of Fe, Zn, Cu, Ni, Cr, Cd and Pb are 513.9 ng/m^3, 320.6 ng/m^3, 141.8 ng/m^3, 120.7 ng/m^3, 87.8 ng/m^3, 81.2 ng/m^3 and 289.0 ng/m^3, respectively in descending order of Fe > Zn > Pb > Cu > Ni > Cr > Cd. Further, the concentrations of all the HMs were higher in winter and followed by post-monsoon, monsoon and summer. Meteorology played an important role in concentration of HMs in $PM_{2.5}$. Turbulent conditions resulted in higher concentration owing to re-suspension and external input whereas, low wind speed, low temperature and high relative humidity favoured low concentration of the pollutants. The evaluation of enrichment factor revealed that Pb, Ni, Cu, and Cr are emitted, chiefly from anthropogenic sources and Fe and Zn are associated with natural sources.

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1. Introduction

The aerosols play an important role in regional air quality, atmospheric chemistry & physics and climate change especially over central India (Ambade, 2012). They are originating from different

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sources generally have different particle size ranges and chemical composition. Fine particles are usually emitted from anthropogenic sources, such as combustion processes, or are produced by gas-to-particle conversion, while coarse particles, like dust and sea salt, are mostly from natural processes. Consequently, observations on the particle size distribution and chemical composition of aerosols would be valuable for understanding their physical/chemical characteristics, sources, and actions and formation mechanism. The effects of inhaling particulate matter which have been widely studied in humans and animals include asthma, lung cancer, cardiovascular disorders, and premature death (Pope and Burnett, 2002; Spurny, 1996; Olivieri and Scoditti, 2005; Ambade and Ghosh, 2013). Concern regarding the harmful effects of these particles on human health has been increasing as a consequence of many epidemiological and toxicological studies carried out from the 1990s (Schwartz, 1994; Schlesinger, 1995; Harrison and Yin, 2000; Laden et al., 2000; Mar et al., 2000; Samet, 2000). Changes in anthropogenic and biogenic emissions may also have a substantial influence on future air quality. Changes in anthropogenic emissions (excluding control related reductions) are primarily driven by population growth and urbanization. In recent years the levels of PM in the urban atmosphere have been of concern the world over because several studies indicate that particles may induce severe effects on public health (Schwartz, 1994). Many studies have addressed the problem of pollution by heavy metals including Cu, Cr, Fe, Ni, Pb, Zn, V, As, Be, Cd, Mn etc. Most of these are short-term studies of coarse suspended particulates or total suspended particulates (TSP) (Negi et al., 1996; Khillare et al., 2004; Tripathi et al., 2004).

Wind speed and direction have also been reported as important parameters for a better characterization of heavy metal behaviour in fine and coarse particle fractions (Harrison et al., 1997). Wind direction has been used as data input for models forecasting metal concentration maxima and estimating the direction of optimal concentrations (Ziomas et al., 1995; Somerville et al., 1996; Patel et al., 2012). Meteorological parameters play a significant role in transport, diffusion and natural cleansing in the atmosphere. (Ambade, 2012).

The present study aims to focus on the relationship between atmospheric concentrations of trace metals and selected meteorological parameters measured during the monitoring period. In particular, the seasonal concentrations of metals (Fe, Zn, Pb, Cr, Co, Ni and Cd), in meteorological variables, were recorded. principal component analysis (PCA) was used for the source identification/appointment for selected airborne trace metals following the standard procedures (Manoli et al., 2002; Statheropoulos et al., 1998).

The Dongargarh is one of the prominent places of worship which is located at a distance of 35 km from Rajnandgaon city and 67 km from Durg city in the state of Chhattisgarh, India. Dongargarh is the main tourist as well as pilgrimages of the Rajnandgaon district. The famous temple of Maa Bamleshwari is on a hilltop of 1600 ft in the town of Dongargarh.

2. Materials and methods

2.1. Site description

Dongargarh is situated at 21.2° North latitude, 80.73° East longitude and 355 meters elevation above the sea level. As per the 2001 India census, Dongargarh had a population of 34,440 (Census, 2001). It is located in the western part of Chhattisgarh state in Central India (Fig. 1). Dongargarh has been derived from two words: 'Dongarh' meaning 'mountains' and 'garh' meaning 'fort'. Dongargarh is the main tourist as well as pilgrimages of the Rajnandgaon district in Chhattisgarh state, Central India. The famous temple of Maa Bamleshwari is on a hilltop of 1600 ft in the town of Dongargarh. The sampling was carried out in hilltop of Dongargarh.

2.1.1. Sample collection

Sampling was done for $PM_{2.5}$ on hilltop of Dongargarh (height 1600 ft). $PM_{2.5}$ samples were collected with fine particulate dust sampler Envirotech (New Delhi, India) APM-550 high volume sampler, having a minimal particle size cutoff with diameter of 2.5 mm. The $PM_{2.5}$ collected by Teflon micro fibre filter paper (2 μm PTFE) of size 46.2 mm. The sum totals of 80 samples were collected.

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