DISTRIBUTION OF SUSPENDED PARTICULATE MATTER WITH TRACE ELEMENT COMPOSITION AND APPORTIONMENT OF POSSIBLE SOURCES IN THE RANIGANJ COALFIELD, INDIA

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Abstract. Ambient air monitoring for suspended particulate matter was carried over a period of one year in some coal mining areas of the Raniganj coalfield. Concentrations of seven elements in suspended particulate matter were determined. The set of data obtained was analysed to determine the sources of trace elements by factor analysis. The data could be interpreted on the basis of five factors. These factors are attributed to various sources of particulate matter by noting the dependence of factors on the elements.

1. Introduction

Coalmining operations inevitably lead to the release of particulate pollutants into the atmosphere. In underground mines, blasting and loading operations generate considerable amounts of dust which is ultimately released into the atmosphere through the mine’s ventilation system. Wind erosion of coal stockpiles, and vehicular movement on both paved and unpaved roads, are other major sources of dust pollution in mining areas. Studies have shown that such non-traditional sources contribute more to suspended particulate matter (SPM) levels than conventional sources (Evans and Copper 1980). These open sources of air pollution are too great in extent to be controlled through enclosure or ducting and are, perhaps, responsible for the serious air pollution problems being faced in Indian coal mining areas.

Studies conducted around Jharia coalfield (Banerjee and Hussain 1989, Bose et al. 1982, Ghosh et al. 1982) and Raniganj coalfield (Bose et al. 1986, Sharma and Singh 1990, Singh and Sharma 1991) have reflected high levels of SPM in these regions. Continued exposure to high levels of SPM pose a health hazard to the workers in the site as well as to the local residents living in the mining areas. It has been found that several toxic elements including lead (Pb), vanadium (V), zinc (Zn), chromium (Cr), manganese (Mn) and their compounds are associated with fine particulate matter and it is, therefore, important to study composition of SPM for realistic assessment of health hazards.

Study of the composition of SPM can also aid in identification of the sources which contribute to total particulate load at a given place. Several studies (Greenberg et al. 1978, Negi 1987) have been carried out to determine the composition of urban aerosols and a number of attempts (Bogen 1973, Gaarrenstroom et al. 1977,
Hopke et al. (1976) have been made to relate the observed elemental concentration to those sources which may contribute trace elements. However, most of these studies have been carried out in urban centres and little is known about the levels of trace elements in coal mining areas and of their sources.

The present investigation was carried out to study spatial distribution of SPM over a part of Raniganj Coalfield and to determine atmospheric levels of seven elements, viz., Cr, Cu, Fe, Mn, Pb, V and Zn in SPM. Results obtained were used to determine the sources which contribute to total particulate load.

2. Methodology

SPM samples were collected in Raniganj coalfield, which is situated about 200 km north-west of Calcutta. Samples were collected from ten different sampling stations located between 23°37'12" to 23°41'50" and 87°8'4" to 87°20'. There are five underground mines in the chosen study area. A map of the study area and location of these stations is given in Figure 1.

Samples were collected on pre-weighed Whatman microglass, fiber filter papers (GF/A and EPM 2000) using Envirotech High Volume Air Samplers which were operated for 12 h at an average flow rate of 1.0–1.5 m$^3$ min$^{-1}$. The study was carried out for about one year from August '88 to June '89. A total of 640 samples were collected, of which 80 samples were collected on EPM 2000 specifically for toxic element analysis.

The mass concentration ($\mu g$ m$^{-3}$) of SPM in ambient air was computed by measuring the mass of collected particulate and the volume of air sampled.

The concentrations of elements were determined using procedures similar to those described by Thompson et al. (1969 and 1970) and Warner (1975). Elements were determined after digesting the filter with 75 ml of 50% HNO$_3$ for 6 h. A Varian AA-575 Atomic Absorption Spectrophotometer (AAS) was used for the analyses. Samples were introduced directly into the flame by continuous aspiration through polyethylene tubing and the concentration of the object element (in $\mu g$ ml$^{-1}$) was obtained. The concentration of the element in the atmosphere was calculated from the following relation.

\[
\text{Concentration} = \frac{\text{amount of element} \times \text{total volume of sample}}{\text{volume of air} \times \text{percentage of the collected sampling area used} \times \text{percentage of the coll-}}
\]

\[
(mg \text{ ml}^{-1}) = \frac{\text{ml}}{\text{mg} \text{ m}^{-3}} \times \text{percentage of the coll-}
\]

\[
\text{spected area used} \%}
\]

The data set obtained is analysed to determine the sources of trace elements by factor analysis (FA). FA is a branch of multivariate analysis which deals with the internal structure of correlation matrix variables. The technique has been described in detail by a number of authors (Hopke et al. 1976, Gaarrenstroom et al. 1977). FA is applicable whenever one quantity can be expressed as a linear combination