Spatial pollution screening of the road-dusts within "The Bombay Arc", India: Magnetometry as a pollution proxy

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Abstract: Spatial magnetometric and heavy metal distribution of 250 environmental sensitive dusts accumulated on major roads of Mumbai and its suburban cities, were evaluated and categorised according to the defined pollution indices. Road dusts were collected from 4 individual sectors with characteristics settlement structure ranging from residential, commercial to industrial environment. Road dust magnetic and chemical characterization, together with microscopic investigation is performed to observe the spatial distribution pattern, identification of pollution hot spots and discrimination of pollutant source. Statistical investigation like bivariate correlation, principal component analysis and pollution indices are performed on the entire dataset to know about magnetic metal relationship, metal sources to road dusts and for the evaluation of toxicity status of concerned metals both at site specific and sectoral level.

Susceptibility (χ) values obtained for these road dusts are too high in comparison with the χ values obtained from other pollution studies. Results of descriptive statistics clearly shows insignificant contribution of χFD% to the road dust material as the dusts are mainly composed of unweathered basalt remnants and atmospheric fall-outs having mainly the grain sizes in MD and PSD range. The κ-T runs indicate a dominant ferrimagnetic phase of magnetite mineral having Curie temperature (T_c) of 600°. A trace quantity of elemental Fe cannot be ruled out as all the curves show small positive κ value up to 720°C. Magnetite is confirmed in the low temperature thermomagnetic runs where at -150°C a hump occur called Verwey transition (T_v). The hysteresis loops of all the dust samples looks similar and of PSD or MD type of ferrimagnetic magnetite or titanomagnetite nature.

The extremely high concentrations of Pb, Zn, Cu, Sn, As etc in the road dusts of "The Bombay Arc" region is unlikely from the natural background source and suggests various anthropogenic loading to the dust composition. The spatial distribution pattern of Pb, Zn and Cu confirms the results obtained from magnetic analysis of the road dusts earlier and strengthen the utility of magnetic analysis. In general, Pb prone areas have been outlined well using suitable magnetic parameters such as χ, Soft IRM prior to any chemical analysis. Sites with "magnetically uncoupled" Pb contents were also observed in the Taloja industrial area, suggesting the Pb source not being outlined by magnetic proxies.

The toxicity status of each site as evaluated using various pollution indices namely enrichment factor, pollution load index and geoaccumulation index revealing extreme toxicity for Pb for all the sites followed by Zn, Cu, As and Sn. Integrated assessment of metal toxicity assessed using PLI reveal almost every sites being polluted to certain extent. Some sites were identified as extremely polluted in the South Mumbai sector might be caused from the extreme traffic densities on these roads.

Principal component analysis performed on the dataset identifies the principal metal sources as geogenic, traffic born, metal smelters and chemical industries. The anthropogenic components mostly dominates in South Mumbai and Vashi-Turbhe sector where as at Chembur-Trombay sector the geogenic components dominates. The high temperature combustion sources of metal inputs to the dusts were confirmed from microphotograph analysis of the magnetically extracted dusts.

Keywords: Magnetic susceptibility, road dusts, toxicity, Mumbai, heavy metals