# Chemical Characterization of Mineral Aerosols: Sources, Transport and Atmospheric Transformations

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By

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# *D E C L A R A T I O N*

I Mr. **Ashwini Kumar**, S/o: Mr. Lalit Kumar Jha, resident of C-3, PDF Qtrs, PRL residences, Navrangpura, Ahmedabad – 380009, hereby declare that the research work incorporated in the present thesis entitled "**Chemical Characterization of Mineral Aerosols: Sources, Transport and Atmospheric Transformations**" is my own work and is original. This work (in part or in full) has not been submitted to any University for the award of a Degree or a Diploma. I have properly acknowledged the material collected from secondary sources wherever required. I solely own the responsibility for the originality of the entire content.

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Date: (Ashwini Kumar)

# *C E R T I F I C A T E*

I feel great pleasure in certifying the thesis entitled "***Chemical Characterization of Mineral Aerosols: Sources, Transport and Atmospheric Transformations***" by **Ashwini Kumar** under my guidance. He has completed the following requirements as per Ph.D. regulations of the University

(a) Course work as per the university rules.

(b) Residential requirements of the university

(c) Regularly submitted six monthly progress report

(d) Presented his work in the departmental committee

(e) Published/accepted minimum of one research paper in a referred research journal.

I am satisfied with the analysis of data, interpretation of results and conclusions drawn.

I recommend the submission of thesis.

*Date:* *Name and Designation of Supervisor*

*Countersigned by*
*Head of the Department*

*Dedicated to my*

*"Ma and Papa"*

**ABSTRACT:**

With the natural variability in emissions, atmospheric circulation patterns and the current changes brought about by the anthropogenic activities, the distribution and chemical properties of mineral aerosols and their direct/indirect effects on climate are the focus of present-day scientific issues. This thesis study presents a first comprehensive data set on the chemical composition of size-segregated aerosols ($PM_{10}$ and $PM_{2.5}$) collected from a high-altitude site located in a high-dust semi-arid region (Mt. Abu, 24.6 $^{o}$N, 72.7 $^{o}$E, 1680 m asl) of western India. The principle objective is to asses the temporal variability in the atmospheric abundance of mineral dust, its chemical composition and to assess the chemical transformation processes occurring during the long–range transport from source regions. The chemical data reveals a uniform and dominant contribution (60 – 80 %) of mineral dust in the coarse mode ($PM_{10-2.5}$) over the annual seasonal cycle. During summertime (March-June), the Fe/Al weight ratio averages around 0.5, quite similar to their ratio in the crustal material. However, enriched Ca/Al and Mg/Al ratios suggest significant contribution from carbonate minerals in the coarse fraction. The impact of anthropogenic sources is significantly pronounced in the fine mode ($PM_{2.5}$), during wintertime (Nov-Feb), as evident from the increase in concentrations of nss-$SO_4^{2-}$ and $NH_4^+$ as well as high enrichment factors of Cd and Pb. A significant increase in the fractional solubility of aerosol iron with a concomitant decrease in the mass fraction of mineral dust further suggest the dominant role of combustion products (emissions from biomass burning and fossil-fuel). The water-soluble ionic composition (WSIC) constitutes 50 % of the $PM_{2.5}$ mass with a dominant contribution from $SO_4^{2-}$ and $NH_4^+$. In the coarse mode, contribution of WSIC is consistently low (average ~ 20 %) with predominance of $Ca^{2+}$ and $HCO_3^-$. The neutralizing capacity of mineral dust for acidic species ($SO_4^{2-}$ and $NO_3^-$) is near quantitative (95 %) in the coarse mode; whereas $NH_4^+$ is a major neutralizing constituent in the $PM_{2.5}$.

To sum up, this thesis study provides useful parameters on the atmospheric transport of mineral dust and chemical transformation in order to validate regional models for forecasting climate-state and climate-change.

***(Keywords: Aerosol Chemistry, Mineral dust, Acid uptake, Aerosol iron solubility, Deposition fluxes, Marine atmosphere)***

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