Characteristics, sources and seasonal variations of water soluble ions in aerosols over the central Himalayas, Nepal

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Summary

- Water soluble inorganic ions from the aerosols were analyzed
- Highest concentration of major cation was Ca^{2+}
- The highest concentration of major anion was SO_4^{2-} with an average of 10.96 and 4.06 µg m^{-3} at Bode and Dhunche respectively.
- The soluble ions showed the decrease in concentrations from urban site (Bode) to the rural site (Dhunche).
- Linear correlations showed that SO_4^{2-}, NO_3^- and NH_4^+ were derived from the anthropogenic sources.
- Ca^{2+} and Mg^{2+} were from crustal sources.
- Seasonal variations: higher concentrations during pre-monsoon and winter (dry-periods) due to limited precipitation amount and lower concentrations during the monsoon.
- K^+ (tracer of biomass burning) had significant peaks during pre-monsoon season when the forest fires were active around the regions.
- In general, the results suggest that the atmospheric chemistry is influenced by natural and anthropogenic sources.

Background

Air pollution has become more serious problem in South Asia, especially in the Himalayan region, Nepal. Atmospheric aerosols are of major environmental concern due to their adverse affect on human health (Davidson et al., 2005), decrease visibility and enhance climate change (Anderson et al., 2002). Aerosols not only reflect and affect regional atmospheric environmental characteristics, but also affect globally due to long-range transport. Therefore, there is an increasing attention to study the chemical characteristics of atmospheric aerosols.

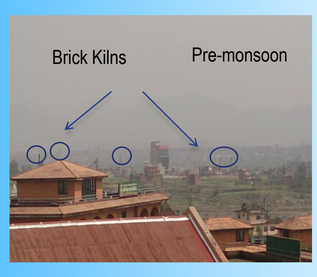
Water soluble ions consists of a huge portion of aerosol particles (Ali-Mohamed, 1991).The WSIIs in aerosols can provide valuable information and knowledge on the effect of regional and local pollution and the health of the ecosystem (Wang et al., 2005).

The southern side of Himalayan region is facing long-term poor air quality problems with aerosol as a major pollutant. Therefore, this work is important to understand the chemical compositions, seasonal and spatial variations of WSIIs in aerosols and to identify their possible sources in the Himalayan region, Nepal.

Materials and Methods

Sampling Sites:

- Two sites for TSP sampling were chosen: Bode (1318m) and Dhunche (2065m)
- Aerosol samples were collected from April, 2013 to March, 2014
- Major sources of pollutants at Bode: vehicular emission, industries and brick kilns.
- Dhunche is a small town located in the Langtang National Park with minimal anthropogenic inputs.



Urban site (Kathmandu)

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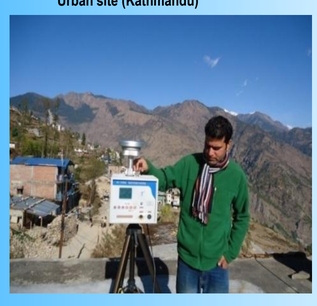
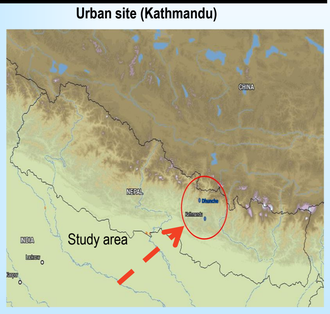


Rural site (Dhunche)



Sampling sites

Sampling Equipment

- Type KC-120H Intelligent Mid-flow TSP sampler designed for 90 mm filters
- Quartz filter
- Volume: 80-125 Lpm
- Once a week for 24 hours

Laboratory analysis

- 1.13 cm^2 punched slices of each filter
- Extracted by 10 ml deionized water and shaken in mechanical shaker
- Sonicated for 1 hour
- Filtered with 0.45mm micro porous membrane
- Ion chromatography was used to analyze the concentrations of 8 major water soluble ions.

Results

Water soluble Ionic Composition in aerosols at 2 sites

- Highest mass concentration in urban site Bode (39.9 µg m^{-3}) and lower in Dhunche (14.1µg m^{-3})
- Highest percentage mass cations: Ca^{2+} followed by NH_4+
- Dominance of dust aerosols and fertilizers in agricultural activities, livestock breeding which are prevailing around the region.
- Highest percentage mass anions: SO_4^{2-} followed by NO_3^-
- Emitted from different anthropogenic sources

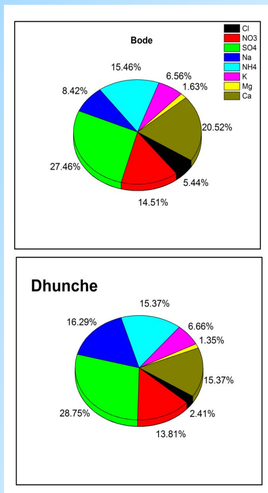
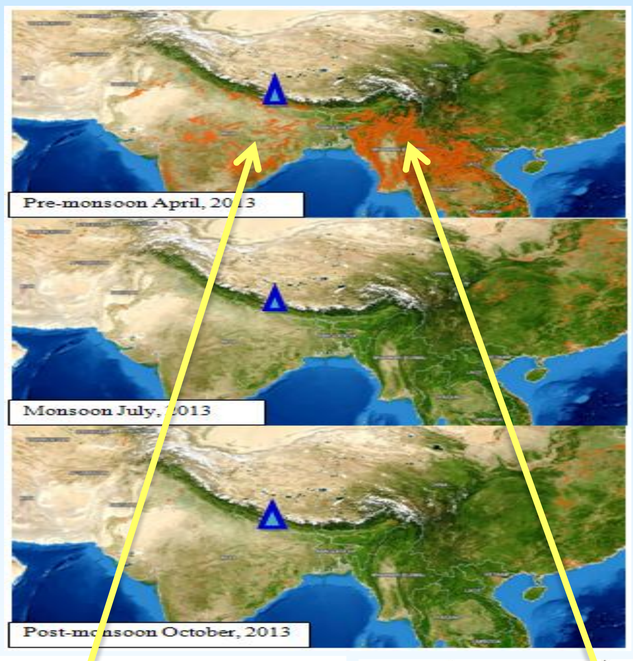


Fig. Percentage of ionic mass concentrations

Seasonal variations of water soluble ionic species



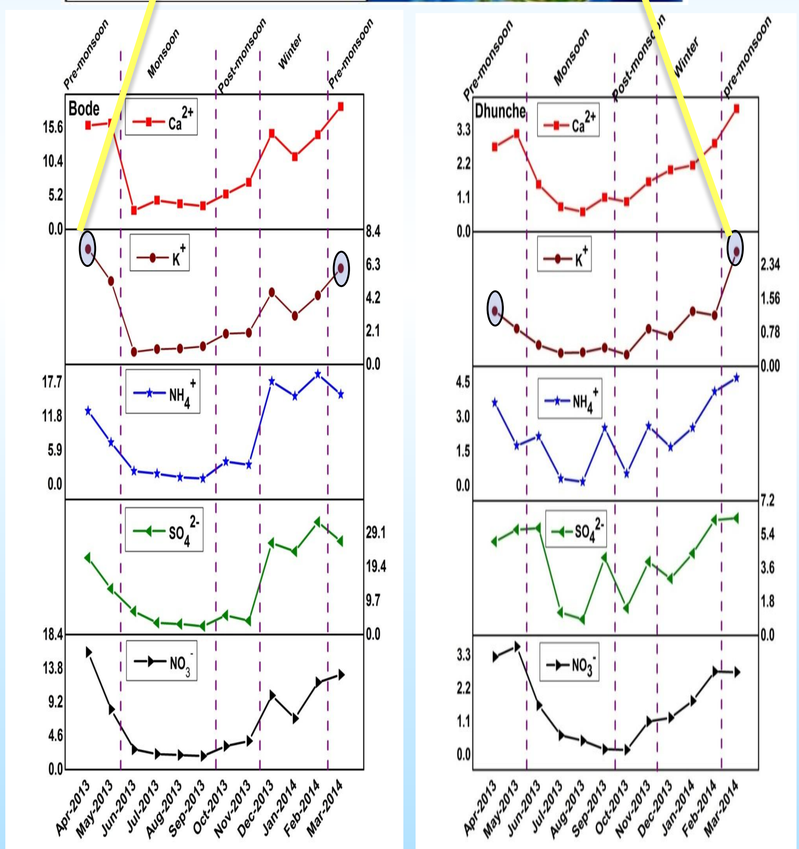


Fig. Seasonal variations of WSIIs in aerosols

- ✓ Anthropogenic ions (SO_4^{2-}, NO_3^- and NH_4^+) were higher during winter and Pre-monsoon (Dry period, less rainfall and less scavenging)
- ✓ Lower during monsoon (large amount of rainfall that washes out aerosols)
- ✓ K^+ is a tracer of biomass burning
- ✓ Major fuel used for cooking and heating activities in this region is biomass
- ✓ Biomass burning and forest fire occurring during this period (Dry) has contributed to the higher peak of K^+ during the pre-monsoon period.

Relationship between the WSIIs

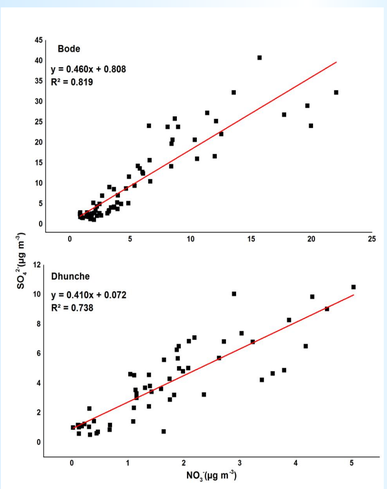


Fig. Correlations between SO_4^{2-} and NO_3^-

- SO_4^{2-} and NO_3^- showed very good correlations
- ✓ origin from similar sources
- ✓ similarity in their behavior in the atmosphere
- ✓ mainly related to fossil fuel combustion

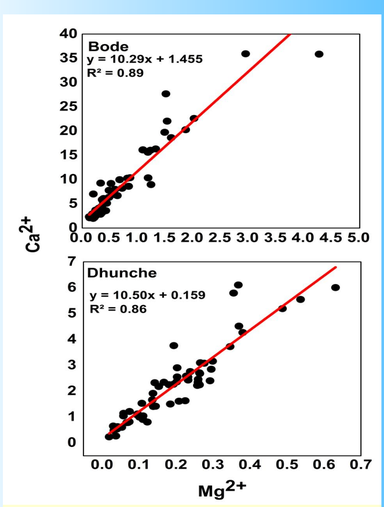


Fig. Correlations between Ca^{2+} and Mg^{2+}

- Ca^{2+} and Mg^{2+} showed very good positive correlations suggesting their similar source
- ✓ Ca^{2+} is the tracer of crustal dusts
- ✓ from natural crustal sources

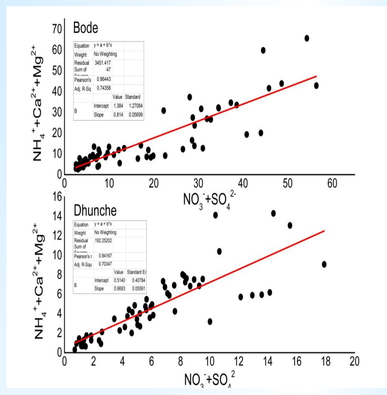


Fig. Regression between NO_3^- and SO_4^{2-} with Ca^{2+}, Mg^{2+} and NH_4^+

- The correlation coefficient at two sites: Kathmandu and Dhunche were 0.86 and 0.84.
- Ca^{2+} and NH_4^+ as the major neutralizing agent in the atmosphere
- Mg^{2+} insignificant role

Conclusions

- Aerosol composition is mainly controlled by regional crustal dust, anthropogenic emissions, biomass burning in the central Himalayas, Nepal.
- Distinct and clear seasonal variation was observed at both the sites (lower concentrations during monsoon period).
- Higher concentrations at urban site.

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Acknowledgements

This work was supported by the Strategic Priority Research Program (B) of the Chinese Academy of Sciences (Grant No. XDB03030504).

We would like to thank the staffs from both sites for sampling work.