International Journal of Chemistry and Chemical Engineering.
ISSN 2248-9924 Volume 3, Number 3 (2013), pp. 149-154

http://www.ripublication.com

Identification of Nature and Sources of Dustfall at Mukteshwer in Kumaon Region of Central Himalaya, India

Bablu Kumar*, Y. Meena, G.P. Gupta, S Singh and U.C. Kulshrestha

School of Environmental Sciences, Jawaharlal Nehru University,
New Delhi–110067 INDIA.

Abstract

The wind-driven transport and deposition of dust particles can cause considerable physical and chemical changes to the atmospheric environment. Recently it has been realized that dust aerosol are very important and these play an important role in radiative forcing and acid rain. During most part of the year, prevailing dry weather conditions increase the significance of dustfall deposition. Ambient concentrations of reactive gases such as SO_2 and NO_2 etc. are controlled by continuous input of atmospheric dust contributed by suspended soil. Despite evidence of the ecological importance of dust deposition, the studies on chemistry of dustfall and their sources are not extensively carried out through space and time in Indian region especially in hilly region. Hence, the present work is aimed to study chemical composition of dustfall at Mukteshwer in Kumaun region of central Himalaya to find out their association with anthropogenic and crustal sources. High pH (7.14) at this site indicating the alkaline nature of dustfall and high alkalinity may be due to Soil derived aerosols which are rich in $CaCO_3$. Among anions, SO_4^{-2} concentration was the highest which were associated with Ca^{+2} similar to other reports in Indian region. This is primarily because SO_2 adsorb onto dust particles resulting in the formation of Calcium Sulphate. Very high SO_4^{-2} concentration could be due to long range transport since nearby no any significant source of SO_2 exit. Higher concentration of NO_3^- can be attributed to high vehicular emissions due to increased tourist activities with long range transport of aerosol, which becomes integral part of dust. Among cations, dustfall extract showed very high K^+ after Ca^{+2} indicating wood burning used for cooking and heating purposes. Calculation of marine influxes and crustal contribution suggested a significant influence of non-marine sources at this site. In general, it was found that the concentrations of acidic species are lesser than China and USA but higher than Europe while the concentrations of basic radicals like calcium was very high at Indian site indicating the maximum neutralization of acidic species.

Keywords: Dustfall, Mukteshwer, Anthropogenic, Long Range Transport, Crustal.

1. Introduction

Mineral dust derived from the crustal surface is the major contributor to aerosol loading and an important component of the atmosphere. Estimated quantifications of global dust emissions vary considerably in the range of 1500-2600 Tg yr^{-1} (IPCC, 2007). This particulate matter plays an important role in atmospheric processes since dust particles provide reaction sites for many heterogeneous reactions involving atmospheric gases. Furthermore, the accumulation of dust is now accepted as a control of biogeochemical cycling in many ecosystems. The atmospheric mineral dust has potential to impact global atmospheric chemistry, cloud properties and precipitation development (Andrae and Crutzen, 1997; Kulshrestha et al., 2009). During most part of the year, dry weather conditions prevail which determine the atmospheric deposition chemistry in India. Ambient concentrations of reactive gases are controlled by continuous input of atmospheric dust contributed by suspended soil. Hence, dustfall deposition is a significant removal mechanism in India as it provides very efficient sink for acidic gases (Kulshrestha et al., 2003b; Rodhe et al., 1992). Despite evidence of the ecological importance of dust deposition, the studies on chemistry of dustfall and their sources are not extensively carried out through space and time especially Himalayan region in India. Hence, the present study was carried out to know chemistry of dustfall at Mukteshwer in Kumaun region of central Himalaya, India.

2. Methodology

2.1 Sampling site and sample collection

Mukteshwer is located at 29.47°N 79.64°E, 51 km NE of Nainital, India (Fig. 1).. It sits high in the Kumaon Hills of central Himalaya at an altitude of 2286 meters. It lies 51 km from Nainital, 72 km from Haldwani and 395 km from Delhi. There is no major local sources of pollution exist except wood burning by local peoples and road dust suspension due to increased tourist activities. Samples of dustfall (n=30) were collected using a plastic tray kept one meter high on the roof surface of a building during 2012. This tray was exposed in air for 48 hours. The deposited material was dissolved into 20 ml of high quality deionised water and preserved at 4^0C before chemical analysis.

2.2 Chemical analysis

The pH of water dissolved dustfall sample was measured by using EUTECH pH meter. HCO_3^- was estimated by manual titration method using 0.0025 N H_2SO_4 (APHA, 1998). The major cations (Na^+, NH_4^+, K^+, Ca^{2+} and Mg^{2+}) and major anions (F^-, Cl^-, NO_3^- and SO_4^{2-}) were analyzed by ion chromatograph (Metrohm 883 Basic IC Plus). The anions were determined by using Metrosep A SUPP 4, 250/4.0 column and an eluent of 1.8 mmol/L Na_2CO_3 and 1.7mmol/L $NaHCO_3$ at a flow rate of 1.0 ml/min with Metrohm suppressor technique. The cation separation was achieved with the Metrosep C4-100/4.0 column and an eluent of 1.7 mmol/L Nitric acid and 0.7 mmol/L Dipicolinic acid at a flow rate of 0.9 ml/min without suppressor.

3. Results & Discussion

3.1 pH, alkalinity of dustfall and ion balance

The pH, alkalinity and major ionic species of dustfall estimated at Mukteshwer. The average pH (7.14) of sample was high at this site indicating the alkaline nature of dustfall which is typical feature of Indian region. The average alkalinity (13 mg/l) was high at site may be due to Soil derived aerosols which are rich in $CaCO_3$. High alkalinity observed in dustfall is due to high concentration of Ca^{+2}. As reported by Kulshrestha et al (1999) and Kulshrestha et al (2009), soil derived aerosols which are rich in $CaCO_3$ are responsible for higher values of alkalinity of dustfall.

It is to be noted that in reported major anions (Cl^-, NO_3^-, SO_4^{-2}) and cations (Na^+, NH_4^+, K^+, Ca^{+2}, Mg^{+2}), the ions balance has a huge difference. This gap is minimized by inclusion of HCO_3^- ion. This further emphasizes the need of HCO_3^- measurements in India (Kulshrestha et al 2003a).

3.2 Dustfall deposition fluxes of major ionic species

Among cations, dustfall deposition fluxes followed following order-, Ca^{+2}> K^+>Mg^{+2} >Na^+> NH_4^+ while anion followed following order- SO_4^{-2}> NO_3^-> Cl^- (Fig.1). Very high concentration of K^+ after Ca^{+2}could be due to burning of wood used by local people for cooking and heating purposes. Ca^{+2} concentrations are the highest among all cations. This is a characteristic feature of Northern India. Dustfall deposition fluxes of Ca^{+2} have been reported the highest by other workers also (Kulshrestha et al, 1999, 2003b). High concentrations of Ca^{+2} and high alkalinity indicated that soil derived $CaCO_3$ dust particles have significant influence on atmospheric environment. Dustfall at this site has high influence of SO_4^{-2} and NO_3^-. NO_3^- is very high which may be due to increased vehicular emissions used by tourists and local people. In India high SO_4^{-2} concentrations associated with Ca^{+2} are reported (Kulshrestha et al, 1999).

In Indian weather conditions, atmospheric soil dust is effective scavenger of SO_2 (Kulshrestha et al 2003b). Also, wintertime meteorology plays favorable role in the oxidation of SO_2 onto dust particles (Kulshrestha et al 2009). The inter comparison of this study was done with other site globally. In general, it was found that the concentrations of acidic species are lesser than China and USA but higher than Europe (Italy and others) while the concentrations of basic radicals like calcium was very high at Indian site indicating the maximum neutralization of acidic species. This type of findings has been reported by Kulshrestha et al., 1999 at other sites in Indian region.

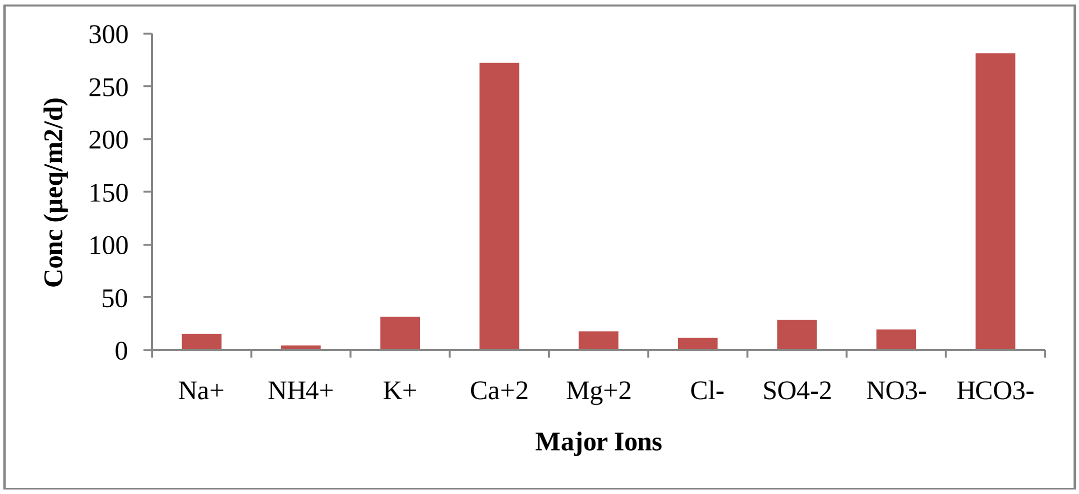

Fig. 1: Average dustfall deposition fluxes of major ions.

3.3 Sources of influence

3.3.1 Marine influence

Na^+ ratio (X/ Na^+, X = Ionic species) were calculated to estimate marine contribution to dustfall (Fig. 2). Very high ratios of various ions suggest almost no influence of marine sources but significant influence of non-marine sources. Non-marine sources may be crustal as well as anthropogenic. Sulphate ratios are high which are probably due to local sources of emission with long range transport. High Ca^{+2} ratios indicating significant influence of non-marine sources especially crustal sources.

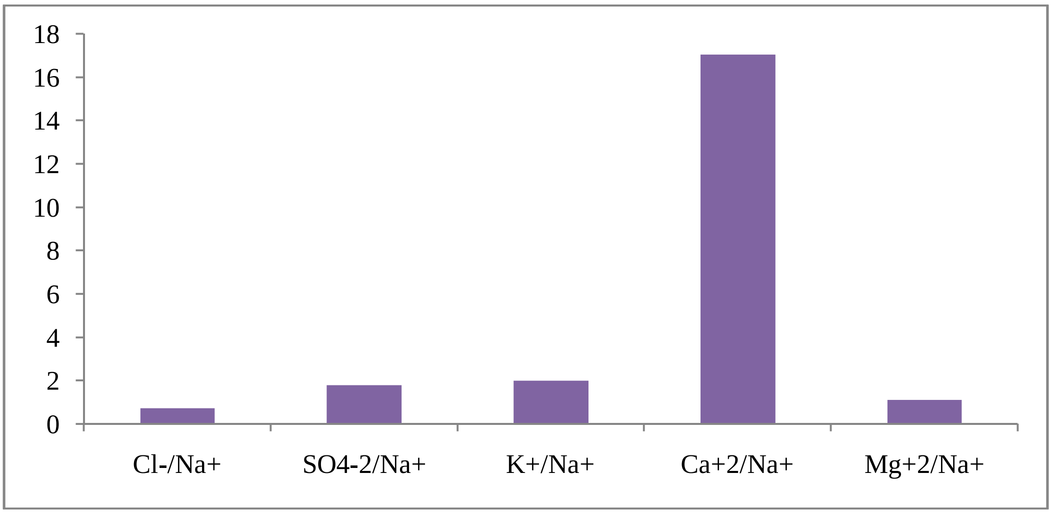

Fig. 2: Na^+ ratios in dustfall.

3.3.2 Crustal and anthropogenic influence

Ca^{+2} ratios (X/ Ca^{+2}) were calculated in dustfall also in order to understand the influence of crustal sources on atmospheric dust (Fig.3). Very low Ca^{+2} ratios at all the sites indicate significant influence of crustal sources. Infact atmospheric dust is composed of crustal material dominated by $CaCO_3$ (Kulshrestha et al., 1999). High sulphate ratio may be because of anthropogenic sources which are responsible for SO_2 emission. Nitrate is high due to vehicular emission used by tourists coming to this area. High potassium ratio could be due to burning of wood used by local people for cooking and heating purposes.

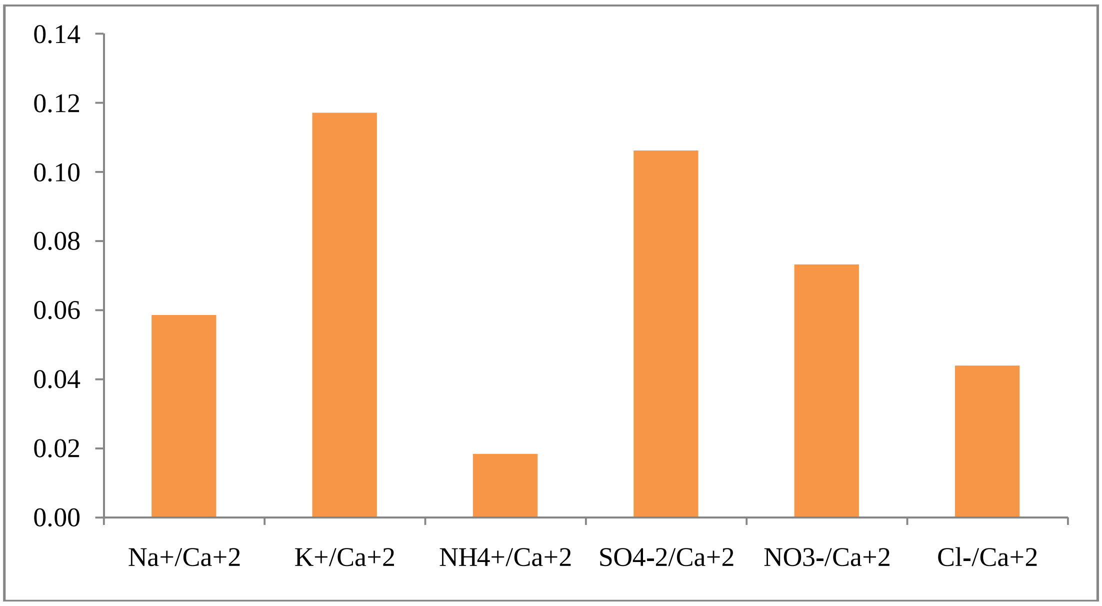

Fig. 3: Ca^{+2} ratios in dustfall.

4. Conclusion

This study was carried out to know chemistry of dustfall at Mukteshwer and finding out their possible sources. The pH of water soluble extract of dustfall at Muktwshwer showed alkaline nature which might be due to high crustal input which are rich in $CaCO_3$. Among anions, SO_4^{-2} concentration was the highest which were associated with Ca^{+2} similar to other reports in Indian region. This is primarily because SO_2 adsorb onto dust particles resulting in the formation of Calcium Sulphate. Very high concentration of NO_3^- at this site can be attributed to increased vehicular emissions used by tourists. Among cations, dustfall extract showed very high K^+ after Ca^{+2} indicating wood burning used for cooking and heating purposes. Calculation of marine influxes and crustal contribution suggested a significant influence of non-marine sources at this site. In general, it was found that the concentrations of acidic species were lesser than basic species like calcium indicating the maximum neutralization of acidic species in India.

5. Acknowledgements
We sincerely thank financial support received from JNU as CBF and LRE. We also thank Department of Science & Technology, New Delhi for PURSE grant which helped us to carry out this work.

References

[1] Andreae and Crutzen, (1997). Atmospheric aerosols: biogeochemical sources and role in atmospheric chemistry. Science 276 (5315), 1052–1058.

[2] IPCC, (2007). Climate change 2007. Synthesis report. In: Core Writing Team, Pachauri, R.K., Reisinger, A. (Eds.), Contribution of Working Groups I, II and III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. IPCC, Geneva, Switzerland, p. 104.

[3] Kulshrestha, M. J.,Kulshrestha, U. C., Parasar, D.C., Vairamani M. (2003b). Estimation of SO4 contribution by dry deposition of SO2 onto the dust particles in India. Atmospheric Environment 37(22) 3057-3063.

[4] Kulshrestha U.C., Jain M., Sarkar A.K, (1999), Influence of crustal aerosol on wet deposition at urban and rural sites in India, Atmoshpheric Environment 34, 5129-5137.

[5] Kulshrestha U.C, Kulshrestha M.J, Sekar R., Sastry G.S.R and Vairamani M. (2003a), Chemical characteristics of rain water at an urban site of south-central India, Atmos. Environ 37, 3019-3026.

[6] Kulshrestha, U.C., Reddy, L.A.K., Satyanarayana, J., Kulshrestha, M. J., (2009), Real-time wet scavenging of major chemical constituents of aerosols and role of rain intensity in Indian region. Atmospheric Environment, vol.43,pp- 5123–5127.

[7] Rodhe, H., Galloway, J., Dianwu Z., (1992). Acidification in Southeast Asia—Prospects for the coming decades. Ambio (in Chinese). 21: 148–150.