SOME ASPECTS OF SNOW CHEMISTRY AT KALPA, HIMACHAL PRADESH

1. The main systems which move across north, northwest India during the winter season are western disturbances. The movement of these disturbances maintains the cold air and provides 20 to 30 per cent of the annual precipitation in northern parts of India. As western disturbances have to travel extensively over sea and land, they pick up both natural and anthropogenic aerosols. The chemical composition of these aerosols can be understood if a remote region, far flung from major industrial stations, is chosen for the study. Kalpa (31° 35′ N, 78° 15′ E, 2724 m amsl), is one such station in the State of Himachal Pradesh, 270 km away in eastnortheast of Shimla, and is surrounded by snow covered peaks of 'Kinnar Kailash' range of Himalayas. Kalpa, under the influence of western disturbances, gets considerable amount of snow during the winter season. In this note, we present the results of the chemistry of snow which fell during 1987-88 winter at Kalpa.

2. Snow samples were collected within the premises of Hydro-Meteorological Observatory of India Meteorological Department at Kalpa. They were collected from a platform built 1 m above the ground level in plastic tubs of radius 20 cm and depth 10 cm. Before placing, each tub was thoroughly rinsed with deionised water. 28 snow samples were collected in 23 days when snow occurred. Because of heavy falls on 3 days, it was possible to collect two or more samples. After every 24 hours, except on three days, the plastic tub was replaced by another tub of similar dimensions. After melting, these were transferred into polythelene bottles, rinsed with deionised water, of capacity 1 litre each and were then sealed to check contamination before being sent to the laboratory. In the laboratory, snow water samples were filtered through Whatman 41 filters and refrigerated at 4°C till the major ions (Cl^-, SO_4^{2-}, NO_3^-, NH_4^+, Na^+, K^+, Ca^{2+} and Mg^{2+}) and pH were determined (Khemani *et al.* 1985).

3. The monthly mean concentrations (in μeq L^{-1}) of major ions in snow water at Kalpa alongwith their pH values are given (Table 1). We see that snow samples had pH values less acidic than that of pure water in equilibrium with atmospheric carbon dioxide (pH = 5.65). NO_3^- concentration was up to 3 times higher than SO_4^{2-} concentration. The mean concentrations of SO_4^{2-} and NO_3^- were respectively larger by 2 and 5 times compared to the means found for three similarly located remote stations of the world, *viz.*, Poker Flat, Alaska, San Carlos, Venezuela, Katherina, Australia (Galloway *et al.* 1982). From this, it is inferred that large amounts of these anions were brought to the Kalpa region by western disturbances. However, these components were not in the form of acids but they were present in the form of their salts. Also very high concentrations of Ca^{2+} were observed at Kalpa due to the presence of $CaCO_3$ in dust transported from the arid regions in the northwest. Observed pH values could be largely due to the presence of Ca^{2+} ion in high concentration in snow water (Casado *et al.* 1992).

4. The Mean concentrations (μeq L^{-1}) of the ions Cl^-, SO_4^{2-}, NO_3^-, Na^+ and Ca^{2+} of snow samples of

TABLE 1

Monthly mean concentrations of major ions in μeq L^{-1} alongwith pH of snow water at Kalpa

Month	No. of sample	Cl^-	SO_4^{2-}	NO_3^-	NH_4^+	Na^+	K^+	Ca^{2+}	Mg^{2+}	pH
December 1987	1	14.7	12.1	15.5	0.9	22.2	9.7	31.4	4.9	5.80
January 1988	5	18.0	11.1	33.5	19.3	25.0	12.9	54.0	13.8	5.94
February 1988	15	16.4	10.5	20.3	7.7	19.6	13.2	63.0	12.4	6.25
March 1988	7	21.3	10.4	28.7	1.8	17.8	8.9	66.2	31.0	6.38

TABLE 2

Comparison of mean composition of snow water at different locations

Location	Concentrations in μeq L^{-1}					pH
	Cl^-	SO_4^{2-}	NO_3^-	Na^+	Ca^{2+}	
Kalpa	17.6	11.0	24.5	21.2	45.4	6.09
Gulmarg	17.9	13.6	10.0	14.9	30.5	6.68
Mount Everest	4.0	5.8	4.0	3.6	38.0	6.24
Mid-Wales	21.0	16.0	11.0	13.0	4.0	4.50
Cairngorm Mountains	90.7	26.3	20.4	51.6	2.5	4.42

Kalpa and their mean pH are presented (Table 2). Similar data in respect of Gulmarg (Khemani *et al.* 1989), Mount Everest (Jenkins *et al.* 1987), Mid-Wales (Tranter *et al.* 1984) and Cairngorm Mountains (Davies *et al.* 1992) are also reported in the Table. The concentrations of SO_4^{2-} and NO_3^- ions were similar at Kalpa, Gulmarg, Mid-Wales and Cairngorm Mountains while they were low at Mount Everest. The concentration of Ca^{2+} ion was high at Kalpa, Gulmarg and Mount Everest but low at Mid-Wales and Cairngorm Mountains. Simultaneously pH values at the first three places were higher while it were lower at the last two places. The values of pH observed at the first three places were due to higher concentration of Ca^{2+} (Casado *et al.* 1992).

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