

Chemical dynamics of snowpack in the Northern Japan Alps during snowmelt season

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(Received February 23, 2008; Revised manuscript accepted May 14, 2008)

Abstract

A snow pit study was conducted on Mt. Norikura in the Northern Japan Alps from January to April 2007 to clarify the chemical dynamics in the snowpack during the snowmelt season. Little snowmelt occurred before February 6, the first snowmelt occurred between February 6 and 21, and the peak of the snowmelt season occurred after March 7. Snow layers with remarkably high Cl^- , NO_3^- , and SO_4^{2-} concentrations in the snowpack were traced; furthermore, the snow layers with high SO_4^{2-} concentrations were found to disappear first. It was concluded that the ease with which the ions were flushed out from the snowpack was $\text{SO}_4^{2-} > \text{NO}_3^- = \text{Cl}^-$.

1. Introduction

In recent years, acid precipitation has been observed all over the world. The effects of acidic precipitation on inland water ecosystems across the many lakes of Scandinavia and eastern Canada have been reported (Gorham, 1961; Minns, 1981). And the pH of snowmelt water in particular has been reported to be extremely low. Therefore, it is important to understand the behaviors of anions in snowmelt water and the snowpack during the snowmelt season.

Before snowmelt, the concentration of dissolved ions in the snowpack is the same as that in the snow. However, these ions flow out with the snowmelt water during the snowmelt season. The concentration of these ions in the snowmelt water is high early in the snowmelt season, and it lowers as snowmelt progresses (Johannessen and Henriksen, 1978; Jones and Deblois, 1987). This is explained by the fact that the ions in a snow particle are released to the surface of the snow particle during the process by which it transforms into a granular snow particle in the snowpack; this phenomenon is due to the difference in freezing point between pure water and water containing dissolved ions. Thus, the snowmelt water that flows over the surface of the snow particle selectively dissolves the ions, leading to a higher concentration in snowmelt water than in the snowpack (Suzuki, 1982). Suzuki (1991) reported that the snow particles that constitute the snowpack release the ions to their surfaces during melting/refreezing cycles.

Since different ions will separate from snow particles at different rates, there must be a certain order in which the ions are flushed out of the snowpack; there have been some reports on this phenomenon (Brimblecombe *et al.*, 1985; Iizuka *et al.*, 2000). For example, Suzuki (1991) measured the daily variation of the anionic components in snowmelt water; he found that when refreeze occurred at the surface of the snowpack in the early morning, the ratios of SO_4^{2-} and NO_3^- were high, and by day the ratio of Cl^- was high. This results suggested that the order of the ease with which ions were flushed was $\text{SO}_4^{2-} = \text{NO}_3^- > \text{Cl}^-$. Brimblecombe *et al.* (1985) conducted snow pit work on two consecutive days in Scotland and compared the order in which different ions were flushed from the snowpack with the snowmelt. His results suggested that the order of the ease with which ions were flushed was $\text{SO}_4^{2-} > \text{NO}_3^- > \text{NH}_4^+ > \text{K}^+ > \text{Ca}^{2+} > \text{Mg}^{2+} > \text{H}^+ > \text{Na}^+ > \text{Cl}^-$. Davies *et al.*, (1987) experimentally defined the order of the flush of each ion and reported it as $\text{Ca}^{2+} = \text{Mg}^{2+} > \text{SO}_4^{2-} > \text{NO}_3^- > \text{Na}^+ > \text{Cl}^-$. Thus, each preceding report has indicated different orders and there is no unified opinion.

In most of the low-lying areas of Japan, snowmelts are frequent, even in the winter season. In contrast, in the high mountainous areas of Japan, snowmelts seldom occur. The chemical substances in a snowpack burst out intensively during the snowmelt season. In other words, the chemical dynamics in the snowpack in high mountainous areas during the snowmelt season are more conspicuous than those in the low-lying areas. The object of this study is to