

Effects of transboundary air pollution on water chemistry around the source area of Hakusan–Tedori River

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In recent years, there have been increasing concerns on the effects of atmospheric deposition on forest ecosystems, particularly on areas along the Sea of Japan. On-site monitoring throughout the year is difficult in most of these areas because of heavy snow. We began monitoring the cycles of major and minor elements in a small forested watershed in the middle part of the Tedori River Basin, Ishikawa Prefecture, Japan, in 2013. Atmospheric nitrogen (N) deposition from rainfall and snowfall was more than $20 \text{ kg ha}^{-1} \text{ year}^{-1}$. Nitrogen input quantity was similar to or more than that reported in N-saturated forested areas of the Kanto district. Therefore, similar to that in the Kanto district, higher N deposition loads from the atmosphere could also be observed due to the effect of nitrogen dynamics and the increase in nitrogen efflux at these forest watersheds. This study aimed to (i) determine the nitrogen input and output at the upper reaches of the Tedori River, including the head waters area that is located at the top of Mt. Hakusan; (ii) reveal the element dynamics and input–output budgets within a forested watershed in a heavy snowy region; and (iii) understand the contribution of transboundary air pollution to the quantity of atmospheric deposition. Stream water and spring water samples ($n = 26$) were collected at the Hakusan mountainous region (altitude 2,000–2,500 m high) and the upper reaches of the Tedori, Ozoe, and Syou Rivers, which originate in Mt. Hakusan. Furthermore, we investigated stream water and ground water samples ($n = 10$) at the middle reaches of the Tedori River. The nitrate concentrations in all the samples ranged from 0.00 to 2.93 mg L^{-1} (median value: 0.69 mg L^{-1}). The stream water and spring water that were collected at the Hakusan mountainous region and the upper reaches of the three rivers showed significantly low nitrate concentrations ($0.00\text{--}1.58 \text{ mg L}^{-1}$, median value: 0.52 mg L^{-1}). At the middle reaches area, the nitrate concentrations of stream water samples ranged from 0.47 to 2.12 mg L^{-1} (median value: 1.13 mg L^{-1}). The nitrate concentrations of ground water samples in the middle and lower reaches of the Tedori River ranged from 1.92 to 2.93 mg L^{-1} (median value: 2.31 mg L^{-1}). In contrast, the nitrate concentrations of stream water in the Tsukuba experimental forest watershed, which is reported as a N-saturated forested area of the Kanto district, were much higher (average value: 7.56 mg L^{-1}) than those in the Tedori Basin. Compared with the input concentrations, the output concentrations of nitrate in the water samples were generally very low around the Hakusan–Tedori River Basin. Therefore, higher N depositions have not yet influenced the nitrate concentrations of the stream water in this area.