Effect of nitrogen deposition on nitrogen output from the forested ecosystems

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Human-induced increases in reactive nitrogen contribute to detrimental changes in nitrogen cycling in terrestrial ecosystems. The effects are expanded from near the source to the surrounding area by atmospheric transportation or solution infiltration in soils.

Forests in Japan provide various benefits to people such as supplying organic material to agricultural fields and maintaining the functioning of aquatic systems. Perhaps the most important function, providing a safe and steady water supply, seems to have been weakened in recent years. The release of nitrate ions ($NO_3{}^-$) into stream water has begun to be reported in suburban forests in Japan where nitrogen deposition is high due to atmospheric transport from polluted urban area.

The purpose of this study was to clarify the nitrogen status of Japanese forests that have received chronic nitrogen deposition. We compared nitrogen cycling in six forest ecosystems with different levels of nitrogen deposition. As nitrogen input to the forest ecosystems, we measured inorganic nitrogen flux in throughfall. The amount of nitrogen in the litterfall and the inorganic nitrogen flux in A_0 layer percolation and soil water were measured to investigate the internal nitrogen cycling in the plant-soil system. As nitrogen outputs from the forest ecosystems, we measured inorganic nitrogen leaching from soils and N_2O emissions from the forest floor.

Ibaraki sites (IK and IY), where nitrogen depositions in throughfall ranged from 12 and 29 kg N ha^{-1} yr^{-1} were sites with high nitrogen deposition. Two Oku-nikko sites (NM and NY) located on the ridge and lower slope of Mt. Maeshirane (2373 m) had 13 and 14 kg N ha^{-1} yr^{-1} of nitrogen deposition, respectively. The other mountainous sites (SC and SD) are located hillside of Mt. Norikura (3026 m) and have very low nitrogen deposition of about 4 kg N ha^{-1} yr^{-1}.

N_2O emissions from the forest floor were measured at the six sites as an index of nitrogen output from the ecosystems. High averaged N_2O emission rates were detected at sites with high nitrogen deposition or high nitrogen internal cycling via litterfall. Moreover, N_2O emission rates showed a seasonal pattern similar to that of inorganic nitrogen fluxes in A_0 layer percolation. These results suggest that N_2O emission will occur at sites where there is a surplus of inorganic nitrogen, over both the short and long terms, for N_2O is generated with mineralized nitrogen.

Our findings indicated that the nitrogen deposition level near urban areas in Japan, where nitrogen saturation has been suspected, is approximately the same as that in nitrogen-saturated forests in Europe. The chronic nitrogen deposition has increased the amount of nitrogen cycling within the plant-soil system. Our findings also suggest that the effect of increased nitrogen deposition in forest ecosystems depends on their capacity for nitrogen maintenance. The N_2O emission rate and $NO_3{}^-$ leaching from soils, they are nitrogen output from an ecosystem, showed positive correlations with total nitrogen deposition and internal cycling of nitrogen.