

Nitrate contamination of mountainous headwater streams from adjacent agricultural and pasture lands beyond the watershed boundary in eastern Hokkaido, Japan

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Introduction

Watershed is a fundamental unit for quantitative understanding of water and nitrogen (N) cycle in forested ecosystem. Nitrogen retention in the forest ecosystem can be mainly evaluated as a balance between input of atmospheric reactive N and hydrological N loss at a watershed scale. As an assumption for the evaluation, it has been proposed that the watershed is completely “closed”, namely, the source of water flowing out from the watershed is rainwater fallen in the watershed. This means that exchange of N transported with water between the watershed and the adjacent watershed beyond the watershed boundary is ignored. However, is this assumption applicable for all forested watersheds? If not, N retention in the watershed may not be evaluated accurately. In our presentation, we aim to elucidate the source of streamwater nitrate-N in the forested watershed whose water balance is not possibly closed.

Material and Methods

This study was conducted in Hokkaido Forest Research Station, Field Science Education and Research Center, Kyoto University, which is located in the eastern part of Hokkaido. The research forest is mainly composed of a cool-temperate deciduous broad-leaved forest and adjacent to the vast agricultural and pasture lands across the watershed. We estimated water and N balance in a gauged watershed (150 ha) within the research forest during 2011-2018. In 2014 and 2017-2019, we collected more than 50 streamwater and stream-bed and bedrock spring water across the forest, and measured nitrate and other major ions, and stable isotopes of nitrate-N and oxygen (O).

Results and Discussion

In the gauged watershed, water discharge rate was 1.5-2.1 times larger than rainfall input, indicating that the watershed is not likely “closed”. It is possible that groundwater derived from areas outside the watershed may spring out. Nitrogen input via throughfall was 4-6 kgN ha⁻¹ yr⁻¹, while hydrological N loss from the watershed was estimated as 7-10 kgN ha⁻¹ yr⁻¹, indicating low N retention. In the streams across the research forest including the gauged watershed, groundwater spring points were widely observed at the streambed. Groundwater from the streambed had high nitrate and chloride concentrations and high $\delta^{15}\text{N}$ of nitrate, implying that the possible source of nitrate is sewage or livestock manure. These results suggest that a large portion of nitrate in streamwater is provided by streambed spring water, which may originate from agricultural and pasture lands adjacent to the research forest.

Keywords: Nitrate, Stable isotope, Groundwater discharge, Streamwater chemistry