Japan Geoscience Union Meeting 2010
(May 23-28 2010 at Makuhari, Chiba, Japan)

MIS006-P20 Room: Convention Hall Time: May 26 17:15-18:45

The role of storm flow on reducing N retention in a forested watershed

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The response of forest ecosystems to chronic N deposition has been a concern in Japan as well as in North America and Europe. NO_xemission, one source of N deposition, has remained high over the last two decades in Japan. Japan has also been receiving long-range transport of N compounds from Asia, where NO_xemissions have been increased by 2.5 times during 1980-1997 and 2.8 times during 1980-2003. In spite of the high levels of N deposition in Japan, N budgets in Japanese forested watersheds have not been fully evaluated. Many Japanese forested watersheds are characterized by steep topography. Steep slopes of watersheds result in small saturated areas that contribute to the large NO_3^- pool size in the near-stream zone. Steep slopes of watersheds also result in increasing N flushing through water discharge. However, the effect of storm flow on N loss and subsequent N retention has not been fully evaluated in Japanese watersheds.
To evaluate the role of storm flow in reducing N retention in forested watersheds, we investigated the inorganic N budget of a Japanese suburban forested watershed for four years where the proportion of direct flow to precipitation is considerably high (mean = 33%; range = 25-42%). Soil net N mineralization and net nitrification were also measured at middle and lower positions of a slope within the watershed to evaluate nitrate (NO_3^-) pool size. Annual mean N deposition via throughfall plus stemflow was 15.5 kg N ha^{-1} yr^{-1} (13.6-17.1 kg N ha^{-1} yr^{-1}), which exceeded the threshold value to potentially induce N leaching from forested watersheds. Net nitrification at the middle position was comparable with the lower position. This suggests that the NO_3^- rich area is large, which could be partly caused by comparable soil moisture conditions with the lower position due to rising ground water levels during storm events. Annual mean N export was 10.4 kg N ha^{-1} yr^{-1} (7.8-12.5 kg N ha^{-1} yr^{-1}), and subsequent N retention was distinctly low 33% (12-53%). Stormflow accounted for more than 80% of total annual N export. Furthermore, N retention was lower (12 and 27%) in years with higher proportions of direct flow than in years with lower proportions (36 and 53%).
In conclusion, storm flow is a significant factor in reducing N retention in forested watersheds. Lower N retention by storm flow could be caused via the following two processes: 1) biogeochemical processes, including increases in the NO_3^- rich area, and 2) hydrological processes via efficient export of NO_3^-. Our results indicate that observation of storm flow is essential for calculating the input-output N budget in a forested watershed, especially when comparing other watersheds with different climate and/or hydrologic conditions.

Keywords: N budget, N retention, annual precipitation, direct flow, suburban forest, forested watershed