

Effects of tree species on nitrogen deposition in forest stands around the livestock area

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In livestock areas, ammonia volatilization occurs during the composting process of livestock manure, which provides a large amount of nitrogen (N) to the surrounding land cover, such as forests. Yet, excess N deposition to forest ecosystems have adverse effects on their biogeochemical cycles. On the other hand, N deposition in throughfall (TF) could vary depending on tree species because the morphology of tree canopy differs between the species, which in turn alters the canopy interaction with rainwater. However, few studies have elucidated differences between tree species and canopy interactions in N deposition in livestock areas. To evaluate them, rainfall (RF) and TF were collected and their N compounds analyzed in forest stands of two species (Birch and Oak) around livestock areas in northern Japan. N deposition in RF was calculated to be $13.5 \text{ kgN ha}^{-1} \text{ y}^{-1}$, which was higher than the national average of N deposition ($10.5 \text{ kgN ha}^{-1} \text{ y}^{-1}$). The results showed no significant difference in N deposition in TF during autumn between the Oak and Birch stands. The amount of N deposited in RF was higher than that in TF, indicating that the tree canopy may be absorbing ammonium deposits.

Key words: nitrogen deposition, rainfall, throughfall, livestock area, tree species

1. INTRODUCTION

In livestock areas, ammonia volatilization occurs during the composting process of livestock manure, which provides a large amount of nitrogen (N) to the surrounding land cover. Therefore, excess N can be supplied from the atmosphere to the surrounding forests in livestock area, which in turn alters biogeochemical cycles in forest ecosystems and consequently causes N saturation.

Tree effectively captures atmospheric pollutants due to its high roughness. Vesterdal et al.¹ showed that atmospheric N deposition differed between tree species due to differences in canopy and bark morphologies, which could affect N standing stocks in trees and subsequent soils. However, few studies have examined differences in N deposition in throughfall (TF) between tree species in areas with high reactive N deposition, such as livestock areas. Additionally, although Birch (*Betula platyphylla* var. *japonica*) and Oak (*Quercus crispula*) are the main deciduous broad-leaved trees in Hokkaido, no comparative research has been conducted to elucidate the differences in N deposition.

N content dramatically changes in rainwater as it passes through the tree canopy, which is called as canopy interaction and can alter N deposition as a N input to forests. Previous studies have shown the canopy interaction based on differences in N deposition between rainfall (RF) and TF^{2,3,4}. However, few studies have observed the canopy interaction in livestock area. Forests will decline in both cases where forests lack and are excessive in N. Therefore, it is necessary to accurately grasp changes in N deposition via the canopy interaction.

In this study, we aimed to examine the following issues: (1) the current status of N deposition, (2) the effect of different tree species on N deposition, and (3) the canopy interaction in the forest stands of Birch and Oak located in the livestock area, northern Japan.

2. METHODS

The study was conducted at Bibi Park in Chitose, northern Japan ($42^{\circ}47'N$, $141^{\circ}42'E$; Fig.1). The 10 m-by-10 m plot was installed in each forest stand of Birch and Oak in Bibi park (Fig.1).

Three rainwater samplers were installed at each plot to collect throughfall (TF) samples and at the open area near the park to collect rainfall (RF) samples (Fig.2). RF and TF samples were collected twice a month from Jun to Nov and from Sep to Nov 2023, respectively.

To account for variations in N deposition caused by the canopy openness during the defoliation period, hemispherical photographs were taken on the sampler in Nov, and the canopy openness was calculated using image analysis software (CanopOn 2).

In collecting water samples, the amounts of RF and TF were measured. After that, nitrate N (NO_3^- -N) and ammonium N (NH_4^+ -N) concentrations in the samples were measured using ion chromatography (ThermoFisher Scientific, DIONEX ICS2100). In this study, N depositions in RF and TF were calculated by multiplying the amounts of RF and TF by their N concentrations (NO_3^- -N and NH_4^+ -N), respectively. Dissolved inorganic N (DIN) deposition was calculated by summing NO_3^- -N and NH_4^+ -N depositions. The annual N deposition in RF was calculated by dividing the cumulative total of N deposition during the observation period by the number of the observation days and then multiplying it by 365 days.

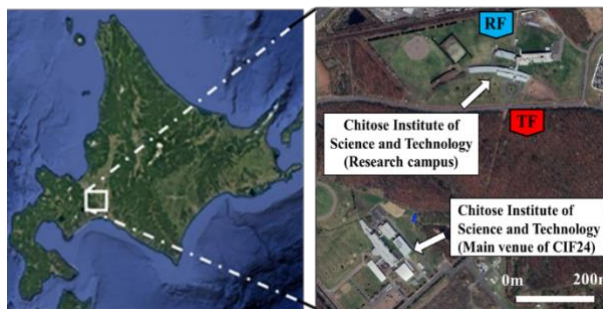


Fig. 1 Sampling point (Source: Google Map)



Fig. 2 Rainwater sampler

3. RESULT

DIN deposition in RF was estimated to be $13.5 \text{ kgN ha}^{-1} \text{ y}^{-1}$ based on the data obtained during Jun to Nov (Fig.3). The DIN deposition in TF was $1.27 \text{ kgN ha}^{-1} \text{ period}^{-1}$ in the Oak stand and $1.20 \text{ kgN ha}^{-1} \text{ period}^{-1}$ in the Birch stand (Fig.4). No significant difference was found between Oak and Birch ($p \geq 0.05$). The average canopy openness in the plot was 55% in the Oak stand, and 57% in the Birch stand during the defoliation period.

4. DISCUSSION

The DIN deposition in RF in the present study was higher than the national average of bulk N deposition ($10.5 \text{ kgN ha}^{-1} \text{ y}^{-1}$). Additionally, NH_4^+ -N deposition accounted for the majority of DIN deposition in RF (Fig.3). Therefore, ammonia derived from the livestock area would contribute significantly to N deposition.

The similar N deposition between the two forest stands was attributable to the fact that the observation period for TF was just two months during the autumn, which was comparable to the period of defoliation. Another reason might be that N deposition was compared between the forest stands with similar canopy structure (canopy openness), such as Oak and Birch. N deposition was higher in RF than in TF. Particularly, differences in NH_4^+ -N deposition between RF and TF was larger than those in NO_3^- -N deposition (Fig. 4). These results suggest that NH_4^+ -N was absorbed by the canopy. This was supported by the results obtained

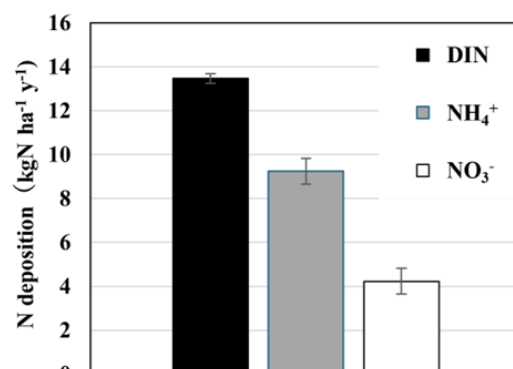


Fig. 3 Comparison of annual N deposition in RF in 2023 ($n = 3$). Error bars indicate standard deviations.

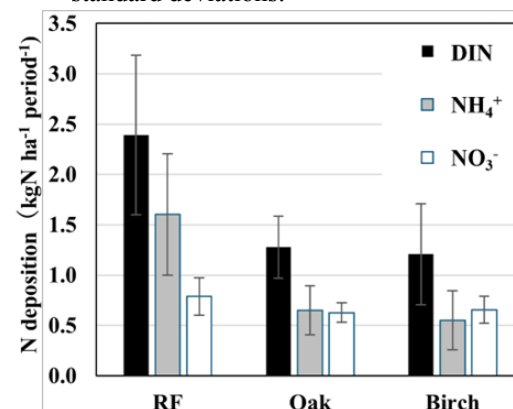


Fig. 4 Comparison of N deposition between RF, Oak and Birch TF in 2023 ($n = 3$). Error bars indicate standard deviations.

by the study conducted by Liu et al².

5. CONCLUSION

In this study, N deposition in both RF and TF was evaluated in forest stands of Oak and Birch near the livestock area, northern Japan. The results showed that N deposition in RF was affected by the surrounding livestock area. On the other hand, no significant difference in N deposition in TF was found between the Oak and Birch stands. This was possibly due to the season of the water sampling and the similar canopy structure between the two species. Our results suggest that N deposition was absorbed by the tree canopy in the area with high N deposition.

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ACKNOWLEDGEMENTS

This work was supported in part by the Grant-in-Aid for Scientific Research (Grant Nos. JP20KK0241; JP21K18113; JP23K23650; 24H00057; 24K01815; 24K01016) from the Japan Society for the Promotion of Science, the FY2023 special research fund, and the SNC research fund from the Chitose Institute of Science and Technology.