EGU24-12077, updated on 07 Feb 2025
https://doi.org/10.5194/egusphere-egu24-12077
EGU General Assembly 2024

Unlocking the nitrogen cycle in glacial forelands: an isotopic perspective

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Glacial forelands are expanding worldwide due to glacier shrinkage[1], exposing new areas prone to the development of post-glacial ecosystems[2,3]. Nitrogen (N) is generally considered as a (co-)limiting nutrient in alpine regions, and deposition of atmospheric N, mainly emitted due to fossil fuel combustion, has for long been admitted as the main source of N[4]. However, other N sources such as glacial meltwaters[5], long-range transport of fertilizers[6] or bedrock erosion[7] have recently been suspected of playing a more significant role than previously thought and could drive the establishment of pioneer microbial and plant communities in glacial forelands.

Here, we show the isotopic composition and concentration of nitrate (δ15N, δ18O, Δ17O) and ammonium (δ15N) in glacial meltwaters, soils and plants from three glacial forelands in the French Alps. Samples were collected along transects expanding from the glacier front to areas deglaciated around 60 years ago. We find that the contribution of atmospheric deposition to the nitrate pool in soils decreases as time since deglaciation increases, but never exceeds 40%, not even at the glacier front where soils are entirely mineral with no detectable nitrification enzymatic activity. This pattern suggests that bedrock nitrogen and glacial meltwaters are the main N sources in post-glacial ecosystems and calls for a better quantification of those inputs.

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