Catchment features controlling nitrogen dynamics in running waters above the tree line (central Italian Alps)

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Abstract. The study of nitrogen cycling in mountain areas has a long tradition, as it was applied to better understand and describe ecosystem functioning, as well as to quantify long-distance effects of human activities on remote environments. Nonetheless, very few studies, especially in Europe, have considered catchment features controlling nitrogen dynamics above the tree line with focus on running waters.

In this study, relationships between some water chemistry descriptors – including nitrogen species and dissolved organic carbon (DOC) – and catchment characteristics were evaluated for a range of sites located above the tree line (1950–2650 m a.s.l.) at Val Masino, in the central Italian Alps. Land cover categories as well as elevation and slope were assessed at each site. Water samples were collected during the 2007 and 2008 snow free periods, with a nearly monthly frequency. In contrast to dissolved organic nitrogen, nitrate concentrations in running waters showed a spatial pattern strictly connected to the fractional extension of tundra and talus in each basin. Exponential models significantly described the relationships between maximum NO₃ and the fraction of vegetated soil cover (negative relation) and talus (positive relation), explaining almost 90 % of nitrate variation in running waters. Similarly to nitrate but with an opposite behavior, DOC was positively correlated with vegetated soil cover and negatively correlated with talus. Therefore, land cover can be considered one of the most important factors affecting water quality in high-elevation catchments with contrasting effects on N and C pools.

1 Introduction

Human activities have dramatically altered the nitrogen (N) cycle by increasing the rate of transformation of N₂ into reactive nitrogen (RN) that includes all the biologically functional N forms. From the late 19th to the late 20th century, the amount of RN derived mainly from food and energy production increased globally by an order of magnitude (Galloway et al., 2004). On a global scale, atmospheric transport and subsequent deposition have become the dominant N distribution processes, and increasing atmospheric N deposition occurs over so much of the earth’s surface that the cumulative effects amount to global-scale change.

Most alpine regions, both in Europe and in the United States, receive N deposition rates exceeding 0.5 kg N ha⁻¹ yr⁻¹, the expected level for ecosystems in the absence of human influence (Burns, 2003; Fenn et al., 2003; Hiltbrunner et al., 2005; Balestrini et al., 2006). Historically, N limited, high-elevation ecosystems show symptoms of N saturation at relatively low N deposition rates (2–4 kg N ha⁻¹ yr⁻¹), as in the case of the Rocky Mountains (Williams et al., 1996). The fluxes reported for European Alpine sites at elevation above 2000 m a.s.l. are between 0.5–3 kg N ha⁻¹ yr⁻¹ (Filippa et al., 2010), but at lower altitude sites these rates greatly increase (Hiltbrunner et al., 2005; Rogora et al., 2008).

Mountain ecosystems, in particular the landscape above the tree line, are highly vulnerable to changes in climate, pollutants and nutrient input. Complex topography, harsh climate, extensive snow cover and a short growing season, all contribute in reducing the ability of these ecosystems to face alterations that affect their physical structure and biological

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