



Nitrous oxide production in riparian zones and groundwater

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Abstract

This paper addresses the question of whether riparian zones and groundwater are 'hotspots' of nitrous oxide (N₂O) flux in the landscape. First, we describe how riparian zones and groundwater function as transformers of N, with a particular emphasis on mechanisms of N₂O production in these ecosystems. We then present specific data on N₂O flux in these ecosystems and attempt to reconcile these data with existing regional scale estimates of N flux for Norway and with estimates of N₂O flux for Norway produced using the OECD/IPCC/IEA Phase II methodology for calculation of regional and global N₂O budgets. While the OECD/IPCC/IEA approach produces estimates of riparian and groundwater N₂O flux that are reasonable, given what we know about regional scale N balances and actual data on N₂O flux, it does not allow us to determine if riparian zones and groundwater are 'hotspots' of N₂O production in the landscape. The approach fails to answer this question because it is unable to account for spatially explicit phenomena such as riparian and groundwater processing of excess agricultural N. Research needs that would allow us to address this question are discussed.

Introduction

This paper addresses the question of whether riparian zones and groundwater are 'hotspots' of nitrous oxide (N₂O) flux in the landscape. Riparian ecosystems are situated at the interface between terrestrial and aquatic components of the landscape (Figure 1) and have unique structure and function due to strong interactions between hydrologic, soil and plant processes in these areas. Many studies have documented the ability of riparian ecosystems to transform nitrogen (N) that leaves N-intensive terrestrial land uses, preventing its movement into streams (Correll, 1997; Hill, 1996). Groundwater ecosystems are of interest because they are the 'receiving water' for much of the excess N that is common in agricultural land uses (Keeney, 1986).

Analysis of riparian zones and groundwater as landscape-scale hotspots in the context of regional and global scale N₂O budgets is complicated by the fact that hotspots are spatially explicit phenomena. Riparian zones and groundwater will have the potential to function as hotspots of N₂O flux only if

excess N physically interacts with the biologically active components of these areas (Schnabel et al., 1994). Analysis of these interactions requires spatially explicit data that are often not available for regional and global scale analyses (DeLong and Brusven, 1991).

Analysis of regional N balances (e.g. for Norway) suggest that there is a high potential for riparian zones and groundwater to function as hotspots of N₂O flux. In Norway, there is a 128 Gg annual surplus of N at the farm level (13 g N m⁻² y⁻¹) (Bleken and Bakken, 1997). Independent estimates suggest that 20 – 50 Gg (2 – 5 g N m⁻²) of nitrate (NO₃⁻) leach to groundwater from agricultural fields each year. Much of the groundwater that leaves agricultural fields passes through riparian zones before it reaches streams. These are large fluxes of N. If a significant portion of this N is transformed into N₂O, the flux would be important in the regional N₂O budget.

In this paper, we first describe how riparian zones and groundwater function as transformers of N, with a particular emphasis on mechanisms of N₂O production in these ecosystems. We then present specific data

