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# Nitrogen changes between rural and peri-urban stream subsurface waters (Yzeron stream, France)

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**Abstract**

Urbanization subjects stream and groundwater to increased loads of organic nitrogen, nitrate, and ammonium. Therefore, studying nitrogen species at the urban stream-aquifer interface is important for water resource management. We report here results on water $^{18}O/^{16}O$ ratios and on nitrogen species in stream subsurface waters upstream and downstream of several combined sewer overflows (CSOs) in a rural area and peri-urban area, respectively. Water $^{18}O/^{16}O$ ratios were measured to trace the mixing of subsurface waters with stream channel water. Organic nitrogen (ON) and carbon (OC) slightly increased between rural and peri-urban environments in the cold season, but not in the warm season. The highest nitrate levels were observed in rural subsurface waters in the cold season. The lowest nitrate levels were found in peri-urban subsurface waters in the warm season; they corresponded to slow exchange of subsurface waters with channel water.


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## 1. Introduction

The fate of the organic and inorganic nitrogen loaded in streams depends on the retention and transformation processes in stream surface and subsurface waters. An important zone for N retention and

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transformation in streams is the stream-aquifer interface. It corresponds to the zone below the streambed in which water exchanges occur between the open channel and subsurface waters and has been shown to be of critical importance for N redox reactions in streams [1]. A key process controlling the distribution of dissolved $O_2$ and nitrogen species in stream subsurface waters is the inflow of channel water into the streambed and its mixing with subsurface waters [1-4]. Despite its importance for N transformations, the interface between surface and subsurface waters remains under-investigated in urban streams. Data on the impact of urban inputs on nitrogen species at the stream-aquifer interface are thus needed.

In the present study, we investigated the changes in the forms of nitrogen (organic nitrogen, $NO_3^-$, $NH_4^+$) between rural and periurban subsurface waters of a stream (Yzeron, France). The rural and peri-urban locations studied were located respectively upstream and downstream from several combined sewer overflows (CSOs) (Fig. 1). The specific questions addressed were: (i) Does the extent of mixing subsurface waters with surface water, as revealed by oxygen isotopes, differ between rural and peri-urban environments? (ii) Does the organic nitrogen content of fine sediments and subsurface waters differ between the two environments? (iii) Do organic nitrogen and biodegradable organic matter content and/or mixing with surface water affect dissolved $O_2$ and nitrate in stream subsurface waters?

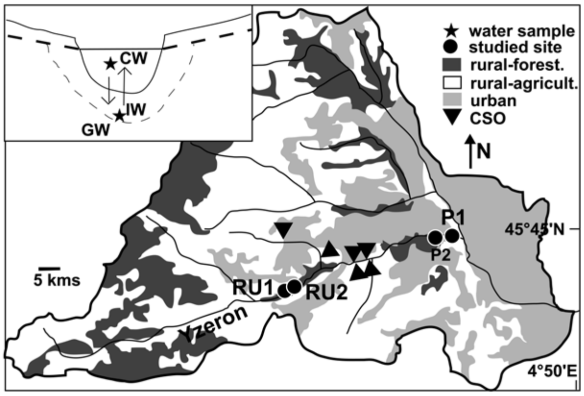


Fig. 1. Map of the Yzeron basin showing the CSOs, the rural (RU1, RU2) and periurban (P1, P2) locations studied. In this granitic-gneissic basin, groundwater is limited to an aquifer in colluvial and stream alluvial deposits. The inset schematically represents the relationship between the channel (CW) and groundwater (GW) components in the interstitial waters (IW) studied. The IWs were taken at a depth of fifty centimetres below the streambed surface.

## 2. Exchange of interstitial with channel waters: oxygen isotope constraints

Water oxygen isotope composition was used to characterize channel (surface) and interstitial (subsurface) waters and evaluate the extent of mixing of interstitial waters with channel water. In June 2004, the sampling was performed 9-11 hours after a storm event. The stream channel was richer in heavy isotopes compared to pre-storm channel waters (ps) (Fig. 2). Peri-urban interstitial waters (-8.5 to -7.8‰; Fig. 2b) kept pre-storm values, thus presenting slight mixing with "new" channel water at a timescale of 9-11 hours. In contrast, the $\delta^{18}O$ value of rural interstitial waters rose (Fig. 2a) approaching that of channel water. A simple oxygen isotope mass balance was used to estimate the fraction of "new" channel water in interstitial waters ($f_{renewed}$). This fraction of "new" channel water in interstitial waters ranged from 0.21 to 1 in the rural reach (with a mean of 0.5) and from 0 to 0.20 in the peri-urban one (with a mean of 0.1). The most rapid exchange was found in the upstream part of the rural riffles with ($f_{renewed}$ between 0.82 and 1) while the slowest exchange was in the downstream end of the peri-urban riffles ($f_{renewed}$ down to 0). In November 2004, the values of rural interstitial waters fell between that of channel water and values that are richer in $^{18}O$. The $^{18}O$-rich end member (Fig. 2a) can be related to groundwater