

Two year study of CO₂, CH₄ and N₂O dynamics and fluxes in four rivers in Belgium (Meuse, Ourthe, Geer and Blanc Gravier)

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Two rivers and two streams close to the city of Liège in Belgium (Meuse, Ourthe, Geer and Blanc Gravier) were sampled to describe the dynamics of CO₂, CH₄ and N₂O (for the first time in Belgium for freshwaters). The four systems were chosen to cover a gradient of size (stream to river) and of human influence (mainly forested to mainly agricultural watersheds). The study covers the period from February 2011 to March 2013 with weekly sampling in surface waters. The variables were very contrasted in the four systems, the Geer showing a strong enrichment in nitrogen NH₄⁺ et NO₂⁻) and phosphorous in relation to the other three systems. The O₂ concentrations were much lower, and the concentration of CH₄, N₂O and pCO₂ were much higher in the Geer than in other three systems. The concentrations in CH₄, N₂O and pCO₂ were higher in the Ourthe than in the Meuse and than in the Blanc Gravier. Marked seasonal variations were observed in the 4 systems. In general the concentration of CH₄, N₂O and pCO₂ were higher in summer than in winter. This is related on one hand to the increase of temperature in summer that stimulates bacterial activity. Also in summer, the availability of organic matter for bacterial activity is higher after the spring phytoplankton blooms and also from allochthonous inputs from the watersheds. The increase of temperature and bacterial consumption of O₂ in the water column leads to a lesser O₂ penetration in the sediments that could stimulate benthic anaerobic processes among which methanogenesis and denitrification, leading to an increase of CH₄ and N₂O in the water column. Also, the production of N₂O by denitrification strongly increases at low O₂. During low water, the increase of residence time of the water mass and the decrease of current (decrease of degasing) allow an accumulation of CO₂, CH₄ and N₂O in the water column. On the contrary during high water, dilution and increase of current (increase of degasing) lead to a decrease of concentrations. The four systems were over-saturated in CH₄, N₂O and CO₂, excepted during spring phytoplankton blooms when an under-saturation of CO₂ was observed in the Ourthe. Hence, the four systems were sources of CH₄, N₂O and CO₂ to the atmosphere. Diffusive CO₂ fluxes varied from 24 to 607 mol m⁻² yr⁻¹ (Ourthe and Geer, respectively). Diffusive CH₄ fluxes varied from 28 to 8199 mmol m⁻² an⁻¹ (Blanc Gravier and Geer, respectively). Diffusive N₂O fluxes varied from 2 to 201 mmol m⁻² an⁻¹ (Ourthe and Geer, respectively).

| | Forest (%) | Grassland (%) | Cropland (%) | Catchment (km ²) | Pop. density (habit. km ⁻²) |
|---------------|------------|---------------|--------------|------------------------------|---|
| Meuse | 64 | 14 | 22 | 36000 | 255 |
| Ourthe | 47 | 32 | 21 | 1837 | 71 |
| Geer | <1 | 7 | 93 | 463 | 194 |
| Blanc Gravier | ~100 | ~0 | ~0 | ~20 | ~0 |

