Effects of the hydrogeochemical stratification on the distribution of GHGs concentrations and their production/consumption processes in groundwater

Olha Nikolenko[1], Philippe Orban[1], Cedric Morana[2], Alberto Borges[2], Pierre Jamin[1], Serge Brouyère[1]

[1] University of Liège, Urban and Environmental Engineering Research Unit, Hydrogeology and Environmental Geology, 4000 Liège, Belgium
[2] Chemical Oceanography Unit, University of Liège, Liège, Belgium

Regulation of the concentrations of greenhouse gases (GHGs) in the environment has become one of the major challenges faced by global community. In order to understand better which measures could be applied to stop the rising concentrations of N_2O, CO_2 and CH_4 in the atmosphere, it is important to better constrain their budgets. Research findings, devoted to the study of GHGs fluxes, have reported that under agricultural areas groundwater is generally characterized with increased concentrations of N_2O due to microbial conversion of N compounds derived from the application of organic and inorganic fertilizers.

Previous investigations performed in the Cretaceous Hesbaye chalk aquifer in Eastern Belgium have characterized the variability of GHGs along the lateral and vertical dimensions of the aquifer taking into account the difference in hydrogeochemistry, hydrogeology and urbanization level. Results obtained from the interpretations of NO_3^-, N_2O, SO_4^{2-}, B isotopes signatures and N_2O isotopomers suggested that the dynamics of N_2O in the chalk aquifer was governed by different, possibly overlapping reaction mechanisms such as nitrification, denitrification or nitrifier-denitrification. They also revealed the occurrence of CH_4 in oxic conditions simultaneously with electron acceptors of higher energy yield.

In order to understand the mechanisms governing the observed trends in GHGs concentrations, local scale investigations have been planified to better constrict the conditions of occurrence of GHGs transformation processes and disentangle their shifting dynamics.

In this context, low-flow groundwater sampling procedures were applied at different depth intervals to obtain better insight into the possible vertical extent of oxic and anoxic zones, occurrence of biogeochemical processes typically active in these zones and accumulation of GHGs in different hydrogeochemical conditions. Afterwards, series of push-pull tests, using NO_3^- and NH_4^+ compounds labeled with heavy ^{15}N isotope were conducted to quantify the rates of nitrification and denitrification processes. Such studies help to clarify which conditions are more prone to the accumulation of high concentrations of GHGs in aquifers and better constrain the mass-balance models of GHGs production/consumption in groundwater.