Using the N2/Ar-Method to check modelled diffuse NO$_3^-$ emissions from soils into the groundwater of Lower Saxony (Germany)

Lisa Krienen (1), Heinrich Höper (2), Wolfram Eschenbach (1), Reinhard Well (1), and Jörg Elbracht (2)

(1) Thünen-Institut für Agrarklimaschutz, (2) Landesamt für Bergbau, Energie und Geologie

Diffuse NO$_3^-$ emissions derived from agricultural N surpluses are the main cause of NO$_3^-$ pollution of aquifers and open water bodies. Denitrification is the key process for the attenuation of these anthropogenic NO$_3^-$ concentrations in soils and groundwater. Since the greenhouse gas N$_2$O is an obligate intermediate of denitrification this process is also a major regulator of N$_2$O emissions from soils and indirect N$_2$O fluxes from aquifers and open water bodies which result from NO$_3^-$-leaching. Up to now the denitrification potential of soils and the potential NO$_3^-$ concentration in the groundwater recharge are modelled from agricultural N-surpluses, water balances (GROWA) and soil properties (DENUZ) (Wendland et al. 2009) (LBEG 2008).

In this study we compare modelled NO$_3^-$ emissions (pot-NO$_3^-$) (DENUZ) to the groundwater recharge with the calculated initial NO$_3^-$ concentrations in the groundwater at time of groundwater recharge (NO$_3^-$t0) (N2/Ar-method (Weymann et al. 2008)). NO$_3^-$t0 can be calculated from the measurement of dissolved gases N$_2$, N$_2$O, Ar and NO$_3^-$ concentrations in groundwater samples.

We analysed groundwater samples from 534 groundwater monitoring wells throughout Lower-Saxony (Germany). Median NO$_3^-$ and NO$_3^-$t0 concentrations were 0.4 and 29 mg NO$_3^-$ l$^{-1}$ respectively, showing that considerable proportions of the anthropogenic N-surplus is denitrified within the saturated zone.

First results showed a good agreement between measure and modelled NO$_3^-$ emissions for areas of coastal marshes in the North of Lower-Saxony (predominantly Fluvisols). Medians of measured and modelled NO$_3^-$ emissions are 12.5 mg NO$_3^-$t0 $\Gamma$1 and 0.3 mg pot-NO$_3^-$ $\Gamma$1 (mean values 20 mg $\Gamma$1 NO$_3^-$ pot and 9.3 mg $\Gamma$1 NO$_3^-$t0), respectively. Compared to the coastal marshes and in accordance with modelled pot-NO$_3^-$ concentrations our measurements show small-scale spatial heterogeneities of NO$_3^-$t0 concentrations in soil regions where the dominant parent material of soils are glacio fluviatile and moraine deposits (predominantly Podzols, Cambisols and Gleysols) in Lower-Saxony. In these regions the median of measured NO$_3^-$t0 concentrations was between 29 and 38 mg NO$_3^-$ $\Gamma$1 and on average 25 to 30 mg NO$_3^-$ $\Gamma$1 below the modelled NO$_3^-$ $\Gamma$1 concentrations. To further compare the modelled NO$_3^-$ emissions (pot-NO$_3^-$) with results of the N2/Ar-method (NO$_3^-$t0 values) we select groundwater monitoring wells with more homogenous soil properties, soil water residence times in their catchment areas.

We expect that further analysis will help to validate existing denitrification models. NO$_3^-$t0 values might then be used as a lower boundary condition if denitrification in soils is modelled.

References:

