Estimation of the denitrification in Baltic Sea deep water from gas tension measurements

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Denitrification is considered to be the most important process removing nitrogen in oceanic waters. 50-70% of marine denitrification occurs in organic rich sediments and oxygen depleted water bodies of continental shelf regions or marginal seas like the Baltic Sea, where a high percentage of riverine discharge of nitrogen is denitrified before entering the open ocean.

Measurements of the gas tension (= sum of the partial pressures of all dissolved gases in the water) provide a new experimental way for the quantification of denitrification by directly measuring the reaction product of this process. Continuous pumping of water from a defined depth trough the gas tension device with a pump-CTD allows getting integrated results.

Changes in $N_2$ concentrations were calculated from gas tension by subtracting the partial pressures of the most important other dissolved gases ($O_2$, $Ar$, $CO_2$, $H_2S$, water vapor). The $p_{O2}$, $p_{CO2}$ and $H_2S$-concentrations were measured; other parameters ($p_{Ar}$, $p_{H2O}$, solubility coefficients) were obtained from temperature and salinity. The method allows the estimation of $N_2$-concentrations with a maximum error of 0.5%, corresponding to a standard error of 1.5 $\mu$mol L$^{-1}$.

Results of gas tension measurements and calculation of $N_2$ concentrations in the Gotland Basin deep water, central Baltic Sea, from 2008 and 2009 are presented. In the deep water below the permanent halocline the estimated $N_2$ partial pressure is continuously rising towards the oxygen depleted water layers. The calculated $N_2$ excess compared to equilibrium concentration reached values up to 20 $\mu$mol N L$^{-1}$ in the stagnant anoxic water layer, indicating a mean N release of 10 $\mu$mol N L$^{-1}$ y$^{-1}$ after 4 years of stagnation.

The increase of total dissolved inorganic nitrogen (due to the $N_2$ excess and formation of ammonium in the deep water) in relation to nitrogen background values was compared with the increase of total inorganic carbon due to mineralization processes. The resulting C:N ratios were close to the Redfield value.