



How does the Danish Groundwater Monitoring Programme support statistical consistent nitrate trend analyses in groundwater?

Birgitte Hansen (1), Lærke Thorling (1), Brian Sørensen (1), Tommy Dalgaard (2), and Mogens Erlandsen (3)

(1) Geological Survey of Denmark and Greenland - GEUS, Denmark (bgh@geus.dk), (2) Department of Ecology, Aarhus University, Denmark, (3) Department of Public Health, Aarhus University, Denmark

The overall aim of performing nitrate trend analyses in oxic groundwater is to document the effect of regulation of Danish agriculture on N pollution. The design of the Danish Groundwater Monitoring Programme is presented and discussed in relation to performance of statistical consistent nitrate trend analyses. Three types of data are crucial. Firstly, long and continuous time-series from the national groundwater monitoring network enable a statistically systematic analysis of distribution, trends and trend reversals in the groundwater nitrate concentration. Secondly, knowledge about the N surplus in Danish agriculture since 1950 from Denmark Statistics is used as an indicator of the potential loss of N. Thirdly, groundwater recharge age determination are performed in order to allow linking of the first two dataset. Recent results published in Hansen et al. (2011 & 2012) will be presented. Since the 1980s, regulations implemented by Danish farmers have succeeded in optimizing the N (nitrogen) management at farm level. As a result, the upward agricultural N surplus trend has been reversed, and the N surplus has reduced by 30-55% from 1980 to 2007 depending on region. The reduction in the N surplus served to reduce the losses of N from agriculture, with documented positive effects on nature and the environment in Denmark. In groundwater, the upward trend in nitrate concentrations was reversed around 1980, and a larger number of downward nitrate trends were seen in the youngest groundwater compared with the oldest groundwater. However, on average, approximately 48% of the oxic monitored groundwater has nitrate concentrations above the groundwater and drinking water standards of 50 mg/l. Furthermore, trend analyses show that 33% of all the monitored groundwater has upward nitrate trends, while only 18% of the youngest groundwater has upward nitrate trends according to data sampled from 1988-2009. A regional analysis shows a correlation between a high level of N surplus in agriculture, high concentrations of nitrate in groundwater and the largest number of downward nitrate trends in groundwater in the livestock-dense northern and western parts of Denmark compared with the south-eastern regions with lower livestock densities. These results indicate that the livestock farms dominating in northern and western parts of Denmark have achieved the largest reductions in N surpluses.

Hansen, B., Thorling, L., Dalgaard, T. & Erlandsen, M., 2011. Trend Reversal of Nitrate in Danish groundwater – a Reflection of Agricultural Practices and Nitrogen Surpluses since 1950. *Environmental Science & Technology*, 45 (1), 228-234.

Hansen, B., Dalgaard, T., Thorling, L., Sørensen, B. & Erlandsen, M., 2012. Regional analysis of groundwater nitrate concentrations and trends in Denmark in regard to agricultural influence. *Biogeosciences*, 9, 3277-3286.