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Harmonized, distributed and nation wide modelling of Nitrogen retention in Danish surface fresh waters

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According to the EU Water Framework Directive all freshwater bodies must obtain good ecological status by 2015. In Denmark this means that all lakes with a surface area above 5 ha must be evaluated individually and mitigation measures must be enforced if the ecological status is below “good”. In consequence, the nutrient pressures from point and diffuse sources must be assessed based on a quantification of the nutrient loading of each lake. In this study we focus on the loading of nitrogen.

Surface water Nitrogen retention is an important parameter in loading estimations of nitrogen to lakes and marine areas. Estimations of the cost, of reducing Nitrogen loadings also largely depends on calculations of surface water retention as large percentages of the load can be removed/ retained in surface waters. Especially the presents of larger lakes on the river network can make a large difference between the loads from different catchments. A standardised calculation on annual (1990 – 2008) Nret percentages has been carried out for all Danish lakes larger than 5 hectares attached to a river network (591 lakes).

The Nret calculation is based on water residence time calculations from each lake. A national 3D hydrological model, covering all major parts of the country estimated runoff for lake catchments. The diffuse nitrogen input to each lake was simulated with an empirical nitrogen load model. Where lakes are located upstream/ downstream of each other, a calculation chain involving the nitrogen retention in lakes was created.

Harmonized national calculations of river nitrogen retention are carried out on the basis of river length and river width information and information on rivers in forested areas. Each river class is given a specific retention pr. unit area.

The total average (1990 – 2008) Nitrogen load to Danish surface waters is modelled to 99000 t/yr. The total surface water retention is estimated to 23700 t/yr (24%). Of the surface water retention, 35% origins from lake retention and 64% from river/ stream retention, the remaining 1% is retained by flood plains.

The modelling concept is validated against measured load at 113 monitoring stations. The mean modelling error in the period 1990 to 2008 is an overestimation of the modelled load of 13%. The largest (2600 km2) and most complex catchment containing 72 lakes have an average error of 2.6% and an r2 = 0.92 on a plot of annual values ($P < 0.001$). The error on the modelled national nitrogen load estimate primarily origins from the national empirical diffuse load model.

The modelling concept enables scientists, environmental planners and decision maker to evaluate the effect of changes in upstream loadings on down stream water bodies. The effect of nitrogen load reduction measures, aiming on increasing retention can also be evaluated. The modelling concept also makes detailed cost minimization calculations possible when deciding the location of nitrogen load reduction measures. At last spin offs of measures focusing on reducing the nitrogen load to upstream lakes can be modelled for down stream water bodies.