Geophysical Research Abstracts
Vol. 12, EGU2010-8011-1, 2010
EGU General Assembly 2010

A national model concept for nutrient loading and retention calculations in Denmark (DK-NP)

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A new model concept has been developed that enables a harmonised calculation of monthly total nitrogen (N) and total phosphorus (P) loadings of surface waters in Denmark. The model concept utilises data from a network of downstream monitoring stations in Danish streams established back in 1989 (coastal loading network). Today it consists of 113 monitoring stations covering 49% of the Danish land area. The remaining of the land area is unmonitored and hitherto different regional methods have been utilised to estimate N and P loadings. The new model concept includes a meta-model for calculation of runoff from ungauged areas (DK-Q). The core of the model concept is two statistical models predicting discharge weighted concentrations of total N and total P from diffuse sources (mainly agriculture) that has been developed from monitoring results from 80 catchments for N and 24 catchments for P, the latter having water sampling being conducted continuously with automatic samplers for an 8-years period. The statistical models has been utilised to estimate the diffuse nutrient loadings to freshwater from a series of 25 km2 catchments in the ungauged parts of Denmark by multiplying the monthly model estimated discharge-weighted concentrations with DK-Q modelled monthly runoff values. For validation reasons the N model has been applied to the gauged areas as well and deviations between monitored and model estimated total N loadings have been evaluated in different Georegions and for specific monitored catchments. The model concept also includes new procedures for estimating retention of N and P in streams, rivers, wetlands and lakes. In the case of 611 larger lakes the lake specific N retentions have been modelled chaining all lakes and catchments within a watershed and modelling incoming water and N for use in a N-retention model. Stream, river and wetland retention is modelled utilising simple retention rates for the different types after having depicted and assessed the individual water bodies with algorithms embedded in GIS.
The new model concept (DK-NP) has been used to recalculate monthly total N and total P loadings to coastal waters around Denmark for the period 1990-2008. The newly recalculated nutrient loadings can be compared with old nutrient loadings calculated with the different regional methods. For the period 1990-2005, the recalculated mean nitrogen loading is 6.6% less than previously reported with annual deviations ranging from 0 to -15%. Contrary for phosphorus recalculated mean loading (1990-2005) is 6% higher than previously reported with annual deviations ranging from -10% to 15%. On a regional and local scale these deviations obviously can be marked higher than the ones for the national loadings. The DK-NP model concept makes it possible to evaluate the importance of nutrient retention in ground water and surface water on national and regional scales. Thus, average annual nitrate-N leaching from the root zone on agricultural and non-agricultural land can be estimated to 212.000 t N during the period 1990-2008. The average diffuse total N loading to coastal waters was only 67.300 t N during the same period. Hence, nitrogen retention – by difference – was 145.000 t N or 68% of the estimated nitrate-N leaching. An average annual amount of 121.000 t N was removed due to nitrate-N reduction in ground waters, whereas the remaining 24.000 t N was calculated to be annually retained in surface waters. The major sinks for N in surface waters are assumed to be lakes (8.400 t N) and streams (15.100 t N), whereas inundated floodplains and wetlands only contribute with 300 tonnes N. In case of P the average annual retention in lakes, wetlands and floodplains is calculated to amount to 163 tonnes P yr-1. The DK-NP modelled nutrient retention is compared with results from other nutrient models in the Pilot River Odense catchment as a way of evaluating the uncertainty.