Geophysical Research Abstracts, Vol. 9, 08956, 2007
SRef-ID: 1607-7962/gra/EGU2007-A-08956

Modelling of nitrogen dynamics in the vadose zone under agricultural soils: application of a process-based model

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Increasing concern for a sustainable land use and drinking water supply in Europe has caused a rethinking in administration and also in population. A high risk of pollution with wide-used substances could be detected particularly for near-surface groundwater in monitoring programmes. Especially a surplus supply with nutrients like nitrogen from agricultural land use has affected soil, water and plants with different interactions in-between. Associated with water flows in vadose soils the leaching losses of nutrients, such as nitrate, can be very significant under wet climate conditions. Therefore differences in nitrogen leaching are very significant between different sites.

A characterisation of soil conditions and land use including soil management was achieved for one experimental site, called Lindhof, near the Baltic Sea. Over a period of five years discharge and nitrate concentration in an artificial drainage system were measured (Deunert & Fohrer 2006). Local climate information as daily values was available for this site. Depending on cultivated crops and their treatment observations showed differences in discharge and nitrogen loss between the years. Derived from these measurements an effective assessment to reduce nitrate leaching from agricultural sites had to consider modelling nitrogen transport in the vadose zone.

The aim of this work is the application of a process-based numerical Soil-Vegetation-Atmosphere-Transfer model, called CoupModel (Eckersten & Karlberg 2004), for the determination of the nitrogen loss under special forage crops and grassland mixture (e.g. clover-grass). This tool is dedicated to problems involving not only transient water flows in a structured soil profile, but also carbon and nitrogen dynamics in soil

and vegetation. The Richard's equation is solved expressed in the matrix potential connected to the water content by the Van Genuchten's model for the prediction of the unsaturated hydraulic conductivity by Mualem. Parameters and initial boundary conditions for water and nitrogen contents, used in the simulations, were achieved by measurements on this site and were derived from pedotransfer functions.

The first simulation runs show plausible results for the water flow. They reproduced observed phenomena, water table and water content variation in daily resolution and the vertical and horizontal transport of nitrate in the soil column. Simulated values and measurements show partly a good agreement in the discharge dynamic. Compared with the measured values the model reacts much faster as the real drainage system. This can be caused by the difference between the complex artificial drainage system and the small scale approach in the model. Based on the water flow dynamics the nitrate load in the drainage water was simulated. Discrepancies between simulated and measured values exist especially in the temporal distribution even though the simulated annual nitrate loss of 25 kg N per hectare was comparable with measured values based on accountings for the residual nitrate in the soil, harvested crop parts and applied nitrogen fertilizers. To improve these results interactions between developing crop with its nitrogen demand and soil processes must be better coordinated. Parameters for the decomposition of organics, initial values in the mineral and organic soil pools have to be examined and adapted in consideration of an integrated plant growth model.