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Forecasting the effects of EU policy measures on the nitrate pollution of groundwater and surface waters

R. Kunkel (1), P. Kreins (2), B. Tetzlaff (1), and F. Wendland (1)

(1) Research Centre Juelich, Institute of Chemistry and Dynamics of the Geosphere, ICG-4: Agroshere; Juelich, Germany (r.kunkel@fz-juelich.de), (2) Johann Heinrich von Thünen-Institut, Federal Research Institute for Rural Areas, Forestry and Fisheries; Braunschweig, Germany (peter.kreins@vti.bund.de)

The fundamental objectives of the European Union-Water Framework Directive and the EU Groundwater Directive are to attain a good status of water and groundwater resources in the member states of the EU by 2015. Following the implementation time table, the EU member States carried out a review about the qualitative and quantitative status for all river basins in the EU. For river basins, whose good status cannot be guaranteed by 2015, catchment wide operational plans and measurement programs are to be drafted and implemented until 2009.

In the river basin district Weser, Germany, which comprises a catchment area of ca. 49.000 km^2, the achievement of the good status is unclear, or rather unlikely for 63% of the groundwater bodies. Inputs from diffuse sources and most of all nitrogen losses from agriculturally used land have been identified as the main reasons for exceeding the groundwater threshold value for nitrate (50 mg/l) and for failing the „good qualitative status“ of groundwater in 2015. For this reason the drafting and implementation of measurement programs in the Weser basin are primarily focused on nitrate.

The achievement of good qualitative status of groundwater bodies entails a particular challenge especially for large river basins as the complex ecological, hydrological, hydrogeological and agro-economic relationships have to be considered simultaneously. Integrated large scale agroeconomic- hydrologic models are powerful tools to analyze the actual pollution loads and “hot spot” areas and to predict the temporal and spatial effects of reduction measures. We used the interdisciplinary model network REGFLUD to predict the nitrogen intakes into groundwater and the nitrogen losses to surface waters by different pathways at the regional scale using an area differentiated approach. The model system combines the agro-economic model RAUMIS for estimating nitrogen surpluses from agriculture and the hydrological models GROWA/DENUZ/WEKU for describing the reactive nitrate transport in the soil-groundwater system. Nitrogen transport by groundwater runoff, surface runoff, drainage runoff and natural interflow is considered.

In a first step the model is used to analyze the present situation using N surpluses from agriculture for the year 2003. In many region of the Weser basin, particularly in the northwestern part which is characterized by high livestock densities, predicted nitrate concentrations in percolation water exceed the EU groundwater quality standard of 50 mg/L by far. In parallel, high nitrogen outputs to surface waters via the different pathways are predicted for these areas. The regional importance of a specific outtake pathway for nitrogen, however, may vary significantly depending on the individual site characteristics.

Based on the results of the analysis of the present situation regionally adapted and hence effective agri-environmental reduction measures need to be derived and implemented to improve groundwater and surface water quality by 2015. These measures include both single measures and combination of measures, which will be analyzed with regard to their impact on the regional quality of percolation water and on their impacts on the regional agricultural income. In this context it is very important to distinguish between the effects of measures, which have already been implemented by current agricultural policy and measures which have to be additionally implemented to meet the environmental targets of the EU Water Framework Directive. For this purpose a baseline scenario is developed, which projects the effects of modified general conditions of the agricultural sector on the nitrogen surpluses to the year 2015. In this baseline scenario the effects of the common agricultural policy (CAP) of the EU, already implemented agri-environmental measures of the Federal States and the expected developments of agri-

culture are considered. According to this scenario the nitrogen surpluses for agricultural areas can be expected to be reduced only by about 10 kg N ha^{-1} a^{-1} on average for the whole Weser basin. However, for the agriculturally intensive used regions the expected N surpluses reduction may be much higher and can amount 40 kg N ha^{-1} a^{-1} or more.

The REGLUD model system is used to quantify the potential effects of these projected N surpluses on the intakes into the groundwater the nitrogen pollution of surface waters. A comparison to the present situation shows that the potential nitrate concentration in the leachate will decrease in almost all regions of the Weser basin, mostly by about 10 mg NO_3/L. In the agriculturally intensive used regions much higher reductions in the order of 40 mg NO_3/L may be expected. Consequently, reduced nitrogen outflows to surface waters via the different pathways are obtained.

Using environmental target values for groundwater and surface waters, e.g. a concentration of 50 mg NO_3/L in the leachate as a target for groundwater protection, the model results can be used directly to identify those regions where additional agri-environmental reduction measures are required. Additionally, a backward calculation by the REGFLUD allows the quantification of maximal permissible nitrogen surplus levels, which can be used as a reference for the derivation of additional regionally adapted and hence effective nitrogen reduction measures.

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