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Modeling nitrogen fluxes in Germany – where does the nitrogen go?

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According to the latest inventory of the EU Water Framework Directive, 26.3% of German groundwater bodies are in a poor chemical state regarding nitrate. Additionally, the EU initiated infringement proceedings against Germany for not meeting the quality standards of the EU Nitrate Directive. Agriculture has been determined as the main source of nitrate pollution due to over-fertilization and regionally high density of livestock farming. The nitrogen balance surplus is commonly used as an indicator characterizing the potential of nitrate leaching into groundwater bodies and thus also serves as a foundation to introduce legislative restrictions or to monitor the success of mitigation measures.
Currently, there is an ongoing discussion which measures are suitable for reducing the risk of nitrate leaching and also to what extent. However, there is still uncertainty about just how much the nitrogen surplus has to be reduced to meet the groundwater quality standards nationwide. Therefore, the aims of our study were firstly to determine the level of the nitrogen surplus that would be acceptable at the utmost and secondly whether the currently discussed target value of 30 kg N per hectare agricultural land for the soil surface nitrogen balance would be sufficient.
The models MONERIS (Modeling Nutrient Emissions in River System) and MoRE (Modelling of Regionalized Emissions), the latter based on the first, are commonly used for estimating nitrogen loads into the river system in Germany at the mesoscale, as well as the effect of mitigation measures in the context of the EU directive 2008/105/EC (Environmental quality standards applicable to surface water). We used MoRE to calculate nitrate concentration for 2759 analytical units in Germany. Main factors are the surplus of the soil surface nitrogen balance, the percolation rate and an exponent representing the denitrification in the vadose zone.
The modeled groundwater nitrate concentrations did not correspond to the regional patterns of the groundwater bodies which fail the good WFD status, the N-surplus or the measured data. The parameters for denitrification and the percolation rate seemed to have a higher model sensitivity than the nitrogen surplus. MoRE was previously validated only for the total N load from groundwater into surface water but the modeling concept for nitrate concentration was seemingly never fitted to observed data and needs refinements. A literature research showed that no groundwater concentrations modeled with MoRE or MONERIS have been published for Germany until now. Instead, only the concentration in percolating water was shown – sometimes misleadingly labeled so that the reader could presume the map displayed groundwater concentrations.
According to the MoRE approach, model parameters such as the percolation rate and denitrification intensity are more sensitive than the N surplus. The surplus can indicate only a potential leaching risk, while the actual threat varies substantially with regional soil and climate conditions. Consequently, the use of the nitrogen surplus as a sole indicator for nitrate leaching should be critically examined. For conception of nitrate reduction programs obviously the regionally varying site conditions cannot be disregarded.