Geophysical Research Abstracts
Vol. 16, EGU2014-4294, 2014
EGU General Assembly 2014

Mitigation scenario analysis: modelling the impacts of changes in agricultural management practices on surface water quality at the catchment scale

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Increasing human pressures on the natural environment through the demand for increased agricultural productivity have exacerbated and deteriorated water quality conditions within many environments due to an unbalancing of the nutrient cycle. As a consequence, increased agricultural diffuse water pollution has resulted in elevated concentrations of nutrients within surface water and groundwater bodies. This deterioration in water quality has direct consequences for the health of aquatic ecosystems and biodiversity, human health, and the use of water as a resource for public water supply and recreation. To mitigate these potential impacts and to meet commitments under the EU Drinking Water and Water Framework Directives, there is a need to improve our understanding of the impacts that agricultural land use and management practices have on water quality. Water quality models are one of the tools available which can be used to facilitate this aim. These simplified representations of the physical environment allow a variety of changes to be simulated within a catchment, including for example changes in agricultural land use and management practices, allowing for predictions of the impacts of those measures on water quality to be developed and an assessment to be made of their effectiveness in improving conditions.

The aim of this research is to apply the water quality model SWAT (Soil and Water Assessment Tool) to the Wensum catchment (area 650 km^2), situated in the East of England, to predict the impacts of potential changes in land use and land management practices on water quality as part of a process to select those measures that in combination will have the greatest potential to improve water quality.

Model calibration and validation is conducted at three sites within the catchment against observations of river discharge and nitrate and total phosphorus loads at a monthly time-step using the optimisation algorithm SUFI-2 (Sequential Uncertainty Fitting Version 2) within the program SWAT-CUP (SWAT Calibration and Uncertainty Programs). Model performance is assessed against a variety of statistical measures including the Nash-Sutcliffe efficiency coefficient (NSE) and percentage bias (PBIAS).

Various mitigation scenarios are modelled within the catchment, including changes in fertiliser application rates and timing and the introduction of different tillage techniques and cover-crop regimes. The effects of the applied measures on water quality are examined and recommendations made on which measures have the greatest potential to be applied within the catchment to improve water quality. This study reports the findings of that analysis and presents techniques by which diffuse agricultural pollution can be reduced within catchments through the implementation of multiple on-farm measures. The methodology presented has the potential to be applied within other catchments, allowing tailored mitigation strategies to be developed. Ultimately, this research provides 'tested' mitigation options that can be applied within the Wensum and similar catchments to improve water quality and to ensure that certain obligatory water quality standards are achieved.