Geophysical Research Abstracts
Vol. 13, EGU2011-6163, 2011
EGU General Assembly 2011

An episodic transit time model for quantification of preferential solute transport

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Variations in the concentrations of naturally occurring isotopes in rainfall provide a ‘continuous’ signal which has the potential to generate more information on how weather conditions control solute transport than traditional field tracer experiments. An isotopically distinct rainfall event can be rapidly transferred through the system when preferential flow occurs. The objective of the study was to develop and test an approach for analyzing how rainfall and soil moisture control preferential transport to tile drains. An episodic solute transit time distributions model that accounts for these effects was developed. Transit time distributions for individual preferential flow events were modelled using the Poisson distribution. Time series of daily isotope ratios in rainfall and in drainage water for soils where macropore flow is significant are needed to test the model. Since no such data were available the model was tested on artificial data generated by the MACRO 5.2 model. The MACRO model was run for three of the FOCUS scenarios for surface water. The three scenarios Lanna, La Jailliere and Vreedepeel were chosen to represent high, medium and low potentials for preferential flow and transport, respectively. In this study data consisted of daily values of tile drain discharge and 18O concentrations in drainage water. However, the model is equally applicable to data from lysimeter studies. Results showed that the transit time model gave an excellent fit to the artificial data for the soil with high potential for preferential flow (Nash-Sutcliffe coefficient=0.78). The dynamics of the preferential flow events were well captured also for the soil with medium potential for preferential flow but the magnitudes were sometimes poorly simulated (Nash-Sutcliffe coefficient=0.42). The artificial data for the soil with low potential for preferential flow could not be reproduced by the transit time model. Once the model parameter values have been determined the model can be used to calculate the amount and distribution over time of preferential flow to tile drains for all daily rainfall data. Model calculations integrate the soil’s potential for preferential flow and the effects of weather conditions and are, therefore, highly relevant as site specific indicators for the risk for preferential leaching of agrochemicals. The approach needs to be evaluated against real field data, however, before its usefulness can be established. The approach taken in this study with individual transit time distributions is based on an understanding of preferential flow and transport as episodic, threshold triggered processes. The model presented here should not be regarded as final, but rather as an example of such models.