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Pesticide and metabolite fate, release and transport modelling at catchment scale

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Pesticides are of great concern in hydrological catchments all over the world. On the one hand they are necessary to guarantee stable agricultural production for an increasing population. On the other hand they endanger life of aquatic animals and freshwater resources. However, not only pesticides but also their degradation products, the metabolites, are toxic to the environment, in some cases even more than the parent material. Thus, it is necessary to optimize pesticide application and management of agricultural land (e.g. grass strips, erosion prevention) with respect and according to their behaviour and degradation in hydrological catchments. Modelling provides a sound tool for assessing the impacts of pesticide management changes on pesticide behaviour at the field and in consecutively surface waters. Most of the various models available in literature do not consider metabolism. This study introduces an applicable integrated model assessing the fate and release of a pesticide and one metabolite at the field and in surface waters of a hydrological catchment.

For the development of the field release model, the single-equation pesticide release formula by the OECD (2000) was used, which combines sorption and degradation in one equation. The part of the equation calculating the degradation forms the input of a second OECD equation representing the metabolite with its own parameters. A fraction can be specified describing how much of the degradation product is transferred to the specific metabolite. The river network is simulated with a further development of the MOHID River Network model (MRN). The integration of a pesticide type and a metabolite, with their degradation and volatilization processes are the main improvements of the hydrodynamic channel model.

Following, the combined model was set up to the Israeli part of the Upper Jordan River basin, especially the Hula valley. According to the local hydrological conditions, a linear storage with a threshold was applied to 26 subbasins as a hydrological base for the OECD equation. Virtually, 1000 kg of Chlorpyrifos were applied to the basin in two doses per year. The metabolite chosen in this test-application was TCP.

The results showed pesticide and metabolite concentrations in the river at the catchment outlet in the expected order of magnitude. Field pesticide followed the application as Dirac-impulse with a subsequent exponential decay and lowering by overland flow removal. TCP field amounts, however, are a combination of two exponential equations resulting in a delayed, smaller and smoothed peak. The river network model showed its ability to simulate transport, mixture and mitigation of the pesticides.

The test run showed the applicability of the new model chain to asses pesticide and metabolite release to surface waters in catchment systems, but has to be validated by measurements of those components. It is expected to gain these validation measurements in late 2010 by the project DYKE.