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Simulating pesticide transport in urbanized catchments: a new spatially-distributed dynamic pesticide runoff model

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Urban areas can significantly contribute to pesticide contamination in surface water. However, pesticide behaviours in urban areas, particularly on hard surfaces, are far less studied than those in agricultural areas. Pesticide application on hard surfaces (e.g. roadsides and walkways) is of particular concern due to the high imperviousness and therefore high pesticide runoff potential. Experimental studies have shown that pesticide behaviours on and interactions with hard surfaces are important factors controlling the pesticide runoff potential, and therefore the magnitude and timing of peak concentrations in surface water. We conceptualized pesticide behaviours on hard surfaces and incorporated the conceptualization into a new pesticide runoff model. The pesticide runoff model was implemented in a catchment hydrological model WetSpa-Python (Water and Energy Transfer between Soil, Plants and Atmosphere, Python version).

The conceptualization for pesticide processes on hard surfaces accounts for the differences in pesticide behaviour on different hard surfaces. Four parameters are used to describe the partitioning and wash-off of each pesticide on hard surfaces. We tested the conceptualization using experimental dataset for five pesticides on two types of hard surfaces, namely concrete and asphalt. The conceptualization gave good performance in accounting for the wash-off pattern for the modelled pesticides and surfaces, according to quantitative evaluations using the Nash-Sutcliffe efficiency and percent bias.

The resulting pesticide runoff model WetSpa-PST (**WetSpa** for **P**e**ST**icides) can simulate pesticides and their metabolites at the catchment scale. Overall, it includes four groups of pesticide processes, namely pesticide application, pesticide interception by plant foliage, pesticide processes on land surfaces (including partitioning, degradation and wash-off on hard surface; partitioning, dissipation, infiltration and runoff in soil) and pesticide processes in depression storage (including degradation, infiltration and runoff). Processes on hard surfaces employs the conceptualization described in the paragraph above.

The WetSpa-PST model can account for various spatial details of the urban features in a catchment, such as asphalt, concrete and roof areas. The distributed feature also allows users to input detailed pesticide application data of both non-point and point origins. Thanks to the Python modelling framework prototype used in the WetSpa-Python model, processes in the WetSpa-PST model can be simulated at different time steps depending on data availability and the characteristic temporal scale of each process. This helps to increase the computational accuracy during heavy rainfall events, especially for the associated fast transport of pesticides into surface water.

Overall, the WetSpa-PST model has good potential in predicting effects of management options on pesticide releases from heavily urbanized catchments.