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What pesticide legislation forgot about: Pesticide transport through hydraulic shortcuts

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Pesticides from agricultural origin may harm surface water quality and pose a risk for aquatic organisms. In Europe, the regulations on agricultural pesticide usage are currently focusing on "classical" pesticide transport pathways, such as surface runoff, spray drift into surface waters, or tile drainage flow. Recent studies have shown that in certain cases also so-called *hydraulic shortcuts* (e.g. road storm drains, or manholes of the tile drainage systems) can be of major importance for pesticide transport into surface waters. However, until now research has widely neglected this transport pathway.

In this study, we investigated the relevance of hydraulic shortcuts for the pesticide transport from arable land to surface waters in Switzerland. We selected twenty small catchments throughout the Swiss midlands as study areas by performing a weighted random selection on a nation-wide hydrological catchment stratification dataset. On average, they have an area of 3.5 km^2 with a fraction of 44 % of arable land. In the agricultural areas of these catchments, we mapped hydraulic shortcuts using different data sources: Field surveys, high-resolution aerial images captured by a fixed-wing drone as well as plans of the road storm drains and the tile drainage systems. Subsequently, we modelled the hydrological connectivity of arable areas to surface waters using a digital elevation model and a D-infinity flow direction algorithm. Within this model, we distinguished between areas with a direct and indirect (i.e. via shortcuts) surface water connectivity.

Our model results show that major fractions of the arable areas with surface water connectivity are not connected directly, but via hydraulic shortcuts: The fraction of indirectly connected areas ranges between 18 % and 90 %, with a median of 52 % for the 20 catchments. In order to check the model robustness we performed sensitivity analyses for different model parameters, such as sink filling depth, maximal flow length, or parameters addressing the influence of roads, forests, and hedges. In certain cases, changes of those model parameters have a strong influence on the absolute extent of directly and indirectly connected areas. However, their fractions compared to the total connected area were insensitive to changes in the model parameters.

In addition, we will present the results of a model predicting the fraction of arable land connected to shortcuts within a catchment, depending on auxiliary quantities (e.g. length of roads of a certain type, land use, slope). Using this model, we can estimate the arable land fraction per catchment on a national scale.