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Spatially explicit exposure assessment for small streams in catchments of the orchard growing region 'Lake Constance'

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1. Introduction

Small streams differ greatly from the standardised water body used in the context of aquatic risk assessment for the regulation of plant protection products in Germany. The standard water body is static, with a depth of 0.3 m and a width of 1.0 m. No dilution or water replacement takes place. Spray drift happens always in direction to the water body. There is no variability in drift deposition rate (90th percentile spray drift deposition values [2]). There is no spray drift filtering by vegetation. The application takes place directly adjacent to the water body.

In order to establish a more realistic risk assessment procedure the Federal Office for Consumer Protection and Food Safety (BVL) and the Federal Environment Agency (UBA) aggreed to replace deterministic assumptions with data distributions and spatially explicit data and introduce probabilistic methods [3, 4, 5].

To consider the spatial and temporal variability in the exposure situations of small streams the hydraulic and morphological characteristics of catchments need to be described as well as the spatial distribution of fields treated with pesticides.
As small streams are the dominant type of water body in most German orchard regions, we use the growing region Lake Constance as pilot region.

2. Materials and methods

During field surveys we derive basic morphological parameters for small streams in the Lake Constance region. The mean water width/depth ratio is 13 with a mean depth of 0.12 m. The average residence time is 5.6 s/m (n=87) [1]. Orchards are mostly located in the upper parts of the catchments.
Based on an authoritative dataset on rivers and streams of Germany (ATKIS DLM25) we constructed a directed network topology for the Lake Constance region. The gradient of the riverbed is calculated for river stretches of > 500 m length. The network for the pilot region consists of 2000 km rivers and streams. 500 km stream length are located within a distance of 150 m to orchards. Within this distance a spray drift exposure with adverse effects is theoretically possible [6]. The network is segmented to approx. 80'000 segments of 25 m length. One segment is the basic element of the exposure assessment.
Based on the Manning-Strickler formula and empirically determined relations two equations are developed to express the width and depth of the streams and the flow velocity [7].
Using Java programming and spatial network analysis within Oracle 10g/Spatial DBMS we developed a tool to simulate concentration over time for all single 25 m segments of the stream network. The analysis considers the spatially explicit upstream exposure situations due to the locations of orchards and recovery areas in the catchments. The application which takes place on a specific orchard is simulated according to realistic application patterns or to the simplistic assumption that all orchards are sprayed on the same day.

3. Results

The results of the analysis are distributions of time average concentrations (mPEC) for all single stream segments of the stream network. The averaging time window can be defined flexibly between 1 h (mPEC1h) to 24 h (mPEC24h).

Spatial network analysis based on georeferenced hydraulic and morphological parameters proved to be a suitable approach for analysing the exposure situation of streams under more realistic aspects. The time varying concentration of single stream segments can be analysed over a vegetation period or a single day. Stream segments which exceed a trigger concentration or segments with a specific pulse concentration pattern in given time windows can be identified and be addressed by e.g. implementing additional drift mitigation measures.

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