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Can mitigation schemes produce detectable long-term temporal trends and spatial patterns in aquatic pesticide pollution?

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Agroecological schemes are implemented worldwide in order to reduce water quality impairment from agricultural pesticide use. However, evaluating the success or failure of these schemes is challenging because other influencing factors can confound their effects. For instance, aquatic pesticide pollution has been found to vary greatly due to the interannual variability in weather conditions (e.g., the timing, intensity, and duration of precipitation events) and changes in pesticide application practices (e.g., changing pest pressure, phasing-out and replacement of specific products, development of pesticide resistance).

Our research investigates the necessary conditions to detect significant trends in pesticide concentrations in the context of the Swiss National Action Plan (NAP), which aims to halve aquatic pesticide pollution risk from agricultural pesticide use within Swiss river networks by 2027.

We base our analyses for temporal trends on a calibrated model for pesticide transport at the catchment scale, which we use to separate the long-term effects of the NAP from interannual variability due to weather conditions. Our results indicate that the interannual variability due to weather conditions can override the effects of even a 50% reduction in pesticide application for rain-driven input. This implies that the concentration levels themselves may be insufficient to demonstrate the effectiveness of the NAP within a reasonable time horizon of a decade. This is because the lowering of in-stream pesticide concentrations can be due to the timing and intensity of precipitation relative to the application of pesticides and not from the effectiveness of pesticide mitigation measures. Therefore, we have further explored potential methods to account for the weather effects on the pesticide concentration levels. Accounting for the weather conditions by considering the dependence of concentration levels on discharge conditions during the application period improves the statistical power to detect trends.

Furthermore, we assess the potential to extrapolate the trends observed at 23 monitoring sites from different catchments (varying in size 1 km^2 to > 20,000 km^2) across Switzerland to the entire Swiss river network. As a first step, we analyzed substances applied to corn because this crop is widespread in the country, is easy to follow as herbicides are applied only once a year, and only a few pesticides are applied. The analysis revealed that for some of these corn herbicides, the seasonal patterns were consistent across many catchments and in agreement with the crop

specific expectations. However, for other herbicides we identified regional patterns with unexpected concentration peaks in the fall. This observation requires more detailed inquiries in regional use patterns and highlights the need to account for regionalized pesticide use when extrapolating monitoring data to larger scales.