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Evaluating the potential of ‘on-line’ constructed wetlands for mitigating pesticide transfers from agricultural land to surface waters

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Pesticides make important contributions to modern agriculture but losses from land to water can present problems for environmental management, particularly in catchments where surface waters are abstracted for drinking water. Where artificial field drains represent a dominant pathway for pesticide transfers, buffer zones provide little mitigation potential. Instead, “on-line” constructed wetlands have been proposed as a potential means of reducing pesticide fluxes in drainage ditches and headwater streams. Here, we evaluate the potential of small free-surface wetlands to reduce pesticide concentrations in surface waters using a combination of field monitoring and numerical modelling. Two small constructed wetland systems in a first order catchment in Cambridgeshire, UK, were monitored over the 2014-2015 winter season. Discharge was measured at several flow control structures and samples were collected every eight hours and analysed for metaldehyde, a commonly-used molluscicide. Metaldehyde is moderately mobile and, like many other compounds, it has been regularly detected at high concentrations in surface water samples in a number of drinking water supply catchments in the UK over the past few years. However, it is unusually difficult to remove via conventional drinking water treatment which makes it particularly problematical for water companies. Metaldehyde losses from the upstream catchment were significant with peak concentrations occurring in the first storm events in early autumn, soon after application. Concentrations and loads appeared to be unaffected by transit through the wetland over a range of flow conditions – probably due to short solute residence times (quantified via several tracing experiments employing rhodamine WT – a fluorescent dye). A dynamic model, based on fugacity concepts, was constructed to describe chemical fate in the wetland system. The model was used to evaluate mitigation potential and management options under field conditions and for a range of different pesticides under alternative flow and wetland dimension scenarios. In agreement with observations, model predictions for metaldehyde losses in the monitored system were negligible. The scenario analysis suggested that, even for pesticides with a relatively short aquatic half life, wetland systems would need to be much larger than those studied here in order to get any appreciable attenuation. Shallow systems have highest potential for promoting losses due to biodegradation, if we assume that most degrading organisms reside in fixed biofilms in the sediment. Sorption is not predicted to represent a significant net sink, except over short time scales in the first runoff event after application.