Doctoral Thesis

Virus and organic carbon removal during bank filtration: the effects of changing hydraulic conditions of large rivers

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by

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Abstract

Near-river aquifers are part of a valuable water resource system for drinking water supply. Such a water supply aims at highest quality standards and any deterioration of resources (such as during flooding events) is of great concern. The aim of this thesis is to investigate the effects of floods, bank restoration and changing water temperatures on the groundwater quality nearby a large river. This thesis focuses on pathogenic viruses and dissolved organic carbon (DOC). Many waterborne pathogenic viruses are highly persistent and mobile in the aqueous environment and of high public importance (Schijven & Hassanizadeh 2000). DOC can be considered a proxy parameter for organic pollutant transport, and furthermore, can act as precursor for disinfection and oxidation byproducts with potential toxicological relevance (Hülshoff et al. 2009). This thesis investigates

- the effect of river water level fluctuations on the extent of the zone where river water mixes with groundwater,
- the effect of increasing river water levels by 1-5 m during flooding events on virus removal during bank filtration,
- how varying water temperatures during flooding events affect virus and organic carbon removal during bank filtration over the seasons and
- the effect of bank restoration on organic carbon removal during flooding events.

In Chapter 2 the three dimensional groundwater flow patterns in a gravel bar at the Danube east of Vienna were investigated. River water level fluctuations were found to be a significant mechanism responsible for increasing the extent of the river-aquifer mixing zone. In Chapters 3 to 5, the effects of changing hydraulic conditions of a large river on virus and organic carbon removal during bank filtration were examined for different scenarios. The results indicate that increases of river water levels by 1-5 m during floods caused by up to 2-4 $log_{10}\frac{C}{C_0}$ elevated virus concentrations (relative virus concentrations C compared to initial concentrations in the river C_0) and the required distance from the river for their removal by 1.2 to 6 times. Results further indicate that seasonal water temperature variations during flooding events can lead to significant variations of virus and organic carbon removal efficiencies during bank filtration. Finally, it was demonstrated that organic carbon concentrations in groundwater may be elevated by 1.25 to 8 times at restored banks as compared to steep banks and their travel time may be shorter because of an increased contact area between the river and groundwater.

The results provided in this thesis demonstrate that the effects of changing hydraulic conditions of large rivers are significant for virus and organic carbon removal during bank filtration and should therefore be considered in future studies.

Contents