Modelling Effects of Redox Conditions and Temperature Variability on Emerging Organic Contaminant Attenuation in a Bank Filtration Site

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Introduction

Bank filtration (BF) is an efficient, low-energetic, and widely used technique to increase drinking water production and groundwater reservoirs. This water quality pretreatment system relies on natural or induced infiltration of the surface water into the nearby aquifer to trigger attenuation of hazardous compounds through biogeochemical reactions. The effectiveness of BF is strongly dependent on the hydraulic and meteorological conditions, whose transient behavior may cause significant alterations on the flow and reactive transport processes in the subsurface; foremost are: aquifer disconnection of the riverbed, as changes in infiltration rates, seepage velocity, and groundwater flow paths; temporal variations of environmental conditions, e.g. pH, temperature; and changes in the availability of reactive compounds, as dissolved electron acceptors of the redox reactions. In this context, it is fundamental to improve the understanding of the fate and behavior of emerging organic contaminants (EOC’s: pharmaceutical and personal care products, industrial chemicals, among others) throughout the soil passage under transient conditions. Many EOC’s are not completely removed during waste water treatment and thus are released into surface waters from where they can enter the subsurface via river bank filtration. Nowadays, process-based models strive for understanding the coupled flow and reactive transport processes at field scale and the estimation of reactive transport parameters valid under natural conditions.

Hypothesis and objective

Based on previous studies [1], this research attempts to address the identification, simulation, and quantitative evaluation of relevant relations between the emerging contaminant attenuation, mainly conducted by biodegradation and sorption, and the seasonal variations of temperature and redox conditions during a large-term bank filtration operation period. We test whether transient values of groundwater temperature and exposure time of EOC’s within each redox zonation may cause annual variations in the effectiveness of natural attenuation. For that purpose, a two-dimensional model of groundwater flow and biokinetic reactive transport processes is setup, calibrated, and validated with the numerical software FEFLOW, and supported by available monthly data base of an intensive monitored field site at the Lake Tegel in Berlin (Germany). Additionally, we expect that the estimated reactive parameters could be extrapolated to other field sites with similar environmental characteristics.
Field site description

The Lake Tegel (surface: 4.61 km²) is in the northwest of Berlin on a glacial valley formed by glaciofluvial and fluvial sands covered by younger organic rich sediments, and interbedded coarse gravels and residual boulder clays. The lake receives outflow significant share of effluent from the Waste Water Treatment Plant Schönerlinde, which is further-treated to reduce the phosphate concentration before discharge in Lake Tegel [2]. The soil passage is formed by two Pleistocene aquifers partially disconnected by an aquitard. Temporary disconnection of the groundwater level may take places in the first meters by the shore of the Lake Tegel during the dry season. Here, we study the Tegel transect shown in Figure 1. This area is monitored by observation wells screened at diverse depths, whilst the well 13 operates as production well inducing artificial bank filtration.

![Figure 1: Scheme cross-section of the Tegel transect [3].](image)

As shown in Figure 2, previous research study in the Tegel transect reproduced the effect of significant seasonal oscillations of temperature and dissolved oxygen concentration, which result in a sequence of cold-oxic plume followed by warm-suboxic plume penetrating in the aquifer [3]. Besides, first-order biodegradation and linear sorption reactive transport model of a group of EOC’s suggested that higher-order kinetic reactions could provide better model outcomes [4]. The site characterization of the present study accounts for those findings, and intends to provide new observations on EOC’s behavior valid for extrapolated applications, as well as useful remarks for further environmental risk assessment at the field site.

![Figure 2. Spatial and temporal distribution of temperature and dissolved oxygen in the existing model domain [3].](image)

References