



Evaluation of VOC fluxes from urban groundwater to surface water at various reach scales

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Assessment of baseflow VOC (volatile organic compound) fluxes from urban contaminated groundwater to surface water has been investigated at various reach scales for the River Tame – Birmingham aquifer system. The Birmingham Triassic Sandstone aquifer is significantly contaminated with chlorinated VOCs including solvents such as TCE (trichloroethene) and its associated degradation products prominent. Baseflow from the aquifer to river has been primarily assessed through networks of riverbed piezometers and is likewise frequently contaminated with chlorinated VOCs over the city-scale reach of 7.4 km length initially studied. Subsequent studies have since focused upon smaller sub-reach scales from 30 m to 400 m examining specific TCE plumes identified in the larger scale study. TCE flux at the city scale was estimated using five flow-concentration methods including methods based on changes in surface water concentration as well as those using riverbed concentrations. Flux estimates were in the range ~20-200 kg/yr along the 7.4km reach. The low end estimate was obtained via product combination of mean riverbed concentration and a Darcy's law flux term based on riverbed hydraulic conductivity and gradients. This range was considered reasonable considering the large measurement scale and geological and chemical heterogeneities present. However, flux estimates based upon surface water concentration increases were towards the upper end of the estimates and may suggest plumes, or plume peaks representing significant mass discharge were missed by the relatively sparse city-scale riverbed piezometer network. Endorsement of this concern was partly corroborated by two relatively localised reaches accounting for a significant proportion (~50 %) of the total flux of the 7.4 km reach. For example, flux estimates (via riverbed piezometer concentration – Darcy's law) were 10.5 kg/yr for one 400 m reach and 0.41 kg/yr for a different 30 m reach. Fluxes are potentially modified by

biodegradation processes occurring in the riverbed although at some localities such reactions do not appear significant as chlorinated VOC compound concentrations were relatively invariant with depth. Smaller scale investigation of one of the sub-reaches found a small area ($<10\text{m}^2$) consisting of silt/peat deposits of low permeability where anaerobic dechlorination was apparent. The degree to which contaminated baseflow is attenuated within or via more permeable deposits circumvents such zones is the subject of on-going studies. Although the study suggests that discharging plumes could be of high concentration locally in the riverbed, the overall impact on surface water quality appears to be limited. Just a $2\mu\text{g/L}$ rise in TCE concentration over the 7.4 km reach was observed which may in part be limited by Henry's law partitioning from the surface water to atmosphere.