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QMRAcatch – faecal microbial quality of water resources in a river-floodplain area affected by urban sources and recreational visitors

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QMRAcatch, a tool to simulate microbial water quality including infection risk assessment, was previously developed and successfully tested at a Danube river site (Schijven et al. 2015). In the tool concentrations of target faecal microorganisms and viruses (TMVs) are computed at a point of interest (PI) along the main river and the floodplain river at daily intervals for a one year period. Even though faecal microbial pathogen concentrations in water resources are usually below the sample limit of detection, this does not ensure, that the water quality complies with a certain required health based target. The aim of this study was therefore to improve the predictability of relevant human pathogenic viruses, i.e. enterovirus and norovirus, in the studied river/floodplain area. This was done by following an innovative calibration strategy based on human-associated microbial source tracking (MST) marker data which were determined following the HF183 TaqMan assay (Green et al. 2011). The MST marker is strongly associated with human faeces and communal sewage, occurring there in numbers by several magnitudes higher than for human enteric pathogens (Mayer et al 2015). The calibrated tool was then evaluated with measured enterovirus concentrations at the PI and in the floodplain river.

In the simulation tool the discharges of 5 wastewater treatment plants (WWTPs) were considered with point discharges along a 200 km reach of the Danube river. The MST marker and target virus concentrations at the PI at a certain day were computed based on the concentrations of the previous day, plus the wastewater concentrations times the WWTP discharge divided by the river discharge. A ratio of the river width was also considered, over which the MST marker and virus particles have fully mixed with river water. In the tool, the excrements from recreational visitors frequenting the floodplain area every day were assumed to be homogeneously distributed in the area. A binomial distributed probability was considered that people practice open defecation in the floodplain area, including a viral prevalence. The release rate and runoff coefficient, defined here as ratios of daily rainfall amounts, were assumed the same for the MST marker and target viruses, and everywhere the same in the floodplain area. They may differ for different years, however, because climatic and hydrologic conditions can change. The model parameter uncertainties were considered in the tool within a Monte-Carlo framework. Random numbers were drawn from preselected statistical probability distributions e.g. of the faecal MST marker concentrations, for each year-day, iterated 10000 times.

The calibrated tool was shown to predict enterovirus concentrations in the Danube river and the floodplain river within the right order of magnitude, when comparing the mean, 95th percentiles and the shape parameters of the Gamma distributions of measured and simulated concentrations over a year. With the calibrated tool, the required target virus reductions from the river Danube and the floodplain river water to produce safe drinking water were estimated. Low and high contamination scenarios (i.e. 5 log10 to no wastewater treatment, small to large percentage of visitors that practice open defecation, low to high viral prevalence) were investigated for guiding robust treatment design criteria of water supplies.

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