Simulating the fate of faecal bacteria in estuarine and coastal waters based on a fractionated sediment transport model

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In recent years, public and professional concerns of estuarine and coastal water quality are growing. Because of the difficulties of direct measurement of pathogens in contaminated water, faecal bacteria are widely used worldwide as indicator to monitor surface water quality. Faecal bacteria are found to exist in estuarine and coastal waters in two forms, either free-living within the water column, or attached to suspended sediment particles. Free-living bacteria may adsorb onto the sediments, transforming to attached bacteria, and the attached bacteria can be desorbed from sediments becoming free-living bacteria. The free-living bacteria move with flow, whereas the attached bacteria move with suspended sediments, which may settle onto the riverbed or re-suspend into the water column. Besides carrying the attached bacteria, suspended sediments can affect light penetration rate in water column, which will further affect the decay rate of bacteria. Some modelling efforts have been made to simulate the fate of bacteria in surface waters. However, most of the previous work was based on the single-fraction (non-fractionated) sediment transport model, while various attachment abilities in terms of particle size were not taken into consideration. A two-dimensional depth-integrated numerical model was refined in this paper to simulate the hydrodynamics, graded sediment transport process and the fate of faecal bacteria in estuarine and coastal waters. The sediment mixture is divided into several fractions according to the grain size. A bed evolution model is adopted to simulate the processes of bed elevation change and sediment grain size sorting. The faecal bacteria transport equation includes enhanced source and sink terms to represent bacterial kinetic transformation and disappearance or reappearance due to sediment deposition or re-suspension. Dynamic decay rates of faecal bacteria and different partitioning ratios versus particle sizes are adopted in the numerical model. The model has been applied to the turbid water environment in the Bristol Channel and Severn estuary, UK. The predictions by present model are compared with field data and those by non-fractionated model.