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A new SPH scheme to model transport of chemotactic bacteria in porous media at the continuum scale

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As recently shown chemotaxis, i.e. the movement of microorganisms toward or away from the concentration gradient of a chemical species, could have a fundamental role in the transport of bacteria through saturated porous media. Chemotactic bacteria could enhance bioremediation by directing their own motions to residual contaminants in less conductive zones of aquifers. The aim of the present work is to develop a proper numerical scheme to define and to quantify the magnitude and the role of chemotaxis in the complex groundwater system framework. We present a new class of meshless Lagrangian particle methods based on the Smooth Particle Hydrodinamics (SPH) formulation of Vila & Ben Moussa, combined with a new Weighted Essentially Non-Oscillatory (WENO) reconstruction technique on moving point clouds in multiple space dimensions. The purpose of this new scheme is to fully exploit the advantages of SPH among traditional meshbased and meshfree schemes and to overcome its problems for modeling chemotaxis in porous media. We test the new scheme against analytical reference solutions and we show, under the assumption of complete mixing at the Darcy scale, that chemotaxis may significantly affect the quantification of field-scale bacterial distribution, therefore influencing reactive mixing and degradation of contaminants.