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Influence of surface water/groundwater interactions on stream and wetland water quality: analytical solutions for coupled contaminant transport equations

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Wetlands are located in transitional zones between uplands and downstream flooded systems and surface water/groundwater interactions are frequently observed especially in riparian wetlands where the water level fluctuates frequently during the rainy season. Moreover, surface water/groundwater interactions also influence the characteristics of contaminant transport in pools and riffles, and in meandering type of streams. Therefore, it is important to investigate and solve these processes accurately to improve the prediction of downstream water quality. Although there are many experimental and numerical studies available in the literature which discuss and model the surface water/ground water interactions in streams and wetlands, very few analytical solutions have been conducted. Analytical solutions are helpful tools for verification of numerical solutions and they provide fast and accurate results for practical problems. Furthermore, they provide an understanding to the influence of each parameter in hydrological and contaminant transport models for streams and wetlands. In order to contribute to the research in understanding the behavior of water quality in streams and wetlands, analytical solutions are developed for the coupled contaminant transport equations of several transient storage and wetland models. Among these models are the wetland model WETland Solute TrANsport Dynamics (WETSAND) developed by Kazezyilmaz-Alhan et al. (2007), the transient storage models developed by Bencala and Walters (1983), and Kazezyilmaz-Alhan and Medina (2006). WETSAND is a general comprehensive wetland model, which has both surface flow and solute transport components. In this wetland model, water quality components are solved by advection-dispersion-reaction equations which incorporate surface water/groundwater interactions by including the incoming/outgoing mass due to the groundwater recharge/discharge. The transient storage model developed by Bencala and Walters (1983) solves the contaminant distribution between main streams and stagnant zones. The transient storage is represented by the mass exchange due to the concentration difference between the stream and the storage zone in this model. The transient storage model developed by Kazezyilmaz-Alhan and Medina (2006) involves several improvements to the transient storage model of Bencala and Walters (1983): advection and dispersion processes are incorporated into the contaminant transport in hyporheic zone and the mass transport between the channel and hyporheic zone is represented by mass flux terms. The solutions of the governing equations are obtained for continuous source type of boundary conditions. Results show that analytical solutions are in good agreement with the numerical solutions.