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A Semi-Analytical Solution to Time Dependent Groundwater Flow Equation Incorporating Stream-Wetland-Aquifer Interactions

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Groundwater is a vital element of hydrologic cycle and the analytical & numerical solutions of different forms of groundwater flow equations play an important role in understanding the hydrological behavior of subsurface water. The interaction between groundwater and surface water bodies can be determined using these solutions. In this study, new hypothetical approaches are implemented to groundwater flow system in order to contribute to the studies on surface water/groundwater interactions. A time dependent problem is considered in a 2-dimensional stream-wetland-aquifer system. The sloped stream boundary is used to represent the interaction between stream and aquifer. The rest of the aquifer boundaries are assumed as no-flux boundary. In addition, a wetland is considered as a surface water body which lies over the whole aquifer. The effect of the interaction between the wetland and the aquifer is taken into account with a source/sink term in the groundwater flow equation and the interaction flow is calculated by using Darcy's approach. A semi-analytical solution is developed for the 2-dimensional groundwater flow equation in 5 steps. First, Laplace and Fourier cosine transforms are employed to obtain the general solution in Fourier and Laplace domain. Then, the initial and boundary conditions are applied to obtain the particular solution. Finally, inverse Fourier transform is carried out analytically and inverse Laplace transform is carried out numerically to obtain the final solution in space and time domain, respectively. In order to verify the semi-analytical solution, an explicit finite difference algorithm is developed and analytical and numerical solutions are compared for synthetic examples. The comparison of the analytical and numerical solutions shows that the analytical solution gives accurate results.