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Hydrodynamic influences of tidal fluctuations and beach slopes on benzene transport in unconfined, sandy costal aquifers

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Oil spills in oceans have led to severe environment and ecosystem problems due to high toxicity substances, large spatial extents, and long temporal durations. The BTEX compounds are key indexes generally used for identifications of such contamination events and also for quantifications of residual substances after remediations. Benzene is one of the BTEX compounds, which is recognized to be high toxicity and may threat near-shore ecosystem and human safety. Therefore, the understanding of benzene transport in costal aquifers is critical for predictions of contaminated zones and managements and organizations of remediation plans. In this study a numerical investigation was conducted to quantify the influence of tidal fluctuations and beach slopes on benzene transport in an unconfined coastal aquifer. More specifically, three different tidal amplitudes and three beach slopes were considered in the two-dimensional HYDROGEOCHEM model to characterize the spatial and temporal behavior of the benzene transport. Simulation results show that tidal fluctuations will lead to shallow seawater circulations near the ground surface where the high tides can reach periodically. Such local circulation flows will trap benzene plume and the plume may migrate to the deeper aquifer, depending on the amplitudes of tides and the surface slopes of the coastal lines. The sine curve tides with 0.5 m amplitudes will create circulation plume sizes of about 50m in length and 20m in depth, while the circulation plume sizes for tides with 1.0 m amplitudes will significantly increase to approximately 150 m in length and 60 m in depth. Additionally, double the beach slopes and keep the same tidal amplitude will lead to 40 m plume movement toward the land. The amplitude of tidal fluctuation is the key factor to decide when and where a benzene plume reaches a largest depth. In general, the plume with tidal amplitude of 0.5 m requires 50 days to reach 90% of the largest depth. However, the plume with tidal amplitude of 1.0 m requires 300 days to reach 90% of the largest depth. Same conclusions can be applied to evaluate the duration times for a benzene plume self-clean, when the benzene source on ground surface is removed.