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Publication date:
2016

Document Version
Peer reviewed version

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Citation (APA):

Grathwohl, P., Haberer, C., Ye, Y., Muniruzzaman, M., & Rolle, M. (2016). Diffusive-dispersive mass transfer in the capillary fringe: Impact of water table fluctuations and heterogeneities. Abstract from 9th International Association of Hydrological Sciences (IAHS) Groundwater Quality Conference (GQ16), Shenzhen, China.

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Diffusive-dispersive mass transfer in the capillary fringe: Impact of water table fluctuations and heterogeneities

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Diffusive–dispersive mass transfer in the capillary fringe is important for many groundwater quality issues such as transfer of volatile compounds into (and out of) the groundwater, the supply of oxygen for aerobic degradation of hydrocarbons as well as for precipitation of minerals (e.g. iron hydroxides). 2D-laboratory scale experiments were used to investigate the transfer of oxygen into groundwater under non-reactive and reactive conditions, at steady state and with water table fluctuations. Results show that transfer of oxygen is limited by transverse dispersion in the capillary fringe and the dispersion coefficients are the same as below the water table. Water table fluctuations cause temporarily increased fluxes of oxygen into groundwater during draining conditions and entrapped air after water table rise. High-permeability inclusions in the capillary fringe enhance mass transfer of oxygen to the underlying anoxic groundwater by increased dispersion due to flow focusing and by significant air trapping in the coarse material inclusions.