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Tracer test modeling for characterizing heterogeneity and local scale residence time distribution in an artificial recharge site.

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Artificial recharge of aquifers (AR) is a standard technique to replenish and enhance groundwater resources, that have widely been used due to the increasing demand of quality water. AR through infiltration basins consists on infiltrate surface water, that might be affected in more or less degree by treatment plant effluents, runoff and others undesirables water sources, into an aquifer. The water quality enhances during the passage through the soil and organic matter, nutrients, organic contaminants, and bacteria are reduced mainly due to biodegradation and adsorption. Therefore, one of the goals of AR is to ensure a good quality status of the aquifer even if lesser quality water is used for recharge.

Understand the behavior and transport of the potential contaminants is essential for an appropriate management of the artificial recharge system. The knowledge of the flux distribution around the recharge system and the relationship between the recharge system and the aquifer (area affected by the recharge, mixing ratios of recharged and native groundwater, travel times) is essential to achieve this goal. Evaluate the flux distribution is not always simple because the complexity and heterogeneity of natural systems. Indeed, it is not so much regulate by hydraulic conductivity of the different geological units as by their continuity and inter-connectivity particularly in the vertical direction. In summary for an appropriate management of an artificial recharge system it is needed to acknowledge the heterogeneity of the media.

Aiming at characterizing the residence time distribution (RTDs) of a pilot artificial recharge system and the extent to which heterogeneity affects RTDs, we performed and evaluated a pulse injection tracer test. The artificial recharge system was simulated as a multilayer model which was used to evaluate the measured breakthrough curves at six monitoring points. Flow and transport parameters were calibrated under two hypotheses. The first hypothesis considered a homogeneous medium where flow and transport parameters were constant for all layers. The second hypothesis considered heterogeneous media and thus parameters were different for each layer.

Heterogeneous model yielded to a better fit, measured as root mean square weighted error, of the measured tracer breakthrough curves. Both homogeneous and heterogeneous models reproduce the long tails observed in some observation points implying that the broad RTDs are caused not only by heterogeneity but also by the mean flow structure. We contend that it is this broad RTD, together with the sequence of redox states produced by our reactive layer, what explains the excellent behavior of the system in removing recalcitrant organic micropollutants.