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title: # Estimation of groundwater recharge in arid regions through unsaturated zone studies

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Semi-arid and arid regions represent 30% of global terestrial surface area expanding (Dregne, 1991). The above fact gives rise to the necessity for accurate determination of groundwater recharge; an issue of paramount importance for the "smart mining" of groundwater resources in such hydrologically sensitive regions. Scanlon et al. (2002) categories the main approaches for groundwater recharge estimation into: (a) surface water, (b) unsaturated zone and, (c) saturated zone studies.

This paper refers to the investigation of the soil moisture content profile within the unsaturated zone through field as well as lab techniques. The field techniques include in-situ measurements of the volumetric soil water content at different depths using Time Domain Reflectometry (TDR). TDR is a geophysical technique (Stacheder et al., 2009) based on the relation between the permittivity of soil and its volumetric water content. Robinson et al. (2003) quote that the majority of the reported case studies regard the installation of TDR equipment within a depth of 60–80 cm from the ground surface.

By applying advanced "direct-push" sounding methods, specially designed TDR sensors can installed at significant depths within the unsaturated zone, providing continuous readings of the soil moisture content. The investigation of the unsaturated zone is also complemented with the determination of the temperature profile for the unsaturated column.

Additionally, multilevel undisturbed soil sampling for the extraction of the containing pore water is applied for the dating of the groundwater through the determination of its isotopic composition. The determination of different isotopic signals such as $\delta^{18}O$, $\delta^{2}H$, ^{3}H, and ^{36}Cl, mainly aim to the investigation of groundwater transit times as well as preferential flow paths through the unsaturated zone. The unsaturated zone experiments are carried out at selected field sites in the Kingdom of Saudi Arabia, representing different potential groundwater recharge scenarios in arid regions. It is expected that the result will lead to a sufficient quantification of present and historic groundwater recharge in arid environments.

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