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Evaluation of chloride mass balance of pore water as an indicator of groundwater recharge to the Monterrey Metropolitan Area, Mexico

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Monterrey Metropolitan Area in Nuevo Leon, Mexico, is the third largest metropolitan area and one of the most important industrial sites of Mexico. Groundwater constitutes 40% of the water supply to this urban area. This supply is under constant stress due to the population increase. The unsaturated zone at six sites along two cross-sections was characterized to evaluate the potential of chloride concentration as an indicator of recharge. The selected sites include the range of topographic elevations, vegetation, and annual precipitation of the study area. In each site, boreholes up to 5 m deep were drilled and soil was sampled every 0.5 m. The grain size of each soil sample was determined and pore water extracted to determine the water content percentage, and the chloride, sulfate and nitrate concentration of the pore water. The undersaturated zone consists of alluvial deposits with an average gravel and sand content greater than 60% for all but one of the sampling sites. The pore water content varies from 0.4 to 25% by weight with a decreasing trend as depth increases in areas with agriculture. Sulfate has the highest anion concentration in the pore waters, ranging from 42 to 45,000 mg/L and no apparent distribution pattern along the soil profile columns. Chloride concentration ranges from 8 to 3600 mg/L with an increase in concentration below 1.5 m depth in all the profiles. Chloride and sulfate concentrations with depth are directly correlated suggesting a common input, possibly dissolution-precipitation of evaporite minerals from nearby outcrops or an anthropogenic input. Hence, it is unlikely that chloride behaves as a conservative ion. As a result, its concentration is not likely to be a good indicator of groundwater recharge. Finally; the nitrate concentration ranges from 2 to 96 mg/L nitrate, without a clear pattern along the soil profiles. Low concentration of nitrate in the soil profiles below agricultural areas may suggest denitrification as suggested by Pastén-Zapata et al. (2014) for the groundwater in the Citrícola Norte aquifer, south of the study area. Groundwater dating and the comparison of solute concentrations in pore and groundwater will further the understanding of the recharge in this urban area.