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Assessment of geochemical evolution of groundwater in a mountainous area under agricultural land

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Zona Citricola is an important area to Mexico for its citriculture. Situated in a sub-humid to humid climate adjacent to Sierra Madre Occidental, this mountainouos valley hosts an aquifer system which represents sequences of shales, marls, conglomerates, and alluvial deposits. Groundwater flows from mountainous recharge areas to the basin-fill deposits and provides base flow to supply drinking water to an adjacent metropolitan area. The objective of this study was to characterize groundwater chemistry of this area and to assess the evolution. Correlation and principal component analysis were used to decipher various underlying natural and anthropogenic processes creating distinct water classes: (1) dissolution of evaporates, (2) surface organic waste or wastewater, and (3) silicate weathering and clay formation. Hierarchical cluster analysis was employed for partitioning the water samples into four hydrochemical groups: recharge waters (Ca-HCO_3), transition zone waters (Ca-HCO_3-SO4 to Ca-SO4-HCO_3) and discharge waters (Ca-SO4). Inverse geochemical models of these groups were developed using PHREEQC to elucidate the chemical reactions controlling water chemistry between an initial (recharge) and final water. The main responsible reactions were: (1) dissolution of rock salts, (2) release of soil gas carbon dioxide, (3) dedolomitization,(4) albite weathering reactions with corresponding precipitation of silica and clay minerals, and (5) input from animal/human waste and manure, accompanied by denitrification processes. The hydrochemical groups could be related to lithological formations.