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Groundwater vulnerability mapping in Guadalajara aquifers system (Western Mexico)

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Groundwater vulnerability mapping is a practical tool to implement strategies for land-use planning and sustainable socioeconomic development coherent with groundwater protection. The objective of vulnerability mapping is to identify the most vulnerable zones of catchment areas and to provide criteria for protecting the groundwater used for drinking water supply. The delineation of protection zones in fractured aquifers is a challenging task due to the heterogeneity and anisotropy of hydraulic conductivities, which makes difficult prediction of groundwater flow organization and flow velocities.

Different methods of intrinsic groundwater vulnerability mapping were applied in the Atemajac-Toluquilla groundwater body, an aquifers system that covers around 1300 km^2. The aquifer supplies the 30% of urban water resources of the metropolitan area of Guadalajara (Mexico), where over 4.6 million people reside.

Study area is located in a complex neotectonic active volcanic region in the Santiago River Basin (Western Mexico), which influences the aquifer system underneath the city. Previous works have defined the flow dynamics and identified the origin of recharge. In addition, the mixture of fresh groundwater with hydrothermal and polluted waters have been estimated. Two main aquifers compose the multilayer system. The upper aquifer is unconfined and consists of sediments and pyroclastic materials. Recharge of this aquifer comes from rainwater and ascending vertical fluids from the lower aquifer. The lower aquifer consists of fractured basalts of Pliocene age. Formerly, the main water source has been the upper unit, which is a porous and unconsolidated unit, which acts as a semi-isotropic aquifer. Intense groundwater usage has resulted in lowering the water table in the upper aquifer. Therefore, the current groundwater extraction is carried out from the deeper aquifer and underlying bedrock units, where fracture flow predominates. Pollution indicators have been reported in some monitoring wells, which have been related to anthropogenic activity.

Vulnerability maps were produced using different parametric methods (e.g.: DRASTIC, GOD, DISCO, AVI), then the results are compared and assessed. Since each one of these methods use different number of parameters and weights, relatively different results were obtained, although the results have been evaluated with common cartographic inputs. The comparison between selected methods shows that the GOD method results are more correlated with the other methods and produces vulnerability maps comparable with them.

Even though groundwater vulnerability is a critical issue around the world, no protection zones have been delineated in Guadalajara city, one of the biggest in Latin America. The groundwater contamination in the study area poses a serious risk for a large population and the environment.

This work aims to propose an approach for groundwater protection cartography, based on the application and the comparison of results from different contamination vulnerability methods. These outcomes may assist water authorities to identify the higher vulnerable zones of the aquifers, in order to improving and adapting the land planning and management according to the protection of the own water resources.