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A spatial model of groundwater chemical composition in Slovenia in GIS environment

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Groundwater is a globally important, valuable and renewable resource. Its chemical status has a decisive influence on the applicability of groundwater as a drinking water resource and on the possibility of groundwater use for technological or recreational purposes. Chemical status also affects the function of groundwater as the maintaining agent of groundwater-dependent ecosystems. Groundwater chemical composition depends on numerous factors, natural as well as anthropogenic. The lithological composition of rocks in the precipitation infiltration area and in the aquifer is definitely one of the most important natural factors. Of course several other factors usually influence groundwater hydrochemical composition, e.g. climatic conditions in aquifer recharge area (amount of precipitation, mean annual temperature), type of vegetation cover and similar. Among anthropogenic influences, urbanization together with agricultural exploitation and various point source loads (municipal waste disposal facilities, industrial plants, sewer system and waste water treatment plant discharges). In spite of the large number of routine hydrochemical analyses of individual water sources, neither a comprehensive overview of groundwater hydrochemical properties nor a detailed interpretation of groundwater chemical composition, especially from the point of view of their origin, have been made in Slovenia.

Therefore the main aim of the research was to find and create the most appropriate algorithm of the spatial model for groundwater chemical composition in Slovenian aquifers, which will enable the prediction of natural chemical characteristics of groundwater in areas with heterogeneous geological structure. For this purpose, sampling for groundwater chemical (Ca^{2+}, Mg^{2+}, HCO_3^- and NO_3^-) and isotopic ($\delta^{18}O$) analysis was carried out at 86 sampling locations in various aquifers between 2009 and 2011. The basic sampling network was complemented by chemical data from 175 sampling points of the national groundwater quality monitoring conducted by the Slovenian Environmental Agency (SEA). A number of spatial data, i.e. the altitude and slope of the terrain, climate characteristics, lithological structure of the territory and land cover in the recharge areas of sampling points were used to produce thematic maps of groundwater chemical and isotopic composition. Three different methods, i.e. ordinary kriging, multiple linear regression, and artificial neural network - multilayer perceptron, were used to predict different chemical parameters in groundwater. In the preparation of thematic maps of isotopic composition of oxygen ($\delta^{18}O$) in groundwater also the general method of GIS modeling was used. The comparison between different models was made solely on the visual logical interpretation of models, as the process of individual methods had not been made under the same conditions. In predicting the spatial distribution of selected chemical and isotopic parameters in groundwater, the four mentioned modeling methods proved to be more or less successful, depending on the modeled chemical parameter in groundwater. According to the results of produced thematic maps, the spatial distribution of modeled parameters in groundwater, prepared with all four methods, is similar. Two methods, general GIS-modeling with incorporated altitude isotopic effect, and multiple linear regression, were found to be the most significant models for predicting the distribution of $\delta^{18}O$ in groundwater. Multiple linear regression

was identified as the most significant model for predicting the distribution of carbonate parameters (Ca^{2+}, HCO_3^-) in groundwater, while artificial neural network – multilayer perceptron shows the best results for Mg^{2+} prediction in groundwater. The most successful method for the prediction of NO_3^- in groundwater has proved to be multiple linear regression.