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Numerical model for mapping of complex hydrogeological conditions: the Chmielnik area (South Poland) case study

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Detailed analysis of hydrogeological conditions at a study area is the basis for characterising adjacent groundwater circulation systems. It is also an essential element during executing hydrogeological documentations.

The goal of this work was to reconstruct on a numerical model natural groundwater circulation systems of the studied area located within the municipality of Chmielnik in the region of Kielce (South Poland). The area is characterized by a complex geological structure, which along with the existing hydrographic network, makes the scheme of groundwater circulation complicated and difficult to map on a numerical model.

The studied area is situated at the border of three geological units: on the North - the extended portion of the Palaeozoic Swietokrzyskie Mountains (mainly Devonian and Permian), in the center - the S-W part of the Mesozoic Margin of the Swietokrzyskie Mountains, and on the South – a marginal zone of the Carpathian Foredeep. The whole area belongs to the Vistula river basin, and it includes catchments of its left tributaries: the Nida and Czarna Staszowska rivers.

Based on the collected field and archival hydrogeological, hydrological and sozological data a conceptual model was built, under which a numerical model of groundwater flow was developed using the specialized software - Visual MODFLOW. The numerical model maps the five-layer groundwater circulation system in conjunction with surface watercourses. Such division reflects appropriately the variability of hydrogeological parameters within the geological structures. Two principal and exploited aquifers comprise: a fractured-porous Neogene and fractured Upper Jurassic formations. The external model borders are based primarily on surface watercourses and locally on watersheds. The modelled area of 130 km^2 was divided into square grids of 50 m. The model consists of 275 rows and 277 columns. Each of five layers was simulated with the same number of active blocks. In the construction of the model boundary conditions of type: I, II and III were established. Data from of 36 groundwater observation points (hydrogeological boreholes and dug wells) measured in September 2015 were used to calibrate the model. The correlation coefficient of the model is 0,998. Two variants were simulated on the model: natural conditions (without water abstraction) and with groundwater exploitation (September 2015).

The carried out analysis of hydrogeological conditions and developed numerical model will be the basis for assessing the impact of a drainage of an open limestone pit mine realized in this area on the soil-water system and for designing a sustainable distribution system of mine waters to protect groundwater depending ecosystems.

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