Geophysical Research Abstracts
Vol. 15, EGU2013-5424, 2013
EGU General Assembly 2013

Dating of young groundwater using tritium and gaseous tracers (SF6, SF5CF3, CFC-12, H-1301): case study from southern Poland

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Groundwater is an important source of potable water in many countries. While it covers ca. 50% of the global drinking water needs, in Europe this share is even higher, reaching approximately 70%. Nowadays, this strategic resource is at risk due to anthropogenic pollutants of various nature entering shallow aquifers. Proper management of groundwater resources requires thorough understanding of groundwater dynamics on time scales characteristic for the history of pollutant input to groundwater.
The bomb-tritium has been used for several decades now as a tracer of choice to detect recent recharge and to quantify groundwater residence times on time scales extending from several years to several decades. The lumped-parameter modeling was the most often employed approach in this context. Since nowadays atmospheric concentrations of tritium are approaching natural levels in most parts of the world, the usage of this tracer has become more problematic. Therefore, there is a growing interest in alternative indicators of groundwater age in shallow aquifers. Anthropogenic trace gases present in the atmosphere, such as freons (CFC-11, CFC-12, CFC-113) and sulfur hexafluoride (SF6), have been applied in numerous case studies as substitutes of tritium.
Here we present the results of a comprehensive study aimed at quantifying mean residence time of groundwater in the recharge area of porous sandy aquifer system located in the southern Poland. The principal economic role of the aquifer, consisting of two water-bearing strata, is to provide potable water for public and private users. The yield of the aquifer is insufficient to meet all the needs and, as a consequence, licensing conflicts arise between water supply companies and industry on the amount of water available for safe exploitation.
To quantify residence time distribution (RTD) functions of water parcels arriving at the production wells located in the recharge area of the aquifer, tritium along with several gaseous tracers was employed. Apart of well-established tracers such as SF6 and CFC-12, also other trace gases present in the atmosphere (SF5CF3 and H-1301) were tested as age indicators of young groundwater. Time series of tracer concentrations in the sampled boreholes were interpreted with the aid of lumped-parameter models. In parallel, the arrival times of tracers to the selected wells were calculated with the aid of 3D flow and transport model available for the studied groundwater system and compared with the RTD functions obtained from lumped-parameter modeling.

Acknowledgements.
Partial financial support of this work through GENESIS project (http:/www.thegenesisproject.eu) funded by the European Commission 7FP contract 226536 and through the funds from the Polish Ministry of Science and High Education (projects Nr. N N525 362637 and 11.11.220.01) is kindly acknowledged.