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Better characterization of young and old groundwater systems through improved groundwater dating by isotope methods

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Increases in world population and water needs have led to greater demands on groundwater as a key resource to provide sufficient water to meet the growing needs for agricultural, industrial, and domestic purposes. Increasing groundwater withdrawals on shallow systems may have adverse effects such as decreases of baseflow in rivers, threatening the existence of wetlands or reducing water quality. In other cases, exploitation of fossil groundwater resources leads to marked lowering of the water table. To ensure a rational management of these resources and minimal long term negative effects, a clear understanding of the hydrological conditions in the area is required. Global climate change brings another factor to consider when planning future water requirements. For these reasons it is important to develop a more comprehensive and predictive understanding of aquifer systems, specifically the recharge rates, flow paths, and residence times of groundwater. Studies should aim to ensure accurate water resource assessments and the development of effective strategies for sustainable withdrawal and protection.

The assessment of aquifer systems under different climatic and geological conditions can be effectively conducted with isotope age dating of groundwater, which may be the only means of building relevant information in many instances. A lack of easy access to analytical facilities and discordant ages estimated from multiple isotope tracers have been two of the important impediments in the wider use of age dating tools.

The IAEA has recently established a helium/noble gas isotope facility to increase the availability of groundwater residence time data from shallow aquifers and river baseflow. A number of pilot studies have been conducted to demonstrate the value of the tritum-helium-3 dating technique for recently recharged groundwaters (< 50 years). In the case of large sedimentary aquifer systems, groundwater ages beyond the limit of radiocarbon are commonly found. The combined use of radioactive tracers such as carbon-14, chlorine-36 and krypton-81, and numerical hydrodynamic modelling showed inconsistencies in residence time estimates made before the extensive use of accelerator mass spectrometry (AMS) dating methods. Most of the inconsistencies in the use of radiocarbon were the result of contamination with atmospheric CO2 during sampling by the conventional precipitation method. Duplicate analysis of radiocarbon by both sampling methods in selected large aquifers showed consistent differences, up to 10 pMC. The lack of radiocarbon in some deep groundwaters has been confirmed by other long-lived radioisotopes. We have re-evaluated groundwater ages of several of these aquifers coupled with 3-D groundwater models. Our study has demonstrated the usefulness of conservative long-lived radioisotopes for assessing groundwater dynamics of large aquifers containing fossil groundwaters, such as the Nubian Sandstone Aquifer System in Africa and the Guarani aquifer in South America. This presentation will discuss these and related IAEA initiatives in the field of isotope age dating of both young and old groundwaters under various climatic conditions.