Chapter 4
Groundwater Resource Investigation Using Isotope Technology on River–Sea Systems

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ABSTRACT

The chapter presents a review of the case study by the implementation of the stable isotope technology for the evaluation of the water cycle and water resource formation in the transboundary region between Romania, Ukraine, and the Republic of Moldova under the impact of climate change. The groundwater is an especially important resource for sustainable development in this situation for the studied region. The isotope tools and related modeling approaches are particularly useful for the groundwater flow evaluation and determination of the recharge sources. The cooperation and synergism between existing European research infrastructure project IAEA technical cooperation projects are considered for the future development of this scientific direction in the Danube River basin and Black Sea region at all.

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INTRODUCTION

The East European region and Danube River Basin are important agricultural areas of Europe. However, this potential is not fully achieved due to historical, economic, and poorly understood hydroclimatic restrictions acting on a regional scale. Climate change is increasing the frequency and duration of droughts and has a strong impact on the water resources availability and economic development of this region. While soils are among the most fertile in Europe, the continental climate of these regions (with hot and dry summers, and an eastward increasing soil moisture deficit) add powerful constrains on the agricultural use of the land, sometimes with catastrophic crop failures (Ciscar et al., 2014; Climate change adaptation in the agriculture sector in Europe, 2019; Climate Change and Security in Eastern Europe, 2016). In this condition, water resources management is strongly needed to support agriculture productivity and country development. Many studies show that key hydrologic parameters such as streamflow, evaporation, snow storage, and soil moisture are sensitive to climatic variation (Clifton et al., 2018; Eckhardt & Ulbrich, 2003; Kristvik et al., 2018; Talib & Randhir, 2017). The use of groundwater resources for different purposes is a critical point for arid zones such as most countries of the Danube River basin.

The key issue in the assessment and management of groundwater resources in many parts of the world is an adequate knowledge of hydrogeology and hydrology, the quantification of residence groundwater time, recharge, groundwater contamination, and precipitation/evaporation rates. In arid and semi-arid regions, isotope techniques provide one of the best approaches that can be used to estimate recharge rate and thus provide critical information for the management and prevention of the over-exploitation of groundwater resources (International Atomic Energy Agency, 2001). Furthermore, they can be used to better understand their vulnerability to the pollution that may help to design adequate prevention and remediation strategies (International Atomic Energy Agency, 2001; International Atomic Energy Agency, 2009; International Atomic Energy Agency, 2013; International Atomic Energy Agency, 2013).

However, hydrogeological information about groundwater age, timing and mechanisms of groundwater recharge is not uniform for all countries in the Danube River basin. East European countries such as Romania, Bulgaria, Ukraine, and the Republic of Moldova have limited data for isotope composition of groundwater for the evaluation of water sources for irrigation (surface vs. ground) and scenarios of future water usage. In this case is important to study the water cycle through stable isotope analyses of precipitation, river and groundwaters. IAEA supported a regional project with several case studies (IAEA, n.d.), The aims of case study in the transboundary region of Romania, Bulgaria, Ukraine, and the Republic of Moldova are the determination of the sources of water (river, young and old groundwater) used for irrigation in the study area; analysis the recharge patterns of young groundwaters, determination of the age of old groundwaters. These results will form the backbone of a more comprehensive study that would help water administrators and local stakeholders plan the sustainable management of water resources.

The importance of the isotope studies was shown by ICPDR in past studies of Joint Danube Surveys (Joint Danube Survey 2, 2008; Joint Danube Survey 3, 2015; Joint Danube Survey 4, 2020). The streamflow of the Danube River was separated into three sectors after the stable isotope analysis in those surveys. However, the full water cycle was not studied in the complex as the interaction between precipitation – surface water – groundwater. The groundwater recharge of transboundary aquifers and other aspects of groundwater management (artificial recharge, contamination characteristic, etc.) using isotope technique can be studied by future research in the Danube River basin, especially in regions with water scarcity for different purposes.