PRELIMINARY FINDINGS OF A WATER ISOTOPE SURVEY IN EVROTAS RIVER BASIN

12th International Hydrogeological Conference
20-22 March 2022
Nicosia (Lefkosia)
Cyprus

MATIATOS I., DIMITRIOU I., PAPADOPOULOS A. and ARVANITIS P.
Hellenic Centre for Marine Research, 46.7 km of Athens-Sounio Ave., 19013, Anavissos Attikis, Greece
Contact: i.matiatos@hcmr.gr

Abstract

Water isotopes are powerful tools to trace sources of river water, hydrological processes, and assess the water balance of watersheds. The average $\delta^{18}O$ and $\delta^{2}H$ values in 5 monitoring points of the Evrotas River Basin (ERB) ranged from -5.9 ‰ to -7.1 ‰ and from -34.7 ‰ to -41.6 ‰, respectively. The *d*-excess values showed water vapor, and consequently precipitation input, originating from the Atlantic Ocean and the Mediterranean Sea, similar to rainwater and groundwater values recorded in the Molai region. The increasing pattern of $\delta^{18}O$ and $\delta^{2}H$ values from headwaters to the outlet of the Evrotas River coincided with a decreasing pattern in altitude. The seasonality of isotopic values was related to the seasonal effect on the isotopic composition of precipitation due to temperature. The isotopic composition of the river sites showed influenced from local precipitation and groundwater.

Introduction

The Evrotas River Basin (ERB) is located in south Peloponnese (Greece) (Fig. 1) and has a Mediterranean climate with mean annual precipitation and air temperature of ~800 mm and ~16°C, respectively. The ERB is covered by limestones, flysch and schists, and alluvial sediments. Parts of the Evrotas River dry out in summer or during long dry periods due to groundwater abstractions and river water infiltration into carbonate formations, such as in Vrontamas Gorge. The ERB is a complex hydrological system with perennial, intermittent, ephemeral and episodic river flows and interactions with groundwater in different parts of the basin.

The aim of this study was to improve understanding of hydrological pathways in the ERB by applying stable isotope tracers. This is the first systematic monitoring of the ERB for water isotopes, which was done under the framework of the International Atomic Energy Agency (IAEA) Global Network of Isotopes in Rivers (GNIR).

Fig. 1. Map of the study area.

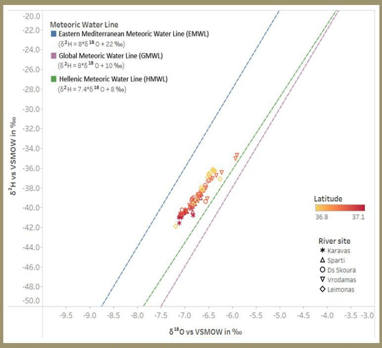
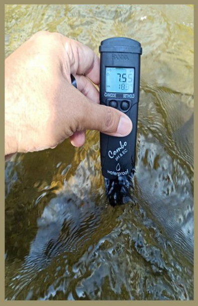
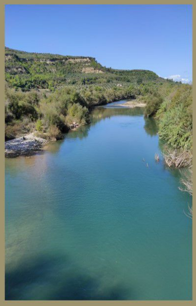


Fig. 2. $\delta^{18}O$ vs $\delta^{2}H$ plot depicting the river water samples.





Methods and Materials

The Evrotas Main River was systematically sampled at 5 monitoring points on a monthly basis in 2019–2021 (Fig. 1). The samples were analyzed for stable isotope ratios ($^{18}O/^{16}O$ and $^{2}H/^{1}H$) at the Isotope Hydrology Laboratory of the IAEA (Vienna, Austria) using a Los Gatos Research Liquid-Water Isotope Analyzer (TLWIA-912). The isotope values were expressed in delta (δ) units with a per mil (‰) notation relative to Vienna Standard Mean Ocean Water (VSMOW):

$$\delta_{sample} (‰) = \left(\frac{R_{sample}}{R_{VSMOW}} - 1\right) * 1000$$

where R_{sample} is the $^{18}O/^{16}O$ or $^{2}H/^{1}H$ ratio of the sample for $\delta^{18}O$ and $\delta^{2}H$, respectively. The analytical uncertainty was ±0.1 for $\delta^{18}O$ and ±0.5 for $\delta^{2}H$. The "deuterium excess" or "*d*-excess" was calculated as follows:

$$d\text{-excess} (‰) = \delta^{2}H - 8 * \delta^{18}O$$

Results & Discussion (I)

- The average $\delta^{18}O$ values in the ERB ranged from -5.9 ‰ to -7.1 ‰, while those of $\delta^{2}H$ ranged from -34.7 ‰ to -41.6 ‰ (Fig. 2).
- The isotopic values were similar to those reported in spring waters and groundwater of the Molai region.
- The river water samples were plotted between the EMWL and the HMWL indicating a meteoric origin.
- The slope of the regression line of the river water samples showed evaporative conditions, particularly during the summer season.
- The upstream site of Karavas showed lower average $\delta^{18}O$ and $\delta^{2}H$ values (-7.0 ‰ and -40.7 ‰, respectively) compared to the downstream site of Leimonas (-6.5 ‰ and -37.3 ‰, respectively).

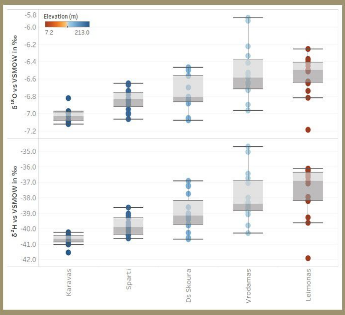


Fig. 3. Box plots of $\delta^{18}O$ and $\delta^{2}H$ values per monitoring site from headwaters (Karavas) to the outlet (Leimonas).

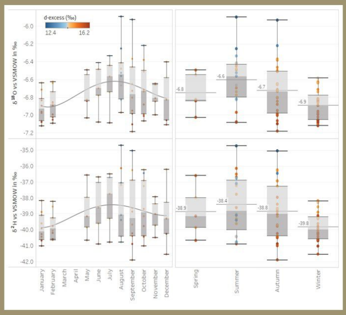


Fig. 4. Monthly and seasonal evolution of water isotope values in the ERB.

Results & Discussion (II)

- The Vrodamas site exhibited a wider range of $\delta^{18}O$ and $\delta^{2}H$ values compared to the Karavas site, which showed the contribution of waters of different origin (e.g., groundwater), apart from the local precipitation (Fig. 3).
- The $\delta^{18}O$ and $\delta^{2}H$ values showed a seasonal variation, with highest average values during summer months (-6.6 ‰ and -38.4 ‰, respectively) and lowest ones during winter months (-6.9 ‰ and -39.8 ‰, respectively) (Fig. 4).
- *d*-excess values ranged between +12.1 ‰ and +16.2 ‰ indicating water vapor originating from the Atlantic Ocean and the Mediterranean Sea.
- Precipitation data at the nearest meteorological stations of the IAEA's Global Network of Isotopes in Precipitation showed similar *d*-excess values at Methoni station, but lower at Patras station.
- Spring waters and groundwater from the Molai region showed a similar average *d*-excess value of +14.7 ‰, whereas rainwater sampled at the same region averaged a *d*-excess value of +16.5 ‰.

Conclusions

We presented the preliminary findings of the first systematic monitoring of water isotopes in the ERB and identified the meteoric origin of the river water, which is probably explained better by a Local Meteoric Water Line. The isotopic values ($\delta^{18}O$ and $\delta^{2}H$) were similar to those recorded in groundwater and rainwater in adjacent catchments. The spatial distribution of $\delta^{18}O$ and $\delta^{2}H$ indicated the altitude effect when moving from headwaters to the outlet. Larger variability of isotopic values per site showed contribution of waters of different origin, such as groundwater, apart from local precipitation. The temporal evolution of the isotopic values showed the influence of seasonality and evaporation processes during summer months.

Acknowledgments

The project was partly funded by the IAEA under contract #GRE24263.

References

1. Argiriou, A.A. and Lykoudis, S. (2006). Isotopic composition of precipitation in Greece. Journal of Hydrology, 327(3-4), pp.486-495.
2. Craig, H. (1961). Isotopic variations in meteoric waters. Science, 133(3465), pp.1702-1703.
3. Dansgaard, W. (1964). Stable isotopes in precipitation. Tellus, 16(4), pp.436-468.
4. Dotsika, E., Lykoudis, S. and Poutoukis, D. (2010). Spatial distribution of the isotopic composition of precipitation and spring water in Greece. Global and Planetary Change, 71(3-4), pp.141-149.
5. Gat, J.R. and Carmi, I. (1970). Evolution of the isotopic composition of atmospheric waters in the Mediterranean Sea area. Journal of Geophysical Research, 75(15), pp.3039-3048.
6. Karaouzas, I., Theodoropoulos, C., Vardakas, L., Zogaris, S. and Skoulikidis, N. (2017). The Evrotas River Basin: 10 years of ecological monitoring. In: The Rivers of Greece (pp. 279-326). Springer, Berlin, Heidelberg.
7. Kendall, C. and Coplen, T.B. (2001). Distribution of oxygen-18 and deuterium in river waters across the United States. Hydrological processes, 15(7), pp.1363-1393.
8. Leontiadis, J.L. (1981). Isotope hydrology study of Molai area in Laconia (No. DEMO--81/4). Democritos Nuclear Research Center.
9. Matiatos, I. and Wassenaar, L.I. (2019). Stable isotope patterns reveal widespread rainy-period-biased recharge in phreatic aquifers across Greece. Journal of Hydrology, 568, pp.1081-1092.