water

MDPI

*Supplementary Material*

# Regional Isotopic Signatures of Groundwater in Croatia

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**Table 1.** Stable isotope data of the karst groundwater: (a) The statistical data, (b) The single values.

| | | $\delta^{18}O$ (‰) | | | | $\delta^{2}H$ (‰) | | | | *d*-excess (‰) | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Sample ID** | **N** | **Min** | **Max** | **Mean** | **St. dev.** | **Min** | **Max** | **Mean** | **St. dev.** | **Mean** | **St. dev.** |
| Bubić jama | 2 | −6.3 | −6.1 | −6.2 | | −41.4 | −39.0 | −40.2 | | 9.5 | |
| Bulaž | 9 | −7.0 | −5.9 | −6.5 | 0.3 | −45.8 | −38.5 | −42.1 | 2.2 | 10.2 | 1.7 |
| Fonte Gajo | 2 | −6.3 | −5.9 | −6.1 | | −40.4 | −40.0 | −40.2 | | 8.6 | |
| Gradole | 9 | −6.6 | −6.3 | −6.4 | 0.1 | −45.5 | −38.9 | −41.2 | 1.8 | 10.4 | 1.1 |
| Rakonek | 2 | −6.6 | −6.5 | −6.6 | | −44.4 | −42.5 | −43.5 | | 9.1 | |
| Rudničke vode | 2 | −6.5 | −6.3 | −6.4 | | −42.5 | −39.1 | −40.8 | | 10.5 | |
| Sv. Ivan | 9 | −7.1 | −6.5 | −6.9 | 0.2 | −47.6 | −41.6 | −43.5 | 2.0 | 11.5 | 1.0 |
| Šišan | 2 | −5.9 | −5.7 | −5.8 | | −42.2 | −38.5 | −40.4 | | 6.0 | |
| Vela Učka | 2 | −8.2 | −8.2 | | | −56.9 | −53.1 | −55.0 | | 10.4 | 2.7 |
| Kristal | 7 | −6.7 | −2.7 | −5.5 | 1.3 | −40.5 | −17.2 | −34.0 | 8.0 | 9.7 | 2.8 |
| Rječina | 23 | −9.5 | −6.8 | −8.1 | 0.6 | −61.6 | −42.2 | −50.1 | 4.4 | 14.5 | 1.6 |
| Zvir | 23 | −8.6 | −7.1 | −7.9 | 0.4 | −54.9 | −42.9 | −49.4 | 3.8 | 14.0 | 1.4 |
| Martinščica | 5 | −8.1 | −8.1 | | | −53.2 | −51.3 | −52.4 | 0.8 | 12.3 | 1.0 |
| Perilo | 4 | −8.2 | −7.9 | −8.0 | 0.2 | −52.9 | −49.2 | −51.3 | 1.9 | 13.3 | 1.0 |
| Novljanska Žrnovnica | 6 | −8.9 | −7.9 | −8.6 | 0.3 | −58.7 | −50.3 | −55.9 | 3.0 | 13.2 | 1.0 |
| Čabranka | 10 | −9.2 | −8.2 | −8.8 | 0.3 | −60.4 | −52.1 | −58.3 | 2.6 | 12.0 | 1.2 |
| Kupa | 5 | −8.3 | −7.6 | −7.9 | 0.3 | −52.8 | −50.5 | −51.7 | 0.9 | 11.5 | 1.6 |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Kupica | 5 | −8.9 | −8.0 | −8.4 | 0.4 | −57.4 | −53.2 | −54.7 | 1.7 | 12.3 | 2.0 |
| Kupari | 5 | −8.3 | −7.5 | −7.9 | 0.3 | −52.6 | −49.9 | −51.0 | 1.1 | 11.8 | 1.6 |
| Mala Belica | 5 | −8.6 | −7.6 | −8.1 | 0.4 | −53.6 | −48.1 | −51.3 | 2.3 | 13.7 | 4.3 |
| Velika Belica | 4 | −8.1 | −7.5 | −7.9 | 0.3 | −50.4 | −48.1 | −48.9 | 1.1 | 13.9 | 2.9 |
| Zeleni vir | 5 | −9.5 | −8.8 | −9.2 | 0.3 | −66.4 | −57.5 | −62.4 | 4.3 | 11.3 | 2.2 |
| Gerovčica spring | 5 | −8.4 | −7.8 | −8.0 | 0.2 | −53.6 | −49.8 | −50.9 | 1.6 | 13.1 | 2.0 |
| Majerovo vrelo | 28 | −10.2 | −9.8 | −10.0 | 0.1 | −71.1 | −64.2 | −67.6 | 1.6 | 12.8 | 1.7 |
| Tonkovića vrelo | 27 | −9.9 | −9.1 | −9.3 | 0.2 | −65.2 | −58.6 | −61.4 | 1.9 | 13.4 | 1.2 |
| Pećina | 29 | −9.4 | −8.7 | −8.9 | 0.2 | −61.6 | −56.4 | −58.8 | 1.1 | 12.7 | 1.4 |
| Klanjac | 14 | −10.0 | −9.0 | −9.6 | 0.3 | −66.3 | −60.5 | −63.5 | 2.0 | 13.4 | 0.8 |
| Grab | 10 | −9.5 | −9.0 | −9.3 | 0.2 | −61.4 | −58.2 | −59.8 | 1.0 | 14.4 | 0.9 |
| Jaz | 10 | −9.6 | −9.0 | −9.3 | 0.2 | −60.8 | −58.3 | −59.8 | 0.9 | 14.6 | 1.2 |
| Knjapovac | 13 | −9.5 | −9.0 | −9.2 | 0.1 | −62.1 | −58.1 | −60.0 | 1.5 | 14.0 | 1.3 |
| Marusino vrelo | 14 | −9.5 | −9.0 | −9.3 | 0.2 | −61.2 | −58.9 | −59.9 | 0.9 | 14.4 | 1.4 |
| Malo vrelo Ličke Jesenice | 3 | −11.1 | −10.2 | −10.5 | 0.2 | −73.4 | −67.6 | −69.6 | 3.2 | 15.4 | 1.1 |
| Veliko vrelo Ličke Jesenice | 3 | −11.2 | −10.3 | −10.7 | 0.4 | −73.8 | −67.0 | −69.7 | 3.6 | 16.1 | 0.7 |
| Jadro | 4 | −7.6 | −7.1 | −7.4 | 0.2 | −49.5 | −43.9 | −46.3 | 2.5 | 12.7 | 0.8 |
| Žrnovica | 4 | −7.7 | −7.0 | −7.4 | 0.3 | −48.2 | −39.7 | −45.5 | 4.0 | 13.8 | 2.2 |
| B−22A | 4 | −6.8 | −6.8 | | | −43.7 | −41.6 | −42.4 | 0.9 | 11.9 | 0.8 |
| Modro oko | 2 | −6.7 | −6.7 | | | −47.5 | −40.6 | −44.1 | | 9.7 | |
| Opačac | 2 | −8.5 | −8.3 | −8.4 | | −58.0 | −54.6 | −56.3 | | 10.7 | |

(a)

| **Sample ID** | **N** | **$\delta^{18}$O (‰)** | **$\delta^{2}$H (‰)** | ***d*-excess (‰)** |
|---|---|---|---|---|
| Funtana | 1 | −5.7 | −37.1 | 8.6 |
| Karpi | 1 | −6.4 | −41.7 | 9.8 |
| Gomirje | 1 | −9.0 | −60.2 | 11.9 |
| Mala Lešnica | 1 | −9.2 | −59.8 | 13.6 |
| Vitunjčica | 1 | −8.7 | −57.6 | 12.2 |
| Kamačnik | 1 | −9.0 | −60.8 | 11.5 |
| Koreničke Rijeka spring | 1 | −10.9 | −71.9 | 14.9 |
| Kameniti vrelac | 1 | −10.2 | −67.9 | 13.9 |
| Koreničko vrelo | 1 | −10.3 | −67.1 | 15.3 |

| | | | | |
|---|---|---|---|---|
| Makarevo vrelo | 1 | −10.5 | −71.2 | 12.7 |
| Mlinac | 1 | −10.5 | −69.6 | 14.1 |
| Stipinovac | 1 | −10.2 | −67.6 | 14.1 |
| Vrulja Modrč | 1 | | | |
| Vrilo Velebita | 1 | −8.2 | −51.7 | 13.8 |
| Krka | 1 | −8.7 | −55.4 | 14.1 |
| Lopuško vrelo | 1 | −7.1 | −45.5 | 11.5 |
| Kosovčice spring | 1 | −7.2 | −47.6 | 10.2 |

(b)

**Table S2.** Stable isotope data of groundwater in the Pannonian part of Croatia: (**a**) The statistical data, (**b**) The single values.

| | | $\delta^{18}O$ (‰) | | | | $\delta^{2}H$ (‰) | | | | *d*-excess (‰) | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Sampe ID** | **N** | **Min** | **Max** | **Mean** | **St. dev.** | **Min** | **Max** | **Mean** | **St. dev.** | **Mean** | **St. dev.** |
| ČDP-9/1 | 7 | −9.2 | −9.0 | −9.1 | 0.06 | −64.3 | −61.1 | −62.6 | 1.1 | 10.2 | 0.8 |
| ČDP-9/2 | 7 | −8.9 | −8.8 | −8.9 | 0.04 | −63.5 | −57.1 | −59.1 | 2.1 | 12.0 | 2.1 |
| ČDP-9/3 | 7 | −8.9 | −8.7 | −8.8 | 0.08 | −61.8 | −57.9 | −59.5 | 1.3 | 11.1 | 1.5 |
| ČDP-23/1 | 7 | −9.6 | −9.4 | −9.5 | 0.04 | −66.0 | −64.1 | −65.1 | 0.6 | 10.8 | 0.6 |
| ČDP-23/2 | 7 | −9.5 | −9.4 | −9.4 | 0.03 | −67.1 | −63.3 | −64.9 | 1.4 | 10.5 | 1.4 |
| ČDP-23/3 | 7 | −9.2 | −9.1 | −9.1 | 0.02 | −63.6 | −61.0 | −62.7 | 1.0 | 10.5 | 0.9 |
| PP-18/20 | 3 | −8.6 | −8.2 | −8.4 | 0.21 | −60.7 | −55.0 | −58.2 | 2.9 | 8.7 | 1.3 |
| PP-18/40 | 3 | −8.9 | −8.6 | −8.8 | 0.18 | −60.6 | −59.0 | −60.0 | 0.9 | 10.3 | 0.6 |
| PP-18/90 | 3 | −9.5 | −9.5 | −9.5 | 0.01 | −65.2 | −64.5 | −64.8 | 0.4 | 11.2 | 0.4 |
| JP-10 | 4 | −9.1 | −8.9 | −9.0 | 0.09 | −63.1 | −59.5 | −60.9 | 1.7 | 11.1 | 1.8 |
| GP-1D | 7 | −9.8 | −9.8 | −9.8 | 0.01 | −67.4 | −65.7 | −66.9 | 0.6 | 11.6 | 0.6 |
| KP-12A | 11 | −9.7 | −9.7 | −9.7 | 0.02 | −67.1 | −64.8 | −65.8 | 0.7 | 11.6 | 0.7 |
| KP-12 | 12 | −10.1 | −10.0 | −10.1 | 0.02 | −70.0 | −68.2 | −69.0 | 0.6 | 11.5 | 0.6 |
| SO-1 | 12 | −9.2 | −9.2 | −9.2 | 0.02 | −63.7 | −62.3 | −62.8 | 0.4 | 10.7 | 0.4 |
| O-6 | 12 | −9.2 | −8.9 | −9.1 | 0.18 | −63.0 | −60.7 | −62.0 | 0.7 | 10.7 | 0.2 |
| VIRJE | 12 | −9.5 | −9.4 | −9.5 | 0.03 | −65.3 | −63.5 | −64.4 | 0.5 | 11.3 | 0.5 |
| SPB-8 | 11 | −10.0 | −10.0 | −10.0 | 0.01 | −68.7 | −68.0 | −68.4 | 0.3 | 11.5 | 0.3 |
| SPB-10 | 7 | −9.9 | −9.8 | −9.9 | 0.02 | −68.7 | −65.5 | −67.2 | 1.0 | 11.7 | 0.9 |
| ĐN-3 | 7 | −9.9 | −9.7 | −9.9 | 0.17 | −68.2 | −65.2 | −67.2 | 1.1 | 11.6 | 1.0 |
| SPB-4 | 17 | −10.2 | −10.1 | −10.1 | 0.03 | −70.5 | −68.8 | −69.5 | 0.5 | 11.4 | 0.4 |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| SPB-9 | 17 | −10.2 | −10.1 | −10.1 | 0.03 | −70.3 | −69.0 | −69.8 | 0.3 | 11.4 | 0.3 |
| SPB-7 | 17 | −10.2 | −10.1 | −10.2 | 0.03 | −70.6 | −69.2 | −69.8 | 0.4 | 11.4 | 0.4 |
| V-13 | 17 | −10.2 | −10.0 | −10.1 | 0.05 | −71.3 | −69.5 | −70.2 | 0.5 | 10.4 | 0.3 |
| SPBPv | 4 | −9.8 | −9.5 | −9.66 | 0.13 | −66.3 | −64.6 | −65.6 | 0.7 | 11.7 | 0.4 |
| B-1 | 4 | −10.0 | −9.5 | −9.69 | 0.21 | −67.6 | −63.1 | −65.6 | 1.9 | 11.9 | 1.9 |
| B-2 | 4 | −10.0 | −9.5 | −9.68 | 0.23 | −68.5 | −64.3 | −66.3 | 1.9 | 11.2 | 1.5 |
| B-3 | 4 | −9.9 | −9.6 | −9.76 | 0.13 | −67.7 | −64.7 | −66.2 | 1.6 | 11.9 | 1.7 |
| Bojanića vrelo | 4 | −10.1 | −9.7 | −9.85 | 0.18 | −69.1 | −65.6 | −67.0 | 1.7 | 11.8 | 0.5 |
| Grabovac | 4 | −10.2 | −9.9 | −10.04 | 0.11 | −68.8 | −67.4 | −68.2 | 0.6 | 12.1 | 1.5 |
| Pašino vrelo | 4 | −9.6 | −9.5 | −9.58 | 0.06 | −67.7 | −63.7 | −65.4 | 1.7 | 11.2 | 2.1 |

(a)

| **Sample ID** | **N** | **$\delta^{18}O$ (‰)** | **$\delta^{2}H$ (‰)** | ***d*–excess (‰)** |
|---|---|---|---|---|
| Veličanka | 1 | −10.7 | −75.0 | 10.9 |
| Dubočanka | 1 | −10.3 | −70.4 | 13.3 |
| Tisovac I | 1 | −11.0 | −74.3 | 10.5 |
| Tisovac II | 1 | −10.8 | −76.0 | 10.6 |
| Tisovac III | 1 | −10.0 | −69.6 | 12.3 |

(b)

**Table S3.** Tritium activity data (TU) in the karst groundwater: (**a**) The statistical values, (**b**) The single values.

| **Sample ID** | **N** | **Min** | **Max** | **Mean** | **Stan. dev.** |
|---|---|---|---|---|---|
| Bubić jama | 2 | 4.3 | 5.0 | 4.7 | |
| Bulaž | 7 | 6.3 | 12.9 | 8.5 | 2.3 |
| Fonte Gajo | 2 | 4.8 | 9.3 | 7.0 | |
| Gradole | 7 | 5.3 | 10.5 | 7.4 | 2.0 |
| Rakonek | 2 | 4.9 | 6.0 | 5.5 | |
| Rudničke vode | 2 | 2.9 | 6.2 | 4.5 | |
| Sv. Ivan | 7 | 5.0 | 13.0 | 8.8 | 2.9 |
| Šišan | 2 | 4.7 | 15.3 | 10.0 | |
| Funtana | 2 | 2.1 | 8.5 | 5.3 | |

| | | | | | |
|---|---|---|---|---|---|
| Karpi | 2 | 3.5 | 9.7 | 6.6 | |
| Martinščica | 4 | 4.2 | 6.4 | 5.5 | 1.0 |
| Perilo | 4 | 6.6 | 8.1 | 7.2 | 0.7 |
| Vela Učka | 2 | 2.1 | 7.2 | 4.6 | |
| Kristal | 7 | 3.3 | 12.9 | 7.0 | 3.3 |
| Rječina | 12 | 3.5 | 13.7 | 7.9 | 3.8 |
| Zvir | 13 | 4.3 | 14.8 | 8.3 | 2.9 |
| Čabranka | 10 | 4.2 | 14.2 | 9.0 | 3.1 |
| Kupa | 5 | 4.6 | 9.3 | 6.5 | 1.8 |
| Kupica | 5 | 5.4 | 11.3 | 7.1 | 2.8 |
| Kupari | 5 | 5.1 | 8.0 | 6.3 | 1.2 |
| Mala Belica | 5 | 5.5 | 11.5 | 8.6 | 2.8 |
| Velika Belica | 4 | 5.1 | 14.3 | 10.6 | 4.5 |
| Zeleni vir | 5 | 3.3 | 11.2 | 6.8 | 3.4 |
| Gerovčica spring | 5 | 6.8 | 14.3 | 9.9 | 2.9 |
| Majerovo vrelo | 21 | 3.2 | 10.0 | 6.3 | 2.0 |
| Tonkovića vrelo | 18 | 3.7 | 19.2 | 6.9 | 3.6 |
| Pećina | 21 | 2.4 | 9.2 | 5.7 | 2.1 |
| Novljanska Žrnovnica | 4 | 4.6 | 9.9 | 6.7 | 2.4 |
| Malo vrelo Ličke Jesenice | 3 | 2.4 | 6.0 | 4.1 | 1.8 |
| Veliko vrelo Ličke Jesenice | 3 | 2.4 | 5.8 | 4.1 | 1.7 |
| Jadro | 4 | 3.3 | 15.3 | 8.0 | 5.5 |
| Žrnovica | 4 | 3.3 | 8.3 | 5.9 | 2.5 |
| B–22A | 4 | 4.7 | 6.3 | 5.3 | 0.9 |

(a)

| **Sample ID** | **N** | **$^{3}$H (TU)** |
|---|---|---|
| Korenička rijeka spring | 1 | 6.5 |

| | | |
|---|---|---|
| Kameniti vrelac | 1 | 5.7 |
| Koreničko vrelo | 1 | 3.7 |
| Makarevo vrelo | 1 | 7.4 |
| Mlinac | 1 | 7.4 |
| Stipinovac | 1 | 4.9 |
| Krka | 1 | 4.8 |
| Lopuško vrelo | 1 | 7.9 |
| Kosovčica spring | 1 | 8.3 |

(b)

**Table S4.** Tritium activity data (TU) in the groundwater in the Pannonian part of Croatia: (**a**) The statistical values, (**b**) The single values.

| Sample ID | N | Min | Max | Mean | St. dev. |
|---|---|---|---|---|---|
| ČDP-9/1 | 7 | 9.2 | 24 | 17.0 | 5.0 |
| ČDP-9/2 | 7 | 7.9 | 20.5 | 14.8 | 4.6 |
| ČDP-9/3 | 7 | 6.1 | 25.2 | 14.9 | 6.9 |
| ČDP-23/1 | 7 | 17.6 | 36.9 | 22.8 | 6.9 |
| ČDP-23/2 | 7 | 13.8 | 25.2 | 18.1 | 4.3 |
| ČDP-23/3 | 7 | 9.1 | 18.2 | 14.2 | 3.1 |
| PP-18/20 | 7 | 20.0 | 23.8 | 21.7 | 23.8 |
| PP-18/40 | 7 | 14.1 | 34.7 | 24.6 | 34.7 |
| PP-18/90 | 7 | 17.1 | 23.7 | 21.5 | 23.7 |
| JP-10 | 7 | 27.7 | 39.1 | 32.7 | 5.0 |
| SPB-J | 2 | 1.6 | 1.9 | 1.8 | |
| KP-12 | 2 | 3.7 | 3.9 | 3.8 | |
| KP-12A | 2 | 5.0 | 6.5 | 5.8 | |
| SPB-8 | 2 | 1.3 | 1.9 | 1.6 | |
| SO-1 | 2 | 5.9 | 6.0 | 6.0 | |
| Banovina-wells | 4 | 4.8 | 8.4 | 6.2 | 1.6 |
| Banovina -springs | 3 | 4.1 | 9.5 | 7.1 | 2.8 |
| Dubočanka | 3 | 5.8 | 14.8 | 8.8 | 5.2 |
| Tisovac I | 3 | 5.4 | 8.0 | 6.4 | 1.4 |
| Tisovac II | 3 | 5.2 | 18.2 | 9.6 | 7.4 |

| | | | | | |
|---|---|---|---|---|---|
| Tisovac III | 3 | 4.3 | 9.7 | 6.2 | 3.0 |
| Sub−thermal spring | 2 | 0.9 | 1.1 | 1.0 | |

(a)

| **Sample ID** | **N** | **$^{3}$H (TU)** |
|---|---|---|
| SPB−7 | 1 | <0.5 |
| V−13 | 1 | 4.9 |
| LO−1 | 1 | <0.5 |
| LO−4 | 1 | 2.0 |
| LO−5 | 1 | <0.5 |
| Škrabutnik | 1 | 6.2 |

(b)