

Article

Distribution of Natural Trace Elements in the Drinking Water Sources of Hungary

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Abstract: Source water quality is a key determinant of drinking water quality. The recast European Union 2020/2184 Drinking Water Directive (DWD) introduced the obligation for comprehensive risk assessment in drinking water supplies, including hazard assessment of the water source. The DWD also requires further elements of natural origin to be monitored, including U, Ca, Mg and K. The current study is the first comprehensive assessment of 15 natural elements (B, Ba, Be, Ca, Co, K, Li, Mg, Mo, Na, Se, Sr, Ti, U and V) in 1155 (82%) Hungarian drinking water sources, including surface water, bank filtered and groundwater sources. Parameters posing a risk to health (Se, V and U) were typically below the limit of quantification (LOQ), but higher concentrations (max. 7.0, 17 and 41 µg/L, respectively) may occur in confined locations. U exceeded the DWD parametric value in one water supply. Mg and Ca in the majority of the water supplies and Li in a small geographic area reached the concentration range assumed to be protective to health. Water sources were grouped in six clusters based on their elemental distribution, some of them also showing clear geographical patterns. Surface and groundwater sources were not differentiated by composition, with the exception of karstic waters (dominated by Ca and Mg). None of the investigated parameters are expected to be a source of public health concern on a national level, but local occurrences of U and Se should be investigated and managed on a case-by-case basis.

Keywords: drinking water source; natural elements; uranium; water quality



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1. Introduction

A risk-based approach to drinking water safety is endorsed worldwide to complement traditional endpoint monitoring. Monitoring at the tap is still an indispensable element of drinking water control but it shifts from being the primary means of safeguarding drinking water quality towards becoming a tool for validating water safety plans (or similar frameworks). The recent recast of the European Union (EU) 2020/2184 Drinking Water Directive (DWD) introduced for the first time the obligation of risk assessment for the entire water supply chain [1]. As drinking water quality is strongly influenced by the water source composition, a better understanding of source water quality and the associated hazards are the cornerstones of a risk-based approach [2]. Hazard assessment of the catchments of drinking water abstraction points is also a requirement under the DWD [1].

Drinking water quality regulations addressing source water-derived parameters generally focus on anthropogenic pollutants and a few geological compounds of recognized health impact, such as arsenic. Monitoring requirements under the former EU regulation

followed the same approach, focusing mainly on heavy metals associated with human pollution (e.g., mercury, lead, cadmium, chromium or nickel) [3]. The number of geogenic pollutants for which substantial monitoring data is available in the EU is limited, comprising generally of arsenic, selenium, boron and fluoride, though national legislations may include additional parameters. The recast DWD extended monitoring requirements (starting from 2026) to new components, including metals of health relevance. Uranium was added with a parametric value of 30 µg/L following the recommendation of the World Health Organization (WHO) [4]. Calcium, potassium and magnesium were also included in the list of parameters to be monitored, but only for consumer information, and no parametric values have been assigned [1].

The newly introduced natural elements have a confirmed or presumptive impact on human health. Uranium is a nephrotoxic pollutant of primarily geological origin [4,5]. Its concentration in natural waters is usually low (<1.0 µg/L), but depending on the geology of the source (e.g., the presence of uranium-rich granite) and the mobilizing capacity of groundwater flow systems, high concentrations can also occur in certain areas (up to 57 µg/L in Mongolia, 85 µg/L in Italy, 288 µg/L in China, 589 µg/L in India and 750 µg/L in Norway) [6–11].

Potassium, calcium and magnesium are essential elements. Potassium concentrations also vary widely in natural waters, but the concentrations present in drinking water are generally not a risk to human health and may be of significance only for sensitive individuals (e.g., those suffering from renal failure) [4]. The inverse association between drinking water hardness (composed of magnesium and calcium salts) and cardiovascular mortality is well established. The protective effect was linked to magnesium, while further evidence is necessary for calcium [12–15]. Low magnesium and calcium intake via drinking water have also been associated with high blood pressure, metabolic syndrome, preeclampsia and amyotrophic sclerosis [16]. For these elements, prior data is scarce, though many jurisdictions, including the Hungarian, require monitoring of total hardness. Direct measurement of magnesium and calcium can support such ecological epidemiology studies.

Vanadium is not regulated by the DWD, but some EU member states include it in national legislation, e.g., Italy, with a parametric value of 140 µg/L [11]. The health effects of vanadium are unclear; both therapeutic and toxic effects are stipulated (e.g., on bone, the cardiovascular system, neurology, the immune system and body weight) [17,18]. Its concentration varies over a wide range in surface waters (0.010 µg/L to 68 µg/L), reaching even higher levels in groundwaters, especially in volcanic areas (up to 350 µg/L) [11,19]. The concentration of lithium in drinking water in European countries ranged from <1 µg/L to 20–60 µg/L in northern England, Lithuania and Italy [20–22], over 100 µg/L in Greece [23] and more than 1000 µg/L in Austria [24]. Under unique geological circumstances, extreme enrichment is (up to 590 mg/L) is also possible in surface water [25]. Several studies have found a protective association between lithium in drinking water and suicide mortality [21,24,26–29]. Li is not regulated in the EU or national jurisdictions.

Molybdenum and selenium are essential elements. The optimal range of Se intake is narrow. Selenium deficiency has been associated with cardiomyopathy and joint disease, while symptoms of selenosis include brittle hair and hair loss, nail malformation and diarrhea [30]. The parametric value of Se has been increased from 10 to 20 µg/L during the recast, based on recent scientific evidence [1,31]. The WHO guideline value is 40 µg/L. Environmental concentrations are generally well below 10 µg/L and the primary source of intake is typically via diet [4,32], except in a few seleniferous areas. The concentration of Mo in drinking water is typically low (<10 µg/L), although near mining areas, this value can be much higher (>200 µg/L). The recommended health-based guideline value from the WHO is 70 µg/L. In Hungary, the primary source of drinking water is groundwater (93% of total production volume), including 31% from bank-filtered water and a smaller proportion of karst water (12%). Surface water accounts for only 7% of the water supply [33]. There are 1403 public utility water supply systems registered in the National Drinking Water Database, operated by 38 water suppliers. Of these systems, 36 supplies use mainly bank

filtration, 116 use karst water and 1201 use other groundwater sources, while 22 rely on surface water abstraction. Drinking water quality is regularly monitored by the water suppliers and the local public health authorities. Monitoring does not cover elements of natural origin beyond the EU DWD requirements, although total hardness is regulated as an indicator parameter (acceptable range: 50–350 mg/L CaO equivalent). Drinking water in Hungary is typically moderately hard (between 100 and 200 mg CaO/L) or hard (>200 mg CaO/L), with total hardness ranging from <1.0 to 393 mg CaO/L [30]. For other unregulated elements, only local studies are available. Previous targeted investigations detected uranium in concentrations up to 25 µg/L in some drinking water sources in Hungary, though not exceeding the new parametric value [34–37].

The present study was the first nationwide survey mapping the presence and distribution of (previously) unregulated elements of natural origin in Hungarian drinking water sources. We have selected components of recognized or stipulated health impact (either positive or negative) but omitted those where extensive prior data were already available (such as arsenic). The objective was to evaluate if any of the elements are a hazard for drinking water production and require further attention in the risk assessment (water safety planning) on a national or local scale. Our hypothesis was that no major health hazard was previously overlooked, but the beneficial health impact of drinking water consumption can be confirmed. We also aimed to identify if the observed distribution of the elements was associated with the water source type or the geographical location of the water supply, reflecting differences in (hydro)geological factors. The survey outcomes provide representative data for ecological epidemiology studies assessing potential health risks or gains associated with these compounds in drinking water.

2. Materials and Methods

2.1. Study Design

The survey was initiated by the National Center for Public and Pharmacy (NCPHP) as the national regulatory authority. All public utility drinking water suppliers were invited to participate. Participation was voluntary. Water suppliers responding positively received sample containers, instructions for sampling, and a data sheet to be completed during sampling. The sampling data sheet recorded the date and exact location of sampling, the type of raw water (surface, deep groundwater (second or deeper aquifer or depth > 50 m), shallow groundwater (from the first aquifer or depth < 50 m), karst, bank-filtered, other/mixed) and information on water treatment and disinfection.

2.2. Sampling

Water samples were collected between March 2018 and June 2022 by the personnel of the drinking water supplies. At least one source water sample was provided from each water supply. Water suppliers were instructed to take a sample representative of the source water composition before water treatment. From water supplies with multiple abstraction points, either a representative subset of the wells or mixed well water representing normal operation were sampled. Samples from water supplies using surface water abstraction were collected after abstraction and mechanical filtration (i.e., removal of debris). Samples from water supplies using bank filtration were taken from selected bank filtration wells or their mixed water. Most water supplies were sampled twice in the sampling period. Samples were collected in 50 mL PP centrifuge tubes, and the pH of the samples was reduced below 2 with high purity (trace element analysis grade) nitric acid for preservation (ISO 5667-11:2009). The samples were transported to the laboratory of the NCPHP and stored at room temperature until analysis within 30 days [38].

2.3. Chemical Analysis

The elements were analyzed by inductively coupled plasma source mass spectrometry (ICP-MS) ((iCAP RQ, Thermo Fisher Scientific, Waltham, MA, USA) according to ISO 17294-2:2016 [39]. Calibration solutions of the elements were prepared from 1000 mg/L

certified standards on each measurement day. The instrument was calibrated on each measurement day and the calibration was validated after every 12th sample using a multi-element certified reference material. For ICP-MS analysis, a helium collision gas was used to reduce interferences and improve the accuracy of the analysis by facilitating dissociation of the polyatomic interferences and reducing background noise, except in the case of lithium and beryllium. The detection limits of the instrument and method, the limit of quantification and the main operating parameters of the ICP-MS are presented in Tables S3 and S4. Scandium, germanium, yttrium, iridium and thorium were used as internal standards. All standards and chemicals were of trace element analytical grade for ICP-MS.

The concentrations of the following elements were measured: boron (B), barium (Ba), beryllium (Be), calcium (Ca), cobalt (Co), potassium (K), lithium (Li), magnesium (Mg), molybdenum (Mo), sodium (Na), selenium (Se), strontium (Sr), titanium (Ti), uranium (U) and vanadium (V).

2.4. Statistical and Geospatial Methods

A statistical evaluation of the results was carried out using the Statistica program (TIBCO Software Inc., Santa Clara, CA, USA (2020). Data Science Workbench, version 14). Values under the limit of quantification (LOQ) were replaced by $LOQ/\sqrt{2}$ in the statistical calculations [40].

A hierarchical cluster analysis (HCA) was used to group the samples based on their elemental composition [41]. In HCA, each sampling point is initially a separate cluster, and then in iterative steps, the two closest clusters are merged into a single cluster. The number of clusters is thus reduced in each step, eventually leaving a single cluster. Ward's method and quadratic Euclidean distance were used for merging the clusters. Discriminant analysis (DA) was used to test the appropriateness of the clusters formed by HCA. Principal component analysis (PCA) was used for data reduction and to reveal the basic characteristics and hidden relationships of the large amount of data [42]. For multivariate statistical analyses (both PCA and HCA), the results were standardized by z-score transformation to reduce the bias resulting from the often orders of magnitude differences in the concentration of the elements. Elemental concentrations of the different clusters were compared using the non-parametric Kruskal–Wallis H-test (p -value: 0.05), and the correlation between elements was tested using Pearson's correlation test (p -value: 0.05). Maps were created using ArcGIS Desktop 10.8. program (Ersi Inc. Redlands, CA, USA, version 10.8.0.12790).

3. Results

3.1. Prevalence and Distribution of Natural Elements

Eighty-seven percent of public utility drinking water suppliers (33 of 38) participated in the survey. Altogether, 1256 samples were collected from 1155 water supply systems (multiple samples from 101 supplies). Water supply systems included in the survey represented 82% of all Hungarian drinking water supplies (Figure 1). Of the samples, 84% were deep groundwater (second or deeper aquifer or depth > 50 m), 8.8% were karst water, 2.5% were bank-filtered water, 2.3% were shallow groundwater (from the first aquifer or depth < 50 m), 1.4% were surface water and <1% were mixed water (a mixture of different types of water).

The results of the elemental analysis are summarized in Table 1. The concentration of Be did not exceed LOQ in any of the samples, and Co concentrations were above LOQ in 1% of samples (13 samples). Therefore, these two elements were not included in the further analyses. Se and V were rarely present in Hungarian drinking water sources, with more than 85% of samples below the LOQ. Median concentrations of U and Mo were below LOQ for both elements, and even the upper quartile values were only 126 and 164% of LOQ, respectively. The concentration of U exceeded the EU parametric value of 30 $\mu\text{g/L}$ in a single sample with a maximum concentration of 41 $\mu\text{g/L}$. Ti, B, Li and Ba were detected in the majority of the samples with concentrations ranging over several orders of magnitude

from below the LOQ to 83, 2570, 265 and 551 $\mu\text{g/L}$, respectively). K and Na were present in almost every sample (21 and 1 < LOQ samples, max 32 and 252 mg/L, respectively), and Mg, Ca and Sr were above the LOQ in every measurement (min-max Mg: 0.55–100 mg/L; Ca: 2.5–174 mg/L; Sr: 21–3310 $\mu\text{g/L}$). A moderate positive correlation ($r = 0.401$ – 0.556) was observed between Li and K; B and Na; Mg and Ca; Mg and Sr; Se and U; and a moderate negative correlation ($r = -0.579$) between Na and Ca (Table 2).

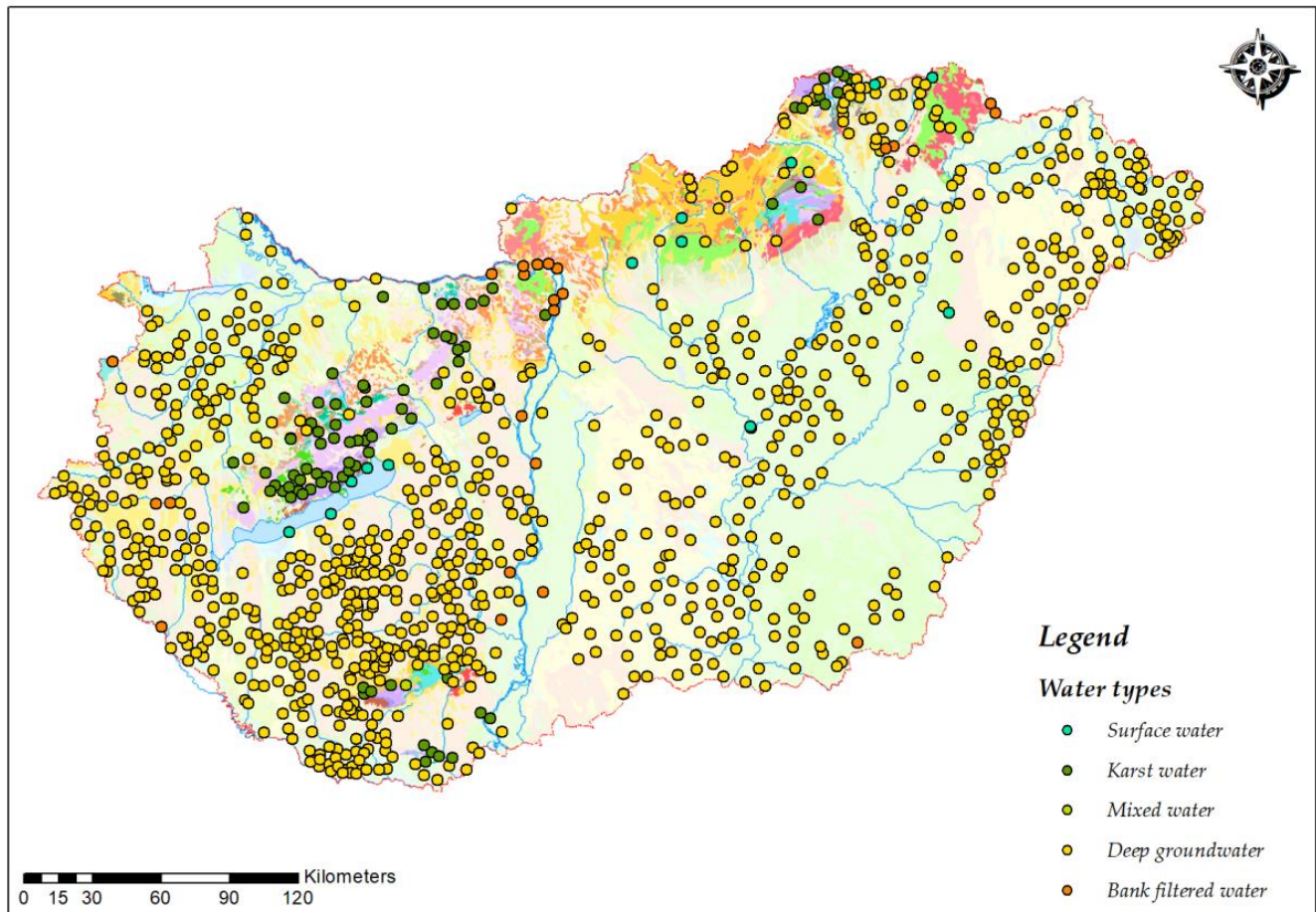


Figure 1. Geographical distribution of the sampled drinking water sources classified by water type (n = 1155).

Table 1. Descriptive statistics of the natural elements measured in Hungarian drinking water sources (n: number of samples, std. dev.: standard deviation, LOQ: limit of quantification).

Variable	Dimension	LOQ	n	Minimum	Lower Quartile	Mean	Std. Dev.	Median	Upper Quartile	Maximum	% of Samples <LOQ
B	$\mu\text{g/L}$	10	1256	<LOQ	13	84	185	25	62	2570	16
Ba	$\mu\text{g/L}$	10	1256	<LOQ	54	120	83	103	170	551	2
Be	$\mu\text{g/L}$	1.0	1256	<LOQ	<LOQ	<LOQ	0	<LOQ	<LOQ	<LOQ	100
Ca	mg/L	0.50	1256	2.5	40	64	31	63	85	174	0
Co	$\mu\text{g/L}$	1.0	1256	<LOQ	<LOQ	<LOQ	0.42	<LOQ	<LOQ	11	99
K	mg/L	0.50	1256	<LOQ	1.1	1.9	1.9	1.4	2.0	32	2
Li	$\mu\text{g/L}$	1.0	1256	<LOQ	5.1	16	25	10	17	265	2
Mg	mg/L	0.50	1256	0.55	15	25	14	23	35	100	0
Mo	$\mu\text{g/L}$	1.0	1256	<LOQ	<LOQ	2.4	6.6	<LOQ	1.6	103	58
Na	mg/L	0.50	1256	<LOQ	15	40	40	25	50	252	0
Se	$\mu\text{g/L}$	1.0	1256	<LOQ	<LOQ	<LOQ	0.46	<LOQ	<LOQ	7.0	86
Sr	$\mu\text{g/L}$	10	1256	21	241	448	354	366	519	3310	0
Ti	$\mu\text{g/L}$	1.0	1256	<LOQ	<LOQ	8.4	14	2.9	7.3	83	31
U	$\mu\text{g/L}$	1.0	1256	<LOQ	<LOQ	1.5	2.4	<LOQ	1.3	41	72
V	$\mu\text{g/L}$	1.0	1256	<LOQ	<LOQ	<LOQ	0.85	<LOQ	<LOQ	17	91

Table 2. Pearson’s correlation matrix of natural elements measured in Hungarian drinking water sources (*p*-value: 0.05, statistically significant correlation marked in **bold**).

Variable	B	Ba	Ca	K	Li	Mg	Mo	Na	Se	Sr	Ti	U	V
B	1.000												
Ba	0.062	1.000											
Ca	−0.342	−0.08	1.000										
K	0.088	0.040	0.131	1.000									
Li	0.224	0.084	−0.081	0.401	1.000								
Mg	−0.275	0.061	0.556	0.147	−0.024	1.000							
Mo	0.317	−0.023	−0.203	−0.007	0.041	−0.159	1.000						
Na	0.537	0.213	−0.579	0.061	0.261	−0.361	0.301	1.000					
Se	−0.061	−0.081	0.112	0.082	0.041	0.186	−0.033	−0.084	1.000				
Sr	−0.098	0.354	0.165	0.193	0.190	0.462	−0.091	0.002	0.062	1.000			
Ti	−0.080	−0.062	0.330	−0.023	−0.048	0.300	−0.071	−0.119	−0.070	0.032	1.000		
U	−0.082	−0.153	0.120	0.136	0.045	0.298	0.020	−0.106	0.433	0.107	−0.006	1.000	
V	−0.035	−0.131	0.017	0.199	−0.047	0.032	0.021	−0.081	0.046	−0.050	−0.023	0.133	1.000

3.2. Water Supply System Clusters by Water Composition

Based on the HCA, six clusters were identified, also confirmed by DA (Wilks’ lambda: 0.00363). The dendrogram is shown in Figure S1 in the Electronic Supplementary Material (ESM). Clusters 3 and 4 were the largest, together comprising two-thirds of the water resources (488 and 343 water sources, respectively). Clusters 2 and 5 accounted for 12 and 16% (151 and 200 of the water resources), respectively. Clusters 1 and 6 were small, with 31 and 43 water sources (2.5 and 3.4%, respectively). In Clusters 1, 2, 4 and 5, 85–99% of the samples were from deep groundwater aquifers (Table 3). Cluster 3 was the most heterogeneous, with deep groundwater comprising 68%, karst water comprising 21% with shallow groundwater and bank filtration comprising 4–4%. This means that Cluster 3 includes the vast majority of all karst, shallow groundwater, bank filtered and surface water samples (91, 69, 63 and 67%, respectively). In Cluster 6, deep groundwater samples accounted for 63% of the samples, with shallow groundwater, surface and bank-filtered samples comprising 14%, 12% and 9.3%, respectively. All surface water samples in cluster 6 are from Lake Balaton.

Table 3. Characteristics of the clusters: dominant elements, number of samples and their distribution by water types.

Cluster Number	Characteristic Element	Σn	Distribution by Water Type					
			Deep Groundw.	Karst w.	Shallow Groundw.	Surface w.	Bank-Filtered w.	Mixed w.
Cluster 1	Li, B, Na, Mo, K	31	27	1	1	1	1	0
Cluster 2	Ti, Ca, Mg	151	138	5	2	0	5	1
Cluster 3	Ca	488	333	101	20	12	20	1
Cluster 4	Ba, Na, Sr	343	340	3	0	0	0	0
Cluster 5	Mo, B, Na	200	196	0	0	0	2	1
Cluster 6	Mg, K, U, Se, V	43	27	1	6	5	4	0

Li concentrations were highest in Cluster 1 (median of 139 µg/L). The concentrations were typically an order of magnitude lower in the other clusters, with the lowest values in Clusters 2 and 3 (median of 9.6 and 7.5 µg/L, respectively) (Figure 2a). Clusters 1 and 5 were characterized by high B, Na and Mo concentrations (median of 198 and 154 µg/L; 73 and 102 mg/L; 1.9 and 2.4 µg/L, respectively), while significantly lower levels were measured in the other clusters, with the lowest in Cluster 3 (median B of 15 µg/L; Na of 15 mg/L; Mo

of <LOQ) (Figure 2b–d). Mg concentrations were the highest in Clusters 6 and 2 (median of 36 and 35 mg/L), moderately high in Clusters 3 and 4 (median of 28 and 22 mg/L), and low in Clusters 1 and 5 (median of 12 and 8.9 mg/L). K was most abundant in Clusters 1 and 6 (median of 3.9 and 2.5 mg/L) and typically low in the other clusters (median between 1.2 and 1.6 mg/L) but more variable in Clusters 2 and 3. Ca concentrations were the highest in Clusters 2 and 3 (median of 81 and 79 mg/L), medium-to-high in Clusters 1, 4 and 6 (median of 40, 54 and 63 mg/L), and low in Cluster 5 (median of 21 mg/L). Cluster 2 had elevated levels of Ti (median of 41 µg/L) compared to the other clusters (median of 1.0–3.0 µg/L). Median concentrations of V and Se exceeded the LOQ only in Cluster 6 (median of 2.0 and 1.1 µg/L, respectively). All six clusters had significant Sr concentrations (median of 239–477 µg/L). The order of the clusters in decreasing concentration from the highest to the lowest are Cluster 4, Cluster 6, Cluster 2, Cluster 3, Cluster 1 and Cluster 5. The concentration of Ba was the highest in Cluster 4 (median of 195 µg/L) and significantly lower in the others, being lowest in Clusters 3 and 6 (median of 61 and 65 µg/L). Median U concentrations were below LOQ in most clusters, except in Cluster 6. (median 6.4 µg/L).

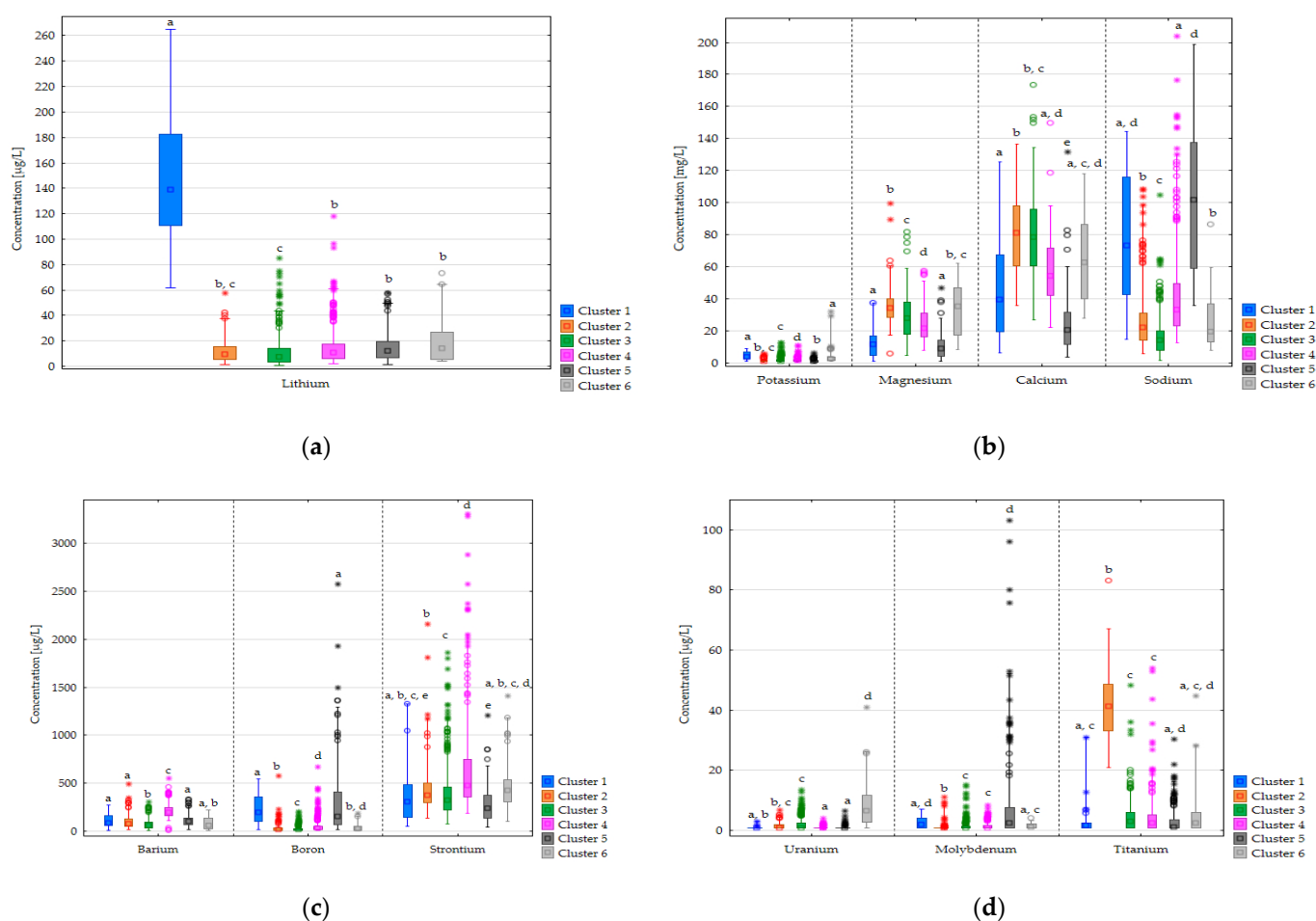


Figure 2. (a–d) Comparison of the six clusters by elements: (a) lithium, (b) potassium, magnesium, calcium and sodium, (c) barium, boron and strontium and (d) uranium, molybdenum and titanium. The boxplots show the median (□), lower and upper quartile (box), 2.5 and 97.5 percentiles (whiskers), outliers (○) and extremes (*), and the statistically significant difference between clusters (letters).

3.3. Spatial Distribution

The geographical distribution of the 6 clusters is shown in Figure 3.

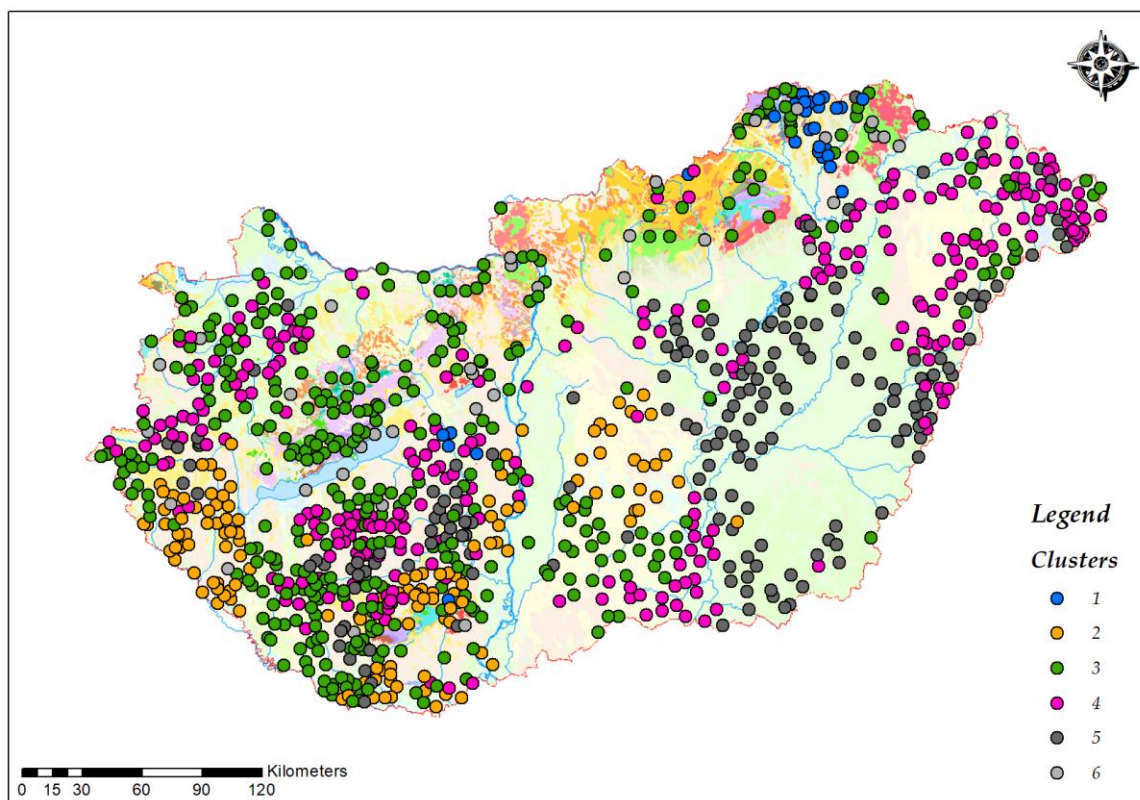


Figure 3. Spatial distribution the sampled drinking water supplies of the six HCA clusters. $n = 1155$.

Geographically, Cluster 1 is a distinct group located in the northern part of Hungary. Drinking water sources belonging to Cluster 2 form recognizable clusters in the southwest, south and central parts of the country. Cluster 3 is dispersed across the country, although it is more prevalent in the western and central parts of the country than in the eastern region. This cluster includes the vast majority of the non-deep groundwater sources (karst, bank-filtered, shallow groundwater and surface water). Drinking water sources classified as Cluster 4 are scattered throughout the country. Cluster 5 drinking water sources are localised in the east-southeast part of the country and a specific area in the western half of the country. Cluster 6 is mainly associated with the southern foothills of the Transdanubian and Northern Ranges. The characteristics of the clusters are summarized in Table 3.

3.4. Principal Component Analysis

PCA analysis identified five principal components (PCs) with eigenvalues greater than 1. These five PCs explain 65% of the total variance. Characteristic elements (loading values < -0.4 or > 0.4) of PC1 are B, Ca, Mg, Mo and Na (total variance 21.7%) and K, Li and Sr in case of PC2 (total variance 14.5%). The loading and eigenvalues of the PCs are presented in Tables S1 and S2 of the ESM. Samples belonging to the six clusters were also grouped together in the PCA, and the clusters were separated by the first two PCs (Figure 4a). Comparing water types, only karst waters formed a distinct group according to the first two PCs (Figure 4b). The overwhelming dominance of groundwater samples masked any other separation by water type.

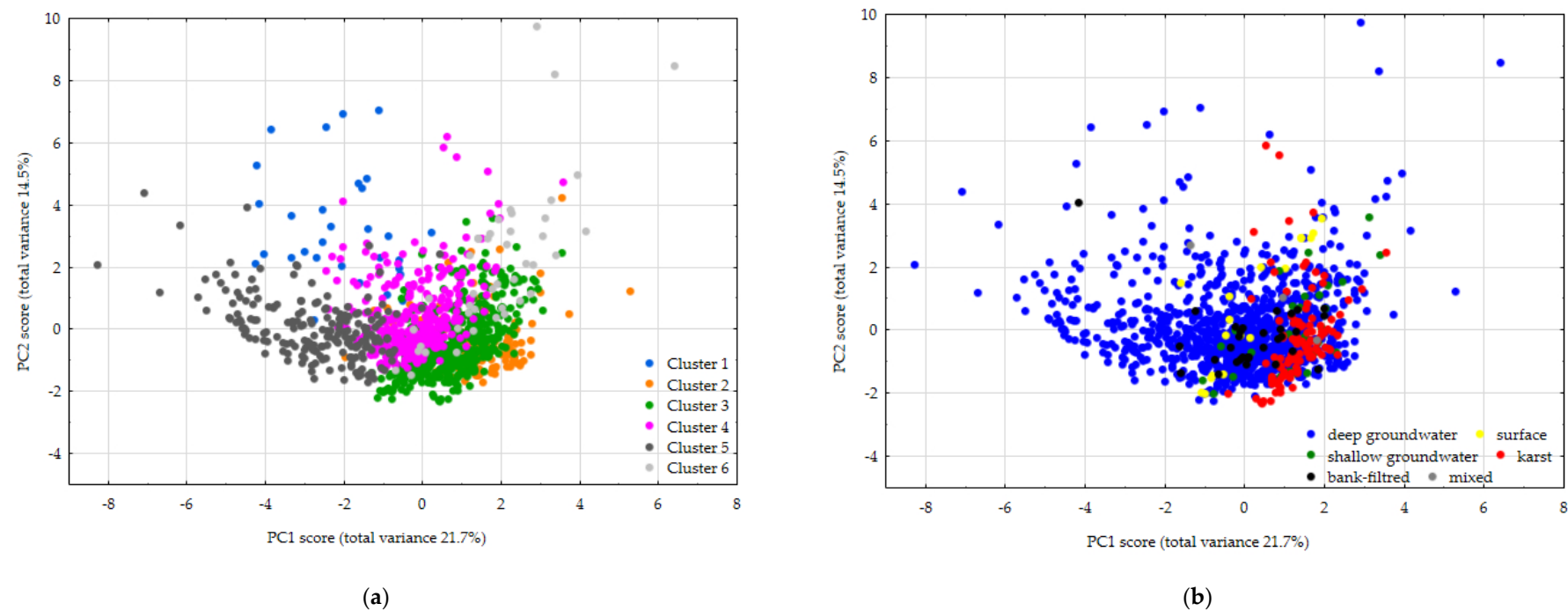


Figure 4. (a,b) Separation of water resource samples along the first two principal components (PC1 and PC2) on a 2D-score PCA plot depicted as (a) clusters and (b) water types.

4. Discussion

Drinking water supply in Hungary relies almost entirely on groundwater sources [43]. Surface water abstraction is limited and, in some areas, seasonal. For example, around Lake Balaton, an important holiday destination, it is used in the summer periods to compensate for the temporary increase of the population. Although by volume, bank filtration contributes significantly to drinking water production; by the number of supplies, deep groundwaters comprise an overwhelming majority. We have hypothesised that the natural element composition of water types liable to surface impact (surface water, bank-filtered water, karst water and shallow groundwater) would differ from deep groundwater, but only karst waters exhibited a unique profile, dominated by Ca and Mg due to the predominantly dolomite karst water reservoirs. The similarity in the elemental compositions of surface waters (specifically Lake Balaton) and groundwaters might be an indication of their interconnection. The significance of groundwater discharge into lakes in Hungary was demonstrated for Lake Balaton [44] and Lake Velence previously [36].

In groundwater, the prevalence of natural elements is determined not only by the geological composition of the aquifer but also by the groundwater flow systems that are characterised by different physicochemical conditions (e.g., pH, temperature, redox potential, dissolved gas content), changing from recharge to discharge areas and from local to regional flow systems [45–47]. These systematic changes control the dissolution of elements and the resulting differences in the composition of the groundwater even within the same aquifer [48].

Of the geological features of the Pannonian Basin, the sediments originating from the ancient Lake Pannon are among the most important water reservoirs of drinking water and thermal water [47,49–52]. As the lake basin was filled, the deep basin and turbidite formations, followed by the various delta facies, change into sediments of fluvial origin at the end of the sequence. These regions, to a large extent, overlap with water sources of high (up to 100 µg/L) arsenic concentrations [53]. For decades, arsenic has been the primary focus of investigations and drinking water quality improvement programmes in Hungary. Since ample historical data was already available for arsenic, it was not part of the current study, but potential overlaps were investigated. High arsenic water sources were evenly distributed between Clusters 3, 4 and 5, and no clear correlation was observed at this level of analysis with the prevalence of other elements.

In the ranges of Hungary, carbonates (dolomite, limestone) and volcanics, and to a lesser extent metamorphic and magmatic (granite) rocks, are most prevalent. The latter ones can be the source of various elements, among others, uranium [34,37,54–56]. According to the current scientific consensus, U has the highest health relevance of the investigated parameters. Observed U concentrations in Hungary are low compared to other European countries [6–9,11,57]. The highest U levels (in Cluster 6) corresponded spatially to locations of elevated gross alpha activity used for the determination of the indicative dose in drinking water [58]. Some of these locations were investigated previously in detail, approaching the groundwater quality problem from the perspective of groundwater flow systems, taking into account (besides geological factors) the subsurface residence time and flow path of groundwater by a basin-scale survey [36,44]. These local studies confirmed that U contributed most to the measured elevated gross alpha activity (up to 0.8 Bq/L), which originated from the mobilizing effect of local flow systems due to oxidising conditions. Neither the calculated indicative dose nor U as a nephrotoxic element were identified as a source of significant health hazard.

Se, V and Mo are typically present at concentrations below the LOQ or in low concentrations in Hungarian water sources. Higher values (>5 µg/L) were measured in a limited number of water supplies (8 and 3 for V and Se, respectively), stipulating a local source. Similar low levels of Mo and Se were observed in drinking water of geographically adjacent (Croatia, with a median concentration of Se < 1.0 µg/L and Mo < 1.0 µg/L) [59] and distant locations (Ethiopia, with a median concentration of Se < 1.0 µg/L [32], and England and Wales with Mo < 1.0–1.5 µg/L) [60]). Studies from other European countries identified

considerably higher levels (e.g., up to 350 µg/L of V in Italy and 40 µg/L of Se in France). However, these problems in other countries are also occur in relatively confined geographic areas (e.g., V together with U in volcanic areas in central Italy and Se in the Chalk Aquifer of Northern France) [11,31]. In the present study, V occurred in areas localised in the Northern Range volcanic complexes. Moderate correlation was seen between U and Se, which occur in the southern foreland of the Velence Hills built-up of granitic rocks.

Li was also measured in significant concentrations, even exceeding 250 µg/L in specific locations, which is relatively high compared to most other European studies [20,21,23,24]. Li is characteristic of the deep groundwater sources, suggesting a longer groundwater residence time (i.e., more time for rock-water interactions). Previous studies found a strong positive correlation between Li and Na (suggesting even that the latter can serve as an indicator of the former), but the present study only indicated a weak (though significant) correlation [61]. Higher concentrations than the ones measured in Hungary were only reported from Austria in Europe [24]. The protective effect of a higher lithium intake via drinking water was also confirmed in a previous Hungarian study using a subset of data from the present study [26].

The presence of Be, Co and Mo is negligible in Hungarian drinking water sources. Neither Be nor Ba exceeded the limit in any of the samples and Mo only four times (0.3%) the guideline value recommended by WHO (12, 1300 and 70 µg/L, respectively) [4].

Median concentrations and lower quartile values of Ca and Mg exceeded the minimum concentrations recommended by several EU member states (30 mg/L and 10 mg/L, respectively) [16]. However, in-country variability was high, and in some regions, especially the Great Plains in southeastern Hungary, the population is at risk of an insufficient intake of Mg and Ca from drinking water. High Ca and Mg concentrations were associated with karst waters, their co-occurrence manifesting as a moderate positive correlation in correlation analysis. In other settings, even stronger associations were found not only between Ca and Mg, but also Ca with Sr and Ba, which were negligible in the present study [62,63]. The correlation of different elements can provide the first step towards understanding the underlying geological basis of the observed variability of the natural element composition in source waters. For instance, while in karst water Ca co-occurs with Mg, in other aquifers hosted by sedimentary rocks, such as sandstone with carbonate cement, it may be abundant beside Na and K as dominant ions [64–66].

5. Conclusions

The study confirmed that none of the previously unmonitored parameters of adverse health impacts are present in Hungarian drinking water sources in such concentrations that would pose a risk to drinking water quality and consequently to the health of the consumers on a national scale. However, local hydrogeological conditions may lead to the emergence of natural elements in higher concentrations in some water supplies. Such local exceedances, e.g., of U or V, require further investigation and, if needed, risk mitigation measures. Drinking water can be a significant source of Ca and Mg for the majority of the population and even Li was found to reach beneficial concentrations in a smaller area. The observed geographical distribution of the natural elements was partially explained by geological factors, but further hydrogeological data (e.g., well depth, lithology and flow system evaluation) would be necessary to fully reveal the origin of these elements.

Supplementary Materials: The following supporting information can be downloaded at: <https://www.mdpi.com/article/10.3390/w16152122/s1>, Figure S1: Dendrogram of HCA; Table S1: Eigenvalues of the PCs; Table S2: PC's loading values of the elements; Table S3: Instrument and method limits of detection (LOD) and limit of quantification (LOQ) of ICP-MS; Table S4: The main operating parameters of the ICP-MS.

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References

1. The European Parliament; The Council of the European Union. Directive (EU) 2020/2184 of the European Parliament and of the Council of 16 December 2020 on the Quality of Water Intended for Human Consumption. 2020. Available online: <https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32020L2184> (accessed on 1 March 2024).
2. World Health Organization. *Water Safety Plan Manual Step-by-Step Risk Management for Drinking-Water Suppliers*, 2nd ed.; World Health Organization: Geneva, Switzerland, 2023. Available online: <https://iris.who.int/bitstream/handle/10665/366148/9789240067691-eng.pdf?sequence=1> (accessed on 1 March 2024).
3. Council of the European Union. Council Directive 98/83/EC of 3 November 1998 on the Quality of Water Intended for Human Consumption. 1998. Available online: <https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:31998L0083> (accessed on 1 March 2024).
4. World Health Organization. *Guidelines for Drinking-Water Quality*, 4th ed.; Incorporating the First and Second Addenda; World Health Organization: Geneva, Switzerland, 2022. Available online: <https://www.who.int/publications/i/item/9789241549950> (accessed on 1 March 2024).
5. European Food Safety Authority (EFSA). Uranium in foodstuffs, in particular mineral water. *EFSA* **2009**, *7*, 1018. [\[CrossRef\]](#)
6. Nriagu, J.; Nam, D.-H.; Ayanwola, T.A.; Dinh, H.; Erdenechimeg, E.; Ochir, C.; Bolormaa, T.-A. High levels of uranium in groundwater of Ulaanbaatar, Mongolia. *Sci. Total Environ.* **2012**, *414*, 722–726. [\[CrossRef\]](#) [\[PubMed\]](#)
7. Cicchella, D.; Albanese, S.; De Vivo, B.; Dinelli, E.; Giaccio, L.; Lima, A.; Valera, P. Trace elements and ions in Italian bottled mineral waters: Identification of anomalous values and human health related effects. *J. Geochem. Explor.* **2010**, *107*, 336–349. [\[CrossRef\]](#)
8. Frengstad, B.; Skrede, A.K.M.; Banks, D.; Krog, J.R.; Siewers, U. The chemistry of Norwegian groundwaters: III. The distribution of trace elements in 476 crystalline bedrock groundwaters, as analysed by ICP-MS techniques. *Sci. Total Environ.* **2000**, *246*, 21–40. [\[CrossRef\]](#) [\[PubMed\]](#)
9. Wu, Y.; Wang, Y.; Xie, X. Occurrence, behavior and distribution of high levels of uranium in shallow groundwater at Datong basin, northern China. *Sci. Total Environ.* **2014**, *472*, 809–817. [\[CrossRef\]](#) [\[PubMed\]](#)
10. Lapworth, D.J.; Brauns, B.; Chattopadhyay, S.; Gooddy, D.C.; Loveless, S.E.; MacDonald, A.M.; McKenzie, A.A.; Muddu, S.; Nara, S.N. Elevated uranium in drinking water sources in basement aquifers of southern India. *Appl. Geochem.* **2021**, *133*, 105092. [\[CrossRef\]](#)
11. Cinti, D.; Poncia, P.; Brusca, L.; Tassi, F.; Quattrocchi, F.; Vaselli, O. Spatial distribution of arsenic, uranium and vanadium in the volcanic-sedimentary aquifers of the Vicano–Cimino Volcanic District (Central Italy). *J. Geochem. Explor.* **2015**, *152*, 123–133. [\[CrossRef\]](#)
12. Jiang, L.; He, P.; Chen, J.; Liu, Y.; Liu, D.; Qin, G.; Tan, N. Magnesium Levels in Drinking Water and Coronary Heart Disease Mortality Risk: A Meta-Analysis. *Nutrients* **2016**, *8*, 5. [\[CrossRef\]](#) [\[PubMed\]](#)
13. Catling, L.A.; Abubakar, I.; Lake, I.R.; Swift, L.; Hunter, P.R. A systematic review of analytical observational studies investigating the association between cardiovascular disease and drinking water hardness. *J. Water Health* **2008**, *6*, 433–442. [\[CrossRef\]](#) [\[PubMed\]](#)
14. World Health Organization. *Calcium and Magnesium in Drinking Water: Public Health Significance (Beneficial Impacts on Health)*; WHO: Geneva, Switzerland, 2009; p. 180.
15. Gianfredi, V.; Bragazzi, N.L.; Nucci, D.; Villarini, M.; Moretti, M. Cardiovascular diseases and hard drinking waters: Implications from a systematic review with meta-analysis of case-control studies. *J. Water Health* **2017**, *15*, 31–40. [\[CrossRef\]](#) [\[PubMed\]](#)
16. Kozisek, F. Regulations for calcium, magnesium or hardness in drinking water in the European Union member states. *Regul. Toxicol. Pharmacol.* **2020**, *112*, 104589. [\[CrossRef\]](#) [\[PubMed\]](#)
17. Russo, R.; Sciacca, S.; I La Milia, D.; Poscia, A.; Moscato, U. Vanadium in drinking water: Toxic or therapeutic?! Systematic literature review and analysis of the population exposure in an Italian volcanic region. *Eur. J. Public Health* **2014**, *24* (Suppl. S2), cku162-080. [\[CrossRef\]](#)
18. Ferrante, M.; Conti, G.O.; Rasic-Milutinovic, Z.; Jovanovic, D. Health effects of metals and related substances in drinking water. In *Metals and Related Substances in Drinking Water*; IWA Publishing: London, UK, 2014.
19. Vasseghian, Y.; Rad, S.S.; Vilas-Boas, J.A.; Khataee, A. A global systematic review, meta-analysis, and risk assessment of the concentration of vanadium in drinking water resources. *Chemosphere* **2021**, *267*, 128904. [\[CrossRef\]](#) [\[PubMed\]](#)

20. Kabacs, N.; Memon, A.; Obinwa, T.; Stochl, J.; Perez, J. Lithium in drinking water and suicide rates across the East of England. *Br. J. Psychiatry* **2011**, *198*, 406–407. [\[CrossRef\]](#) [\[PubMed\]](#)
21. Liaugaudaitė, V.; Mickuviene, N.; Raskauskiene, N.; Naginiene, R.; Sher, L. Lithium levels in the public drinking water supply and risk of suicide: A pilot study. *J. Trace Elem. Med. Biol.* **2017**, *43*, 197–201. [\[CrossRef\]](#) [\[PubMed\]](#)
22. Pompili, M.; Vichi, M.; Dinelli, E.; Pycha, R.; Valera, P.; Albanese, S.; Lima, A.; De Vivo, B.; Cicchella, D.; Fiorillo, A.; et al. Relationships of local lithium concentrations in drinking water to regional suicide rates in Italy. *World J. Biol. Psychiatry* **2015**, *16*, 567–574. [\[CrossRef\]](#) [\[PubMed\]](#)
23. Giotakos, O.; Nisianakis, P.; Tsouvelas, G.; Giakalou, V.-V. Lithium in the Public Water Supply and Suicide Mortality in Greece. *Biol. Trace Element Res.* **2013**, *156*, 376–379. [\[CrossRef\]](#) [\[PubMed\]](#)
24. Kapusta, N.D.; Mossaheb, N.; Etzersdorfer, E.; Hlavín, G.; Thau, K.; Willeit, M.; Praschak-Rieder, N.; Sonneck, G.; Leithner-Dziubas, K. Lithium in drinking water and suicide mortality. *Br. J. Psychiatry* **2011**, *198*, 346–350. [\[CrossRef\]](#) [\[PubMed\]](#)
25. Li, Z.; He, M.-Y.; Li, B.; Wen, X.; Zhou, J.; Cheng, Y.; Zhang, N.; Deng, L. Multi-isotopic composition (Li and B isotopes) and hydrochemistry characterization of the Lakko Co Li-rich salt lake in Tibet, China: Origin and hydrological processes. *J. Hydrol.* **2024**, *630*, 130714. [\[CrossRef\]](#)
26. Izsák, B.; Hidvegi, A.; Balint, L.; Malnasi, T.; Vargha, M.; Pandics, T.; Rimer, Z.; Dome, P. Investigation of the association between lithium levels in drinking water and suicide mortality in Hungary. *J. Affect. Disord.* **2022**, *298*, 540–547. [\[CrossRef\]](#) [\[PubMed\]](#)
27. Barjasteh-Askari, F.; Davoudi, M.; Amini, H.; Ghorbani, M.; Yaseri, M.; Yunesian, M.; Mahvi, A.H.; Lester, D. Relationship between suicide mortality and lithium in drinking water: A systematic review and meta-analysis. *J. Affect. Disord.* **2020**, *264*, 234–241. [\[CrossRef\]](#) [\[PubMed\]](#)
28. Memon, A.; Rogers, I.; Fitzsimmons, S.M.D.D.; Cater, B.; Strawbridge, R.; Hidalgo-Mazzei, D.; Young, A.H. Association between naturally occurring lithium in drinking water and suicide rates: Systematic review and meta-analysis of ecological studies. *Br. J. Psychiatry* **2020**, *217*, 667–678. [\[CrossRef\]](#) [\[PubMed\]](#)
29. Eyre-Watt, B.; Mahendran, E.; Suetani, S.; Firth, J.; Kisely, S.; Siskind, D. The association between lithium in drinking water and neuropsychiatric outcomes: A systematic review and meta-analysis from across 2678 regions containing 113 million people. *Aust. N. Z. J. Psychiatry* **2021**, *55*, 139–152. [\[CrossRef\]](#) [\[PubMed\]](#)
30. Abejón, R. A Bibliometric Analysis of Research on Selenium in Drinking Water during the 1990–2021 Period: Treatment Options for Selenium Removal. *Int. J. Environ. Res. Public Health* **2022**, *19*, 5834. [\[CrossRef\]](#) [\[PubMed\]](#)
31. Barron, E.; Migeot, V.; Rabouan, S.; Potin-Gautier, M.; Séby, F.; Hartemann, P.; Lévi, Y.; Legube, B. The case for re-evaluating the upper limit value for selenium in drinking water in Europe. *J. Water Health* **2009**, *7*, 630–641. [\[CrossRef\]](#)
32. Godebo, T.R.; Stoner, H.; Kodsup, P.; Stoltzfus, M.; Nyachoti, S.; Atkins, S.; Jeuland, M. Selenium in drinking water and cereal grains, and biomarkers of Se status in urine and fingernails of the Main Ethiopian Rift Valley population. *J. Trace Elem. Med. Biol.* **2023**, *77*, 127137. [\[CrossRef\]](#) [\[PubMed\]](#)
33. National Center for Public Health and Pharmacy. Magyarország Ivóvizének Minősége, 2022. 2023. Available online: https://www.nnk.gov.hu/attachments/article/726/2023_9_Ivo%CC%81vi%CC%81zmino%CC%8Bse%CC%81g%202022.pdf (accessed on 1 March 2024).
34. Erőss, A.; Csondor, K.; Izsák, B.; Vargha, M.; Horváth, Á.; Pándics, T. Uranium in groundwater—The importance of hydraulic regime and groundwater flow system’s understanding. *J. Environ. Radioact.* **2018**, *195*, 90–96. [\[CrossRef\]](#) [\[PubMed\]](#)
35. Csondor, K.; Baják, P.; Surbeck, H.; Izsák, B.; Horváth, Á.; Vargha, M.; Erőss, A. Transient nature of riverbank filtered drinking water supply systems—A new challenge of natural radioactivity assessment. *J. Environ. Radioact.* **2020**, *211*, 106072. [\[CrossRef\]](#) [\[PubMed\]](#)
36. Baják, P.; Hegedűs-Csondor, K.; Tiljander, M.; Korkka-Niemi, K.; Surbeck, H.; Izsák, B.; Vargha, M.; Horváth, Á.; Pándics, T.; Erőss, A. Integration of a Shallow Soda Lake into the Groundwater Flow System by Using Hydraulic Evaluation and Environmental Tracers. *Water* **2022**, *14*, 951. [\[CrossRef\]](#)
37. Baják, P.; Molnár, B.; Hegedűs-Csondor, K.; Tiljander, M.; Jobbágy, V.; Kohuth-Ötvös, V.; Izsák, B.; Vargha, M.; Horváth, Á.; Csipa, E.; et al. Natural Radioactivity in Drinking Water in the Surroundings of a Metamorphic Outcrop in Hungary: The Hydrogeological Answer to Practical Problems. *Water* **2023**, *15*, 1637. [\[CrossRef\]](#)
38. ISO 5667-11:2009; Water Quality—Sampling Part 11: Guidance on Sampling of Groundwaters. International Organization for Standardization: Geneva, Switzerland, 2009.
39. ISO 17294-2:2016; Water Quality—Application of Inductively Coupled Plasma Mass Spectrometry (ICP-MS) Part 2: Determination of Selected Elements Including Uranium Isotopes. International Organization for Standardization: Geneva, Switzerland, 2016.
40. Croghan, C.W.; Egeghy, P.P. *Methods of Dealing with Values Below the Limit of Detection Using SAS*; US-EPA: Washington, DC, USA, 2003.
41. Everitt, B.S.; Landau, S.; Leese, M.; Stahl, D. *Cluster Analysis*, 1st ed.; Wiley Series in Probability and Statistics; John Wiley & Sons Ltd.: West Sussex, UK, 2011. [\[CrossRef\]](#)
42. Wold, S.; Esbensen, K.; Geladi, P. Principal component analysis. *Chemom. Intell. Lab. Syst.* **1987**, *2*, 37–52. [\[CrossRef\]](#)
43. Bufa-Dörri, Z.; Sebestyén, Á.; Izsák, B.; Schmoll, O.; Pándics, T.; Vargha, M. Dual system of water safety plan auditing in Hungary: Benefits and lessons learnt. *J. Water Health* **2023**, *21*, 1663–1675. [\[CrossRef\]](#) [\[PubMed\]](#)

44. Tóth, Á.; Baják, P.; Szijártó, M.; Tiljander, M.; Korkka-Niemi, K.; Hendriksson, N.; Mádl-Szőnyi, J. Multimethodological Revisit of the Surface Water and Groundwater Interaction in the Balaton Highland Region—Implications for the Overlooked Groundwater Component of Lake Balaton, Hungary. *Water* **2023**, *15*, 1006. [\[CrossRef\]](#)
45. Ingebritsen, S.E.; Sanford, W.E.; Neuzil, C.E. *Groundwater in Geologic Processes*, 2nd ed.; Cambridge University Press: Cambridge, UK, 2006. [\[CrossRef\]](#)
46. Tóth, J. *Gravitational Systems of Groundwater Flow: Theory, Evaluation, Utilization*; Cambridge University Press: Cambridge, UK, 2009.
47. Czauner, B.; Erőss, A.; Szkolnikovics-Simon, S.; Markó, Á.; Baják, P.; Trásy-Havril, T.; Szijártó, M.; Szabó, Z.; Hegedűs-Csondor, K.; Mádl-Szőnyi, J. From basin-scale groundwater flow to integrated geofluid research in the hydrogeology research group of Eötvös Loránd University, Hungary. *J. Hydrol. X* **2022**, *17*, 100142. [\[CrossRef\]](#)
48. Tóth, J. Groundwater as a geologic agent: An overview of the causes, processes, and manifestations. *Hydrogeol. J.* **1999**, *7*, 1–14. [\[CrossRef\]](#)
49. Lenkey, L.; Zsemle, F.; Mádl-Szőnyi, J.; Dövényi, P.; Rybach, L. Possibilities and limitations in the utilization of the Neogene geothermal reservoirs in the Great Hungarian Plain, Hungary. *Central Eur. Geol.* **2008**, *51*, 241–252. [\[CrossRef\]](#)
50. Csondor, K.; Czauner, B.; Csobaji, L.; Győri, O.; Erőss, A. Characterization of the regional groundwater flow systems in south Transdanubia (Hungary) to understand karst evolution and development of hydrocarbon and geothermal resources. *Hydrogeol. J.* **2020**, *28*, 2803–2820. [\[CrossRef\]](#)
51. Tóth, J.; Almási, I. Interpretation of observed fluid potential patterns in a deep sedimentary basin under tectonic compression: Hungarian Great Plain, Pannonian Basin. *Geofluids* **2001**, *1*, 11–36. [\[CrossRef\]](#)
52. Hungarian Academy of Sciences. *National Atlas of Hungary—Natural Environment*; Hungarian Academy of Sciences, Research Centre for Astronomy and Earth Sciences, Geographical Institute: Budapest, Hungary, 2018.
53. Dura, G.; Rudnai, P.; Kádár, M.; Vargha, M. The health risks of consuming drinking water with elevated arsenic content of geochemical origin. *Central Eur. Geol.* **2014**, *57*, 307–316. [\[CrossRef\]](#)
54. Smedley, P.; Kinniburgh, D. Uranium in natural waters and the environment: Distribution, speciation and impact. *Appl. Geochem.* **2023**, *148*, 105534. [\[CrossRef\]](#)
55. Vengosh, A.; Coyte, R.M.; Podgorski, J.; Johnson, T.M. A critical review on the occurrence and distribution of the uranium- and thorium-decay nuclides and their effect on the quality of groundwater. *Sci. Total Environ.* **2022**, *808*, 151914. [\[CrossRef\]](#) [\[PubMed\]](#)
56. Baják, P.; Csondor, K.; Pedretti, D.; Muniruzzaman, M.; Surbeck, H.; Izsák, B.; Vargha, M.; Horváth, Á.; Pándics, T.; Erőss, A. Refining the conceptual model for radionuclide mobility in groundwater in the vicinity of a Hungarian granitic complex using geochemical modeling. *Appl. Geochem.* **2022**, *137*, 105201. [\[CrossRef\]](#)
57. Gjengedal, E.L.F.; Joudi, B.; Heim, M.; Steffensen, I.-L.; Lund, V. Uranium and lanthanum in Norwegian drinking water—Is there cause for concern? *Sci. Total Environ.* **2023**, *889*, 164287. [\[CrossRef\]](#) [\[PubMed\]](#)
58. National Center for Public Health and Pharmacy. Módszertani Útmutató Ivóvizek Radiológiai Paramétereinek Vizsgálatához és Értékeléséhez. 2023. Available online: https://www.nnk.gov.hu/attachments/article/726/2023_8_M%C3%B3dsz.%C3%BAtm._Iv%C3%B3viz_radiologiai%20vizsg..pdf (accessed on 1 March 2024).
59. Ćurković, M.; Sipos, L.; Puntarić, D.; Dodig-Ćurković, K.; Pivac, N.; Kralik, K. Arsenic, Copper, Molybdenum, and Selenium Exposure through Drinking Water in Rural Eastern Croatia. *Pol. J. Environ. Stud.* **2016**, *25*, 981–992. [\[CrossRef\]](#) [\[PubMed\]](#)
60. Smedley, P.L.; Cooper, D.M.; Lapworth, D.J. Molybdenum distributions and variability in drinking water from England and Wales. *Environ. Monit. Assess.* **2014**, *186*, 6403–6416. [\[CrossRef\]](#) [\[PubMed\]](#)
61. Sharma, N.; Westerhoff, P.; Zeng, C. Lithium occurrence in drinking water sources of the United States. *Chemosphere* **2022**, *305*, 135458. [\[CrossRef\]](#) [\[PubMed\]](#)
62. Abdo, N.; Alhamid, A.; Abu Dalo, M.; Graboski-Bauer, A.; Al Harahsheh, M. Potential health risk assessment of mixtures of heavy metals in drinking water. *Groundw. Sustain. Dev.* **2024**, *25*, 101147. [\[CrossRef\]](#)
63. Radulescu, C.; Bretcan, P.; Pohoata, A.; Tanislav, D.; Stirbescu, R.M. Assessment of drinking water quality using statistical analysis: A case study. *J. Phys.* **2016**, *61*, 1604–1616.
64. Ahada, C.P.S.; Suthar, S. Hydrochemistry of groundwater in North Rajasthan, India: Chemical and multivariate analysis. *Environ. Earth Sci.* **2017**, *76*, 203. [\[CrossRef\]](#)
65. Priya, K.; Arulraj, G.P. A correlation–regression model for the physicochemical parameters of the groundwater in Coimbatore city, India. *Environ. Technol.* **2011**, *32*, 731–738. [\[CrossRef\]](#) [\[PubMed\]](#)
66. Arroyo-Figueroa, C.; Chalá, D.C.; Gutiérrez-Ribón, G.; Quiñones-Bolaños, E. A Framework to Evaluate Groundwater Quality and the Relationship between Rock Weathering and Groundwater Hydrogeochemistry in the Tropical Zone: A Case Study of Coastal Aquifer Arroyo Grande, in the Caribbean Region of Colombia. *Water* **2024**, *16*, 1650. [\[CrossRef\]](#)

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