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DOMINIKA DĄBROWSKA[1], MAREK RUMAN[2], WOJCIECH RYKAŁA[3]

Testing the quality of spring waters in tourist area in Leśniów (southern Poland)

Introduction

Springs are important to ecosystems because they are naturally occurring outflows of groundwater to the surface. The intricate relationships that exist between surface water and groundwater make them a special part of aquatic ecosystems (Thapa et al. 2020; Hamed et al. 2024), and they flow to the surface by means of faults or fractures or through water-rock contact (Asnin et al. 2022). The existence of springs is influenced by rock properties (porosity), lithological formation, and the amount of precipitation, among other factors (Ansari et al. 2015; Kayastha et al. 2015). Geological and climatic conditions and land use are the main factors shaping their physicochemical properties (Asnari et al. 2015; Meng et al. 2016). Due to the fact that spring waters are located at the interface between surface water

✉ Corresponding Author: Dominika Dąbrowska; e-mail: dominika.dabrowska@us.edu.pl

[1] University of Silesia, Katowice, Poland; ORCID iD: 0000-0002-6762-8885; e-mail: dominika.dabrowska@us.edu.pl

[2] University of Silesia, Katowice, Poland; ORCID iD: 0000-0001-9424-7589; e-mail: marek.ruman@us.edu.pl

[3] University of Silesia, Katowice, Poland; ORCID iD: 0000-0001-7382-8755; e-mail: wojciech.rykala@us.edu.pl

and groundwater, they are often more susceptible to contamination (Adeyemo et al. 2008; Lahr and Kooistra 2010; Badr et al. 2011). Their level of pollution is influenced by the slope of the land and land use directions (the presence of pollution sources such as landfills, incinerators, and agricultural fields), but also by the amount and intensity of precipitation (Li et al. 2023; Quan et al. 2023; Vesković et al. 2024).

An example of formations that are highly susceptible to pollution is karst systems, which are characterized by large, exposed bedrock and thin soil covering carbonate rocks (Qin et al. 2017). They are a significant global source of drinking water, which they provide to around 9% of the world's population (Chen et al. 2017). Karst springs are not the primary source of water, despite the fact that they can be used as a backup. It is also important to keep in mind that while the springs may sustain economic activity, their reduced efficiency and incapacity to supply drinking water have an impact on the landscape's aesthetic qualities. As such, springs are often located in recreational or tourist areas, and they are often used by local residents and tourists (Ruman and Dąbrowska 2024). Additionally, they are excellent points for monitoring the migration rate and changes in contaminant concentrations in karst systems (Geyer et al. 2007; Janik et al. 2024). The hydrology and ecology of springs are closely related to changes in the interactions of surface and groundwater, so spring waters contain minerals from the surrounding rocks but are also susceptible to chemical changes due to atmospheric precipitation (Sari et al. 2022; Paikaray and Mahajan 2023). Rapid alterations are noted in the microbial characteristics of karst spring fluids in addition to changes in their physicochemical characteristics (Katz et al. 2011). This, in turn, means that contaminated water may have a negative impact on human health, primarily causing diseases of the digestive system (Juntunen et al. 2017; Beeckman et al. 2018; Shukla and Saxena 2020).

Due to the fact that small, local springs do not provide the population with drinking water, they are not subjected to physicochemical or bacteriological tests, and their water quality remains unknown. Municipalities within which springs are found usually have archival data from state environmental monitoring. The monitoring of spring waters is crucial in karst areas because it can identify sources of pollution and thereby protect water resources and health (Kumar et al. 2017; Zhu et al. 2023). This article draws attention to the hydrological and hydrogeological characteristics as well as the bacteriological composition of a spring located in the karst tourist area in the town of Leśniów (southern Poland). 34 distinct physico-chemical and bacteriological parameters were measured during the spring's examination in three measurement series. The number of microorganisms, including pathogens and potential pathogens that could seriously endanger human health and well-being (e.g., enterococci, *P. aeruginosa*, *C. perfringens*, and coliform bacteria in feces), as well as the variability of the content of the major ions and metals, were assessed. The risk of water pollution can be evaluated using a variety of techniques, such as artificial neural network modeling, ranking techniques, and parametric techniques. But the majority of them need a great deal of information and variables. In the case of screening tests, index methods work best. Many of the indices mainly concern metal pollution, but they can also be used for other indicators. The most popular methods include the Water Quality Index, the Landfill Water Pollution Index, the Nemerow Index, and the Contamination Index, which was designed specifically to assess the metal content in water (Backman et al. 1998; Tamasi and Cini 2004; Talalaj 2014; Talalaj and Biedka 2016; Karkocha 2021).

The examined spring is an unregulated component of the aquatic ecosystem, even if it is not the primary source of water for the locals. The presence of bacteriological or physicochemical contamination in spring waters can have detrimental effects on the region's water resource management as well as pose a health risk. The article's objectives are to present the results of chemical analyses for three monitoring series, highlight the risks to the water quality in the examined spring, the importance of natural springs in preserving the appropriate chemical state of waters, and the necessity of routine environmental monitoring of such establishments.

1. Material and methods

At an elevation of 345 meters above sea level, three measurement series were conducted at the outflow of the slope, crevice, and falling spring in the town of Leśniów, which is part of the Żarki commune (southern Poland). Tourists and pilgrims use the spring, which is situated in the Sanctuary of Our Lady of Leśniów, to get water. This region is part of the Silesian-Cracow monocline, specifically the Kraków-Częstochowa Upland (Okoń et al. 2020). There are soils composed of clays, dusts, and brown earth in the examined area, as well as calcareous sands with a narrower range.

Here, the average yearly temperature is between 7.5 and 8.0°C. The warmer half of the year (maximum in July) is when precipitation is most prevalent. 750 mm of rain falls on average each year. The latter two months of the year have the highest relative humidity. According to hydrography, the Czarna Struga (Leśniówka) catchment area is where the spring in Leśniów is located (Figure 1).

The Variscan fold level, the Alpine fold level, and Cenozoic formations are the three structural levels that make up the examined research region. Triassic and Jurassic epicontinental deposits cover the eroded Paleozoic layers, creating a piece of the Silesian-Kraków monocline. Mesozoic deposits in this area can reach a thickness of 700 meters (Heliasz et al. 1992).

Rocky limestones, shoal limestones, and plate limestones with marl intercalations that have been identified within the upper Middle and Upper Oxfordian are examples of the Upper Jurassic (Matyszkiewicz et al. 2006). The rock beds are between 30 and 100 cm thick. Rocky limestones range in hue from white to light cream and are large, compact, and rigid. The thin-bedded marly limestones known as plate limestones have a layer thickness of roughly 10 cm. River sands and gravels up to 50–70 meters thick make up the Quaternary (Matyszkiewicz et al. 2006). In this region, valley depressions up to 20 meters thick are filled with sandy and sandy-silt deposits (Figure 2).

Fig. 1. Study area

Rys. 1. Obszar badań

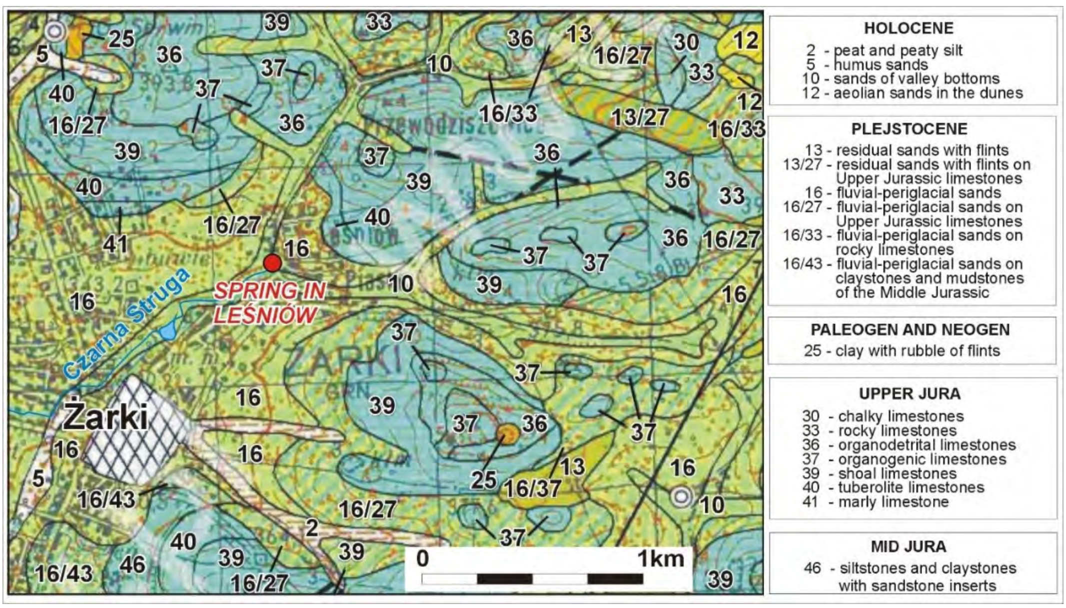

Fig. 2. Geological map of the study area (based on Heliasz et al. 1992)

Rys. 2. Mapa geologiczna badanego obszaru

The spring is situated in a porous, fractured karst medium that is connected to Upper Jurassic strata. On average, Jurassic rocks have a porosity of 9.3%. Due to its limited resources and lack of consistency, the Quaternary aquifer is not very significant in the spring region. The aquifer is no more than five meters thick. These waters are vulnerable to pollution because of the Quaternary zone's direct supply and the aeration zone's moderate thickness. The primary source of water is the Jurassic aquifer. It comprises two aquifer levels. The spring is situated in the aquifer related to the Middle Jurassic sands and sandstones. According to Różkowski et al. (1997), the hydraulic conductivity of the aquifer can reach 5.8 m/d, and its thickness can reach up to 40 meters. The regional outflow from this aquifer is towards the north-east (Figure 3).

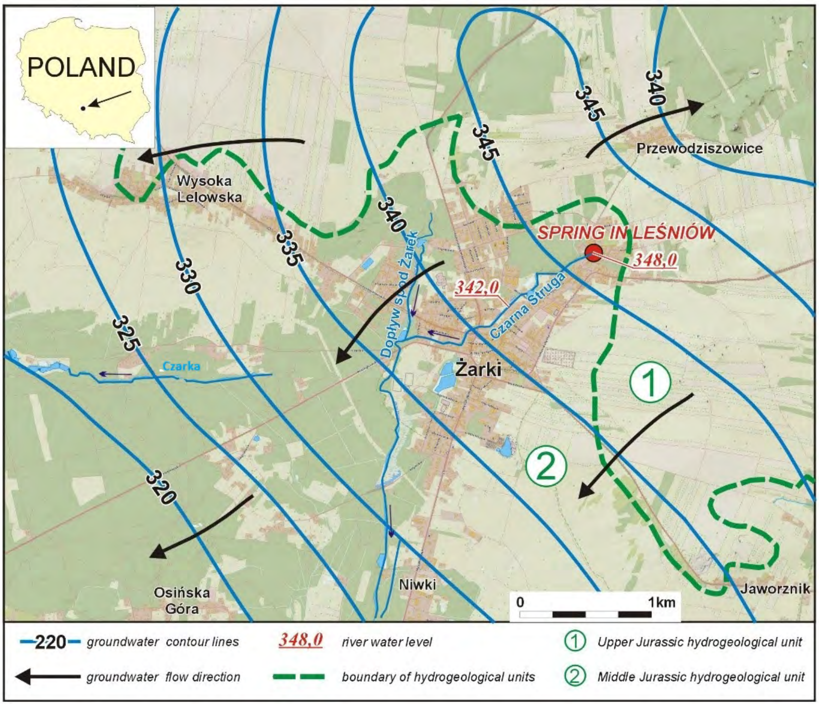

Fig. 3. Hydrogeological map of the study area

Rys. 3. Mapa hydrogeologiczna badanego obszaru

The base of drainage in a hydrodynamic system is a spring. Classified as quality class II, the water needs just basic treatment. The waters in this region are thought to be extremely vulnerable to pollution (Troiano et al. 2009; Singh et al. 2015; Oke et al. 2016), and the time taken for pollutants to reach groundwater has been estimated to be less than 5 years (Biran and Ron 2018).

The research on the spring in Leśniów included three measurement series carried out in November 2023, February and May 2024. The choice of observation months was motivated by the desire to capture the variability of parameters in different seasons. As part of the field work, measurements of flows, temperature, pH, electrical conductivity, and dissolved oxygen were made. The choice of the spring in Leśniów as the research area was dictated by the fact that it is a tourist area from which water for consumption is constantly taken. It is worth paying attention to the quality of spring waters and preventing possible illnesses after drinking water containing bacteria or elevated metal concentrations. Physicochemical and bacteriological analyses were performed in an accredited laboratory. In each series, one water sample was collected in the quantity necessary to perform the analysis in the laboratory, with the possibility of repeating the analysis if an analysis error exceeding 10% was detected. Electrical conductivity (EC), pH, Ca^{2+}, Na^+, K^+, Mg^{2+}, Fe^{2+}, Al^{3+}, Mn^{2+}, Ni^{2+}, Cu^{2+}, Sr^{2+}, S^{2-}, Cl^-, SO_4^{2-}, HCO_3^-, NO_3^-, NO_2^-, NH_4^+, PO_4^{3-}, Kjeldahl nitrogen, TOC, Pb^{2+}, Cd^{2+}, Cr^{6+}, Hg^+, Zn^{2+} and alkalinity were analyzed. The number of coliforms, the number of *Escherichia coli*, the number of enterococci, the number of *Clostridium perfringens*, the total number of microorganisms at a temperature of 22±2°C, the number of *Pseudomonas aeruginosa* and the total number of microorganisms at a temperature of 36±2°C were determined. Each parameter was measured once, without repetitions. The parameters were selected as the best to assess possible water contamination by fecal bacteria (Biran and Ron 2018). The following standards were taken into account in the laboratory tests: PN-EN ISO 11885:2009 (metals except mercury), PN-ISO 9297:1994 (chlorides), PN-ISO 9280:2002 (sulfates), PN-EN ISO 9963 -1:2001 (bicarbonates), PN-EN ISO 13395:2001 (nitrogen compounds), PN-EN ISO 6878:2006 point 4 (phosphates), PN-EN 1484:1999 (total organic carbon), PN-EN ISO 12846 :2012 point 7 (mercury), PN-EN 27888:1999 (conductivity), PN-EN ISO 9308-1:2014-12, PN-EN ISO 9308-1:2014-12/A1:2017-04 (coli bacteria), PN-EN ISO 7899-2:2004 (number of enterococci), PN-EN ISO 14189:2016-10 (number of *Clostridium perfringens*), PN-EN ISO 16266:2009 (number of *Pseudomonas aeruginosa*), PN-EN ISO 6222:2004 (total number of microorganisms at 22±2°C and total number of microorganisms at 36±2°C). In the case of the PN-EN ISO 11885:2009 Methodology, an ICP-OES Optima 7300 DV from Perkin Elmer was used, and for the PN-EN ISO 12846:2012 Methodology point 7, PN-EN ISO 12846:2012/Ap1:2016-07 (Mercury), a CV-AAS PinAAcle 900T from Perkin Elmer was used. The total number of microorganisms was determined by deep inoculation, and the rest of the parameters were examined by membrane filtration.

The flow rate in the spring was determined using the bucket method (Nielsen 2006). To obtain more reliable results, the flow tests were repeated three times. The results of the physicochemical and bacteriological analyses were compared with the permissible values in the Regulation of the Minister of Health of December 7, 2017, on the quality of water intended for human consumption, the Regulation of the Minister of Maritime Economy and Inland Navigation of October 11, 2019, on the criteria and method of assessing the status of groundwater bodies and the standards from the Guidelines for Drinking-water Quality (GDWQ) proposed by WHO (Harichandan et al. 2017).

The Water Quality Index (WQI) and the Nemerow Index (NPI) were chosen as metrics to evaluate the danger to water. Reference values for drinking water were taken from the national standard. The Nemerow Pollution Index is one of the most commonly used techniques for assessing water quality (Adimalla and Qian 2019; Szkleniarz 2024). It is calculated based on the following formula (Equation 1):

$$NPI = \frac{C_i}{L_i} \tag{1}$$

C_i – measured value of the *i*-th parameter,
L_i – allowable limit of the *i*-th parameter (based on the regulation).

An NPI value of less than 1 suggests low pollution, a value from 1 to 3 equals to moderate pollution, a value from 3 to 6 and the remaining values indicate very high pollution. The index was determined based on the parameters EC, Na, Mg, Fe, Al, Mn, Ni, Cl, SO_4, nitrogen compounds, Pb, Cd, Cr, and Hg according to the values outlined in the Regulation of the Minister of Health of December 7, 2017, pertaining to the quality of water intended for human consumption. The Water Quality Index was calculated for each series based on the same regulation norms according to the following procedure (Bhuiyan et al. 2016):

- weights were assigned to the physicochemical parameters,
- a rating scale was developed,
- the WQI was calculated.

On the basis of the literature (Karkocha 2021), the WQI was calculated for six selected parameters: dissolved oxygen (0.22), total number of microorganisms at 22±2°C (0.21), pH (0.15), total phosphate (0.13), nitrates (0.13), and EC (0.16) using Equation 2:

$$q_i = \frac{C_i}{S_i} \cdot 100 \tag{2}$$

C_i – concentration of parameters,
S_i – standard value of parameters from the regulation.

The WQI was calculated using Equation 3:

$$WQI = \sum_{n=1}^{N} SI \tag{3}$$

SI – subindex calculated from Equation 4:

$$SI = W_i \cdot q_i \tag{4}$$

Water is categorized by the index into three classes:

- WQI 50 for excellent water,
- WQI 50–100 for good water,
- WQI 100 for poor water.

This choice of indices was made because they are among the most widely used metrics for evaluating the quality of water and estimating the risk to it, they allow for parameter selection in the final calculation of the value, and they allow for comparison of the results with those from other research sites.

2. Results and discussion

The spring discharge measurement results were 22 l/s in November 2023, 31 l/s in February, and 17 l/s in May 2024. The water temperature results were 8.6, 9.5, and 10.5°C, respectively. With the exception of the mercury level in the first measurement series and the dissolved oxygen, all other parameters satisfied the standards when the findings of the chemical analyses were compared to the limit values specified in the drinking water quality regulation (Table 1). The nickel readings were precisely inside the acceptable limit. When comparing the results obtained in relation to the limit for the first quality class under the regulation on the assessment of groundwater quality, there were exceedances in the calcium content in the first and second measurement series, bicarbonates in the same two series, nitrates in all measurements, and mercury in the first measurement series. With a few exceptions, the WHO's current requirements have the fewest parameters. Only the mercury content in the first measurement series presents a concern with reference to these standards. The water in the spring is of the bicarbonate– calcium chemical type.

The value of electric conductivity ranged from 332 µS/cm (May) to 399 µS/cm (February). Electric conductivity is a parameter used to indirectly assess water mineralization, which can be connected with anthropogenic pollution in shallow waters, in which case it may exceed 1000 µS/cm (Biran and Ron 2018; Chathuranika et al. 2023). The obtained EC values are mostly typical for this area. However, it is worth noting that the highest values were observed in the winter series. This is related to higher amounts of precipitation and increased water supply, and thus greater mobilization of water, which leads to increased mineral dissolution. Conversely, with higher temperatures and low rainfall in April, EC was approximately 20% lower than in the winter series. For the three measurement series, the majority of the metrics stayed rather stable. The amount of potassium, magnesium, bicarbonates, and sulfates rose in the second measurement series, which also had the greatest EC value.

The most controversial issue in the analyzed samples may be the mercury content in the first measurement series. Such a high concentration in a single measurement series must be the result of episodic water pollution in this region, which may be related to the close proximity of houses with no sewage system, the route of a road, or pollution from agricultural fields. The nearest road is 20 meters from the spring, and there are agricultural

Table 1. Physicochemical parameters

Tabela 1. Parametry fizykochemiczne

Physicochemical parameters	Unit	November 2023	February 2024	May 2024	St. dev.	Relative difference [%]	Limits for drinking water[1]	Limits for the first class of quality[2]	WHO standards[3]
EC	µS/cm	384	399	332	35.16	20.18	2,500	700	400
Na	mg/l	5.5	5.8	2.5	1.82	132	200	60	
K	mg/l	0.5	1.5	0.5	0.58	200	–	10	
Ca	mg/l	90	89	41	28.01	117.07	–	50	
Mg	mg/l	1.5	3.4	0.71	1.38	378.87	125	30	
Fe	mg/l	0.002	0.002	0.002	0.00	0	0.2	0.2	
Al	mg/l	0.005	0.005	0.005	0.00	0	0.2	0.1	
Mn	mg/l	0.0005	0.006	0.0005	0.00	1100	0.05	0.05	0.4
Ni	mg/l	0.002	0.002	0.002	0.00	0	0.002	0.005	0.07
Cu	mg/l	0.002	0.002	0.002	0.00	0	–	0.01	2
Sr	mg/l	0.066	0.066	0.066	0.00	0	–		
S	mg/l	9.5	11	12	1.26	–8.33	–		
Cl	mg/l	13	13	13	0.00	0	250	60	200
SO_4	mg/l	36	40	34	3.06	17.65	250	60	
HCO_3	mg/l	202	208	179	15.31	16.20	–	200	
NO_3	mg/l	26	24	21	2.52	14.28	50	10	50
NO_2	mg/l	0.03	0.03	0.03	0.00	0	0.5	0.03	3
NH_4	mg/l	0.065	0.065	0.065	0.00	0	0.5	0.5	
PO_4	mg/l	0.13	0.11	0.22	0.06	–50	–	0.5	
N_K	mg/l	2.5	2.5	2.5	0.00	0	–		1.5
TOC	mg/l	1	1	1	0.00	0	–	5	
Pb	mg/l	0.002	0.002	0.002	0.00	0	0.01	0.01	0.01
Cd	mg/l	0.00025	0.00025	0.00025	0.00	0	0.005	0.001	0.003
Cr	mg/l	0.0015	0.0015	0.0015	0.00	0	0.05	0.01	0.05
Hg	mg/l	0.031	0.00012	0.00012	0.02	0	0.001	0.001	0.006
Zn	mg/l	0.0025	0.022	0.0025	0.01	780	–	0.05	
Alkalinity	mg/l $CaCO_3$	166	171	147	12.66	16.32	–		
Dissolved oxygen (DO)	mg/l	10.5	10.1	9.7	0.40	4.12	8		
pH		7.36	7.01	7.03	0.20	–0.28	6.5–8.5	6.5–9.5	6.5–8.5

[1] Regulation of the Minister of Health of December 7, 2017, on the quality of water intended for human consumption.

[2] Regulation of the Minister of Maritime Economy and Inland Navigation of October 11, 2019, on the criteria and method of assessing the status of groundwater bodies.

[3] The Guidelines for drinking-water quality (GDWQ) proposed by the WHO.

fields approximately 300 meters away. These potential polluting facilities are located in the inflow of the water. The possible effects of such pollution on human health and the preservation of water resources make such high mercury concentrations – more than 30 times higher than the allowable standard for drinking water – worthy of serious consideration, even though they only happened during the autumn series. Mercury, like most metals, very easily accumulates in organisms, causing diseases of the nervous system (Fashola et al. 2016; Siudek et al. 2016; Gworek et al. 2017). Mercury has been added to the list of priority pollutants because of the high levels of this element in the air (Kumar et al. 2023). Fossil fuels and the smelting and burning of solid waste are the primary sources of mercury in the atmosphere. It is important to remember that mercury moves from the atmosphere into the soil and water, raising the element's concentration in water.

More attention should also be paid to nitrate concentrations in the vicinity of this source. Their concentration does not exceed the standard for water intended for drinking, but it is much higher than the standard for first-class quality groundwater. High concentrations of nitrates in water are most often a consequence of pollution from agricultural fields or leaky septic tanks (Ward et al. 2018). It should be taken into account that nitrates may have a negative impact on health and are also considered ingredients in the formation of carcinogens.

Regarding the microbiological parameters, it is important to remember that coliform bacteria were detected in each measurement series. The permissible standard for drinking water is 0 cfu/100 ml, while the average concentration in water is 20 cfu/100 ml. Additionally, *Escherichia coli was* noted in the first two sequences. Two indicators, namely the total number of microorganisms at 22±2°C and the total number of microorganisms at 36±2°C, were also high when compared to the relevant standards (Table 2).

According to Weststrate et al. (2019), *Escherichia coli* is a great indicator of fecal water pollution. Water contamination is caused by mesophilic bacteria that are naturally present in the human body along with excrement. These pollutants may also migrate into springs as a result of increased rainfall. It is important to note that these bacteria have a higher chance of surviving in water under neutral and alkaline conditions. This spring's water has a somewhat high alkalinity (Table 1). One of the variables affecting the makeup of bacterial communities is water temperature, which gives particular bacterial species a competitive edge within particular temperature ranges. It is evident from the findings of the three bacteriological studies that the bacterial content falls with decreasing temperature (Hadi et al. 2021).

The Nemerow Index values for the individual measurement series were 34.82, 3.99, and 2.91, respectively (Figures 4–6). Since mercury was found at a much higher concentration than the permissible limit in the first measurement series, it contributed roughly 92% of the indicator's total value in the November series.

In the same measurement series, calcium and nickel together contributed approximately 3% of the total NPI value. However, it should be noted that the nickel concentration is at the limit of the permissible standard. According to the NPI classification, water collected in November would have been of poor quality and highly polluted.

Table 2. Bacteriological analysis results

Tabela 2. Wyniki analizy bakteriologicznej

Microbiological parameters	Unit	November 2023	February 2024	May 2024	St. dev.	Limits for drinking water[1]	WHO standards[2]
The number of coliform bacteria	cfu/100 ml	35	7	16	14.29	0	0
Escherichia coli	cfu/100 ml	13	3	0	6.81	0	
Number of enterococci	cfu/100 ml	0	0	0	0	0	0
Number of *Clostridium perfringens*	cfu/100 ml	0	0		0	0	0
Total number of microorganisms at 22±2°C	cfu/ml	27	0	300	165.96	100	100
Number of *Pseudomonas aeruginosa*	cfu/100 ml	0	0	0	0	0	0
Total number of microorganisms at 36±2°C	cfu/ml	0	0	48	27.71	20	20

[1] Regulation of the Minister of Health of December 7, 2017, on the quality of water intended for human consumption.
[2] The Guidelines for drinking-water quality (GDWQ) proposed by the WHO.

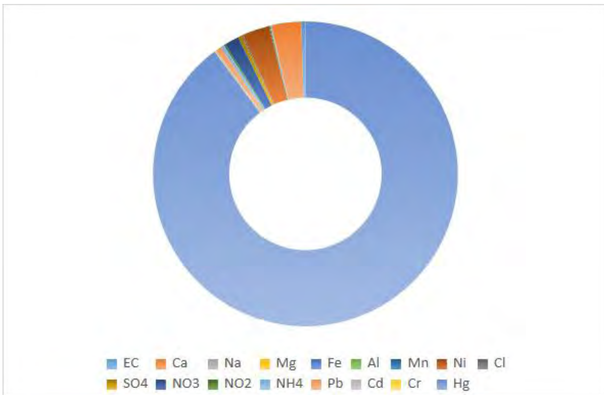

Fig. 4. The proportion of each NPI parameter in the initial measurement series

Rys. 4. Udział poszczególnych parametrów NPI w początkowej serii pomiarowej

The index values obtained in the second and third measurement series are much lower and classify water as moderately polluted or in the same class as the first series, but the index itself is slightly lower than 4 (Figure 5).

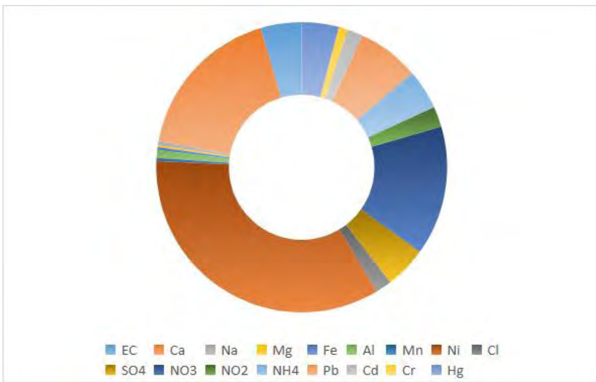

Fig. 5. The proportion of each NPI parameter in the second measurement series

Rys. 5. Udział poszczególnych parametrów NPI w drugiej serii pomiarowej

A sizable portion (roughly 38%) was contributed by nickel, as the composition of this index in the analysis of the second measurement series shows. Based solely on the indicator value, we might draw the conclusion that there is nickel contamination in the water of the Leśniów spring. Meanwhile, the measured values of this parameter are again on the border of the permissible value for drinking water. Approximately 18% of the total index value in this series was contributed by nitrates. This percentage confirms that special attention should be paid to this parameter when monitoring water in this area. However, looking at the concentrations themselves, the nitrate content in the second measurement series was 2 mg/l lower than that in the autumn measurements.

In the third measurement series, the lowest NPI result was obtained. This is due to the decrease in the value of the previously mentioned ingredients. However, calcium and nitrates contributed a significantly larger percentage of the total value of the NPI (Figure 6). In the third measurement series, the values of these components decreased compared to the second series. The decrease is particularly significant in the case of calcium (Table 1).

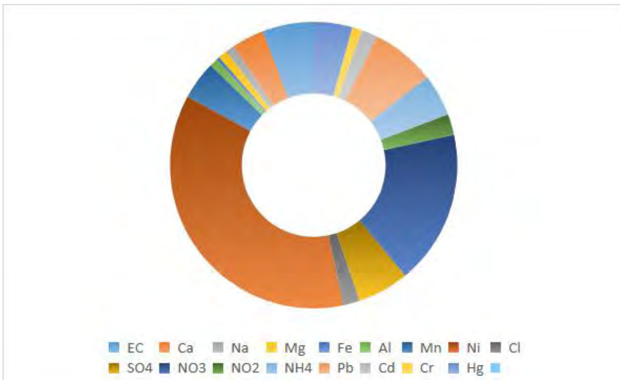

Fig. 6. The proportion of each NPI parameter in the third measurement series

Rys. 6. Udział poszczególnych parametrów NPI w trzeciej serii pomiarowej

Poland's spring waters have not yet been evaluated using this index. It has mainly been applied to evaluate groundwater quality near pollution hotspots. Because different sets of parameters are used at each location, it is challenging to compare the NPI values that are obtained. In the case of water in the vicinity of the municipal waste landfill in Tychy (also in southern Poland), record high values of this index were noted, surpassing 1,400 (Dąbrowska and Witkowski 2022). In the case of other landfill sites, the values of this index reached 20 (Łukasik and Dąbrowska 2022), taking into account the upper limit of the value for the third class of water quality based on the regulation mentioned above.

The second index that was used to assess water quality was the WQI. To calculate this index, parameters measured in the field, physicochemical parameters, and one bacteriological parameter were used. EC, pH, DO, NO_3, and PO_4 values were used for the calculations. The following values of this indicator were obtained in individual series: 62.91, 54.49, and 118.09. The percentages of the individual parameters for the three measurement series are presented in Figures 7–9. According to the previously mentioned classification, the first two series indicate good quality water, and the third series indicates poor quality water.

Rather, the value of the number of coliform bacteria, the final parameter – the total number of microorganisms at 22±2°C – was chosen as the bacteriological parameter. The WQI is determined by applying a particular weight to a given parameter and comparing the measured value to the acceptable standard. Regretfully, the standard has a value of 0 for the quantity of coliform bacteria. This would require dividing by 0, which is, of course, impossible. In this situation, it is appropriate to state that this parameter has been exceeded and not take it into account for further calculations. The values of this parameter vary in individual measurement series, so it is difficult to clearly determine how much they deviate from the norm. It was decided to choose a parameter whose permissible limit is 100. The state of the water supply network and the functionality of the treatment system can be evaluated using this parameter. It should be noted that a categorical value of this parameter is not specified in the legal regulations, necessitating its monitoring to identify results that differ from the normal state, which is estimated through repeated testing. 27 cfu/ml was found in the first measurement series, no microorganisms were found at all in the second, and 300 cfu/ml was found in the third. Nevertheless, considering the bacteriological data acquired, this parameter was the only logical choice.

In the first measurement series, dissolved oxygen contributed the largest share of the total index value. However, it is difficult to assess the quality of water based on a parameter that largely determines the taste of water. Despite the fact that the pH was within the normal range, it contributed 25% of the total WQI value (Figure 7).

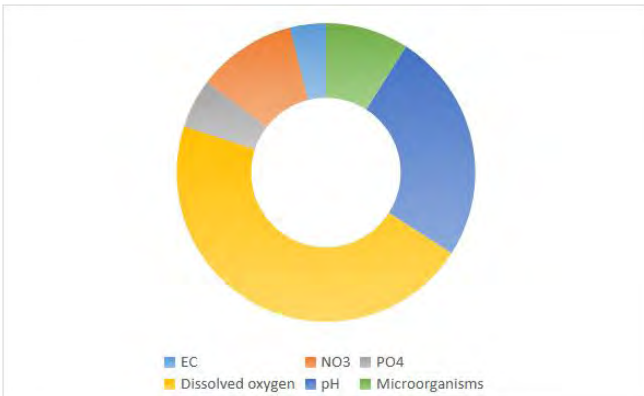

Fig. 7. The proportion of each WQI parameter in the initial measurement series

Rys. 7. Udział poszczególnych parametrów WQI w początkowej serii pomiarowej

Since there were no microorganisms discovered in the second measurement series, the percentage of the remaining ingredients was higher (Figure 8).

A significant increase in the value of the WQI in the third measurement series was the result of an increase in the number of microorganisms to 300 cfu/ml. This is three times

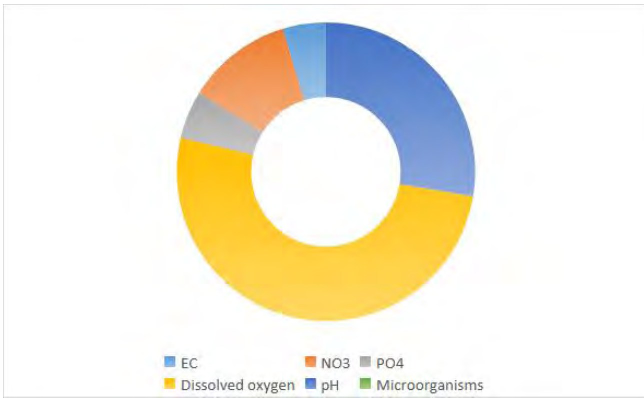

Fig. 8. The proportion of each WQI parameter in the second measurement series

Rys. 8. Udział poszczególnych parametrów WQI w drugiej serii pomiarowej

the limit for drinking water. Overall, this parameter contributed over 50% of the total index value (Figure 9). About 22% of the value was contributed by dissolved oxygen. It should be mentioned that conductivity contributed the smallest share of the WQI for all three measurement series.

The obtained WQI index values are comparable to those obtained for other springs located in the southern part of Poland (Ruman and Dąbrowska 2024). Additionally, monitoring studies are underway in other springs located in the Kraków–Częstochowa Upland for which the WQI exceeds the value of 100.

Raw laboratory findings should also be examined while evaluating the water quality in Leśniów's spring using the two suggested indices. The NPI values indicate that the water

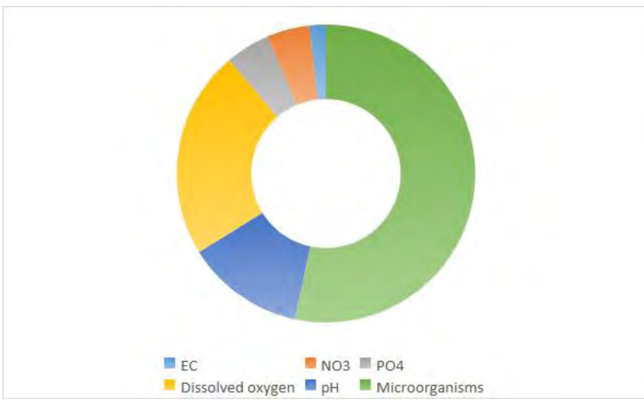

Fig. 9. The proportion of each WQI parameter in the third measurement series

Rys. 9. Udział poszczególnych parametrów WQI w trzeciej serii pomiarowej was most polluted in the first measurement series, while the WQI values suggest that the greatest pollution was observed in the spring series. In both cases, the total index value depends on a single parameter. For the first measure, this is a significant increase in the content of mercury, and for the second measure, it relates to microorganisms. However, based on changes in conductivity, it can be concluded that the spring series contained the most dissolved substances. Selected indicators are helpful in assessing water quality and risk analysis, but they should always be treated as one of several elements.

Similar studies of water quality in karst springs were conducted, among others, by Cahyadi et al. (2024, 2025). The first study determined which factors negatively affect the quality of spring water. Among others, the interaction process between water and rock, causing the process of dissolving carbonate rock, the use of septic tanks, land degradation, erosion processes, and excessive fertilizer usage were indicated. Some of these factors are also observed in the area of karst springs in Poland. The second study obtained the results of the WQI index corresponding to excellent water quality. It is worth noting that the measurement series were divided depending on the dry and rainy seasons. Relatively better results were obtained in the rainy season, due to the fact that any contamination was diluted by precipitation. In the case of karst springs in Poland, it would be possible to determine the seasonality of changes in the index with multi-year studies of water quality.

Conclusions

The article's objectives were to present the results of chemical analyses for three monitoring series, highlight the risks to the water quality in the examined spring, the importance of natural springs in preserving the appropriate chemical state of waters, and the necessity of routine environmental monitoring of such establishments. It was achieved by conducting three series of tests, comparing these results with current standards, calculating the NPI and WQI, and determining further steps in monitoring.

The majority of the parameters continue to be normal, according to the results of physicochemical analyses. The mercury content of the first measurement series is the exception, and it could occasionally lead to contamination. The tested waters had relatively high nitrate levels, but they didn't exceed the allowable limits for drinking water. Microbiological factors are also worthy of consideration. Coliform bacterial contamination (ranging from 7 to 35 cfu/100 ml), which may have detrimental effects on health, was detected in all measurement series.

The NPI (roughly 3 to approximately 35) and WQI (roughly 55 to approximately 120) values serve as the foundation for evaluating water quality and identifying parameters that should be covered by basic monitoring; however, they should only be considered one component of a larger risk analysis addressing human health and water quality. Comprehensive laboratory analyses and a thorough examination of the hydrogeological conditions ought to form the basis of this analysis. It should be noted that there will be no monitoring this spring.

It is worth noting that the tests performed were occasional. In order to determine the seasonality of water quality changes this spring, and to eliminate possible errors, the tests should be conducted continuously.

The commune where the spring is located should carry out additional routine or ongoing assessments of the physicochemical and bacteriological parameters of the water. This is extremely important in the context of tourism in the region. The Kraków–Częstochowa Upland is visited by about half a million tourists each year, which may negatively affect the quality of water. At the same time, many of these people may drink spring water, which may consequently lead to health problems. Using telemetry systems would be a wise course of action in this situation because they offer a number of benefits, including long-term cost savings, time savings through the elimination of manual data collection, straightforward software, and simple network integration. In terms of public education and health safety maintenance, this is definitely a good solution.

The Authors have no conflict of interest to declare.

REFERENCES

Adeyemo et al 2008 – Adeyemo, O., Adedokun, O., Yusuf, R. and Adeleye, E. 2008. Seasonal changes in physicao-chemical parameters and nutrient load of river sediment in Ibadan city. *Global NEST Journal* 10(3), pp. 326–336.

Adimalla, N. and Qian, H. 2019. Groundwater quality evaluation using water quality index (WQI) for drinking purposes and human health risk (HHR) assessment in an agricultural region of Nanganur, South India. *Ecotoxicology and Environmental Safety* 176, pp. 153–161, https://doi.org/10.1016/j.ecoenv.2019.03.066.

Ansari et al. 2015 – Ansari, M.A., Deodhar, A., Kumar, U.S. and Khatti, V.S. 2015. Water Quality of Few Springs in Outer Himalayas – a Study on the Groundwater–Bedrock Interactions and Hydrochemical Evolution. *Groundwater for Sustainable Development* 1(1–2), pp. 59–67, https://doi.org/10.1016/j.gsd.2016.01.002.

Asnin et al. 2022 – Asnin, S.N., Nnko, M., Josephat, S., Mahecha, A., Mshiu, E., Bertotti, G. and Brehme, M. 2022. Identification of Water–Rock Interaction of Surface Thermal Water in Songwe Medium Temperature Geothermal Area, Tanzania. *Environmental Earth Sciences* 81, https://doi.org/10.1007/s12665-022-10594-4.

Backman et al. 1998 – Backman, B., Bodis, D., Lahermo, P., Rapant, S. and Tarvainen, T. 1998. Application of a contamination index in Finland and Slovakia. *Environmental Geology* 36, pp. 55–64, https://doi.org/10.1007/s002540050320.

Badr et al. 2011 – Badr, E., Agrama, A. and Badr, S. 2011. Heavy metals in drinking water and human health, Egypt. *Nutrition and Food Science* 41(3), pp. 210–217, https://doi.org/10.1108/00346651111132484.

Beeckman et al. 2018 – Beeckman, F., Motte, H. and Beeckman, T. 2018. Nitrification in Agricultural Soils: Impact, Actors and Mitigation. *Current Opinion in Biotechnology* 50, pp. 166–173, https://doi.org/10.1016/j.copbio.2018.01.014.

Bhuiyan et al. 2016 – Bhuiyan, M., Bodrud-Doza, M., Islam, A., Rakib, M., Rahman, M. and Ramanathan, A. 2016. Assessment of groundwater quality of Lakshimpur district of Bangladesh using water quality indices, geostatistical methods, and multivariate analysis. *Environmental Earth Sciences* 75, https://doi.org/10.1007/s12665-016-5823-y.

Biran, D. and Ron, E.Z. 2018. Extraintestinal pathogenic Escherichia coli. *Current Topics in Microbiology and Immunology* 416, pp. 149–61.

Cahyadi et al. 2024 – Cahyadi, A., Riyanto, I.A., Acintya, R., Singgih, A. and Putra, R.D. 2024. Characterization of water pollution in Tropical Epikarst Spring in Gunungsewu Karst area, Java Island, Indonesia. *Turkish Journal of Engineering*, https://doi.org/10.31127/tuje.1524600.

Cahyadi et al. 2025 – Cahyadi, A., Riyanto, I., Ismayuni, N., Wacano, D., Putra, R. and Singgih, A. 2025. Temporal variation in the water quality Index of Baron Tropical Karst Spring, Gunungsewu Karst Area, Indonesia. *Iraqi Geological Journal* 58(1C), pp. 188–207, https://doi.org/10.46717/igj.58.1c.15ms-2025-3-30.

Chathuranika et al. 2023 – Chathuranika, I.M., Sachinthanie, E., Zam, P., Gunathilake, M.B., Denkar, D., Muttil, N., Abeynayaka, A., Kantamaneni, K. and Rathnayake, U. 2023. Assessing the water quality and status of water resources in urban and rural areas of Bhutan. *Journal of Hazardous Materials Advances* 12, https://doi.org/10.1016/j.hazadv.2023.100377.

Chen et al. 2017 – Chen, Z., Auler, A.S., Bakalowicz, M., Drew, D., Griger, F., Hartmann, J., Jiang, G., Moosdorf, N., Richts, A., Stevanovic, Z., Veni, G. and Goldscheider, N. 2017. The World Karst Aquifer Mapping project: concept, mapping procedure and map of Europe. *Hydrogeology Journal* 25, pp. 771–785, https://doi.org/10.1007/s10040-016-1519-3.

Dąbrowska, D. and Witkowski, A.J. 2022. Groundwater and Human Health Risk Assessment in the Vicinity of a Municipal Waste Landfill in Tychy, Poland. *Applied Sciences* 12(24), https://doi.org/10.3390/app122412898.

Fashola et al. 2016 – Fashola, M., Ngole-Jeme, V. and Babalola, O. 2016. Heavy Metal Pollution from Gold Mines: Environmental Effects and Bacterial Strategies for Resistance. *International Journal of Environmental Research and Public Health* 13(11), https://doi.org/10.3390/ijerph13111047.

Geyer et al. 2007 – Geyer, T., Birk, S., Licha, T., Liedl, R. and Sauter, M. 2007. Multitracer Test Approach to Characterize Reactive Transport in Karst Aquifers. *Groundwater* 45, pp. 36–45, https://doi.org/10.1111/j.1745-6584.2006.00261.x.

Gworek et al. 2017 – Gworek, B., Dmuchowski, W., Baczewska, A.H., Brągoszewska, P., Bemowska-Kałabun, O. and Wrzosek-Jakubowska, J. 2017. Air Contamination by Mercury, Emissions and Transformations – a Review. *Water, Air, and Soil Pollution* 228, https://doi.org/10.1007/s11270-017-3311-y.

Hadi et al. 2021 – Hadi, M., Hoese, M. and Tornyeviadzi, R. 2021. Modelling the impact of water temperature, pipe, and hydraulic conditions on water quality in water distribution networks. *Water Practice and Technology* 16(2), pp. 387–403, https://doi.org/10.2166/wpt.2021.002.

Hamed et al. 2024 – Hamed, Y., Hadji, R., Ahmadi, R., Ayadi, Y., Shuhab, K. and Pulido-Bosch, A. 2024. Hydrogeological investigation of karst aquifers using an integrated geomorphological, geochemical, GIS, and remote sensing techniques (Southern Mediterranean Basin – Tunisia). *Environment, development and sustainability* 26(3), pp. 6943–6975, https://doi.org/10.1007/s10668-023-02994-8.

Harichandan et al. 2017 – Harichandan, A., Sekhar, P.H. and Mohan, S.K. 2017. Evaluation of Water Quality of Local Streams at Gandhamardan Iron Mines, Suakati, Keonjhar District of Odisha, India. *Journal of Pollution Effects and Control* 5(3), https://doi.org/10.4172/2375-4397.1000199.

Heliasz et al. 1992 – Heliasz, Z., Lewandowski, J. and Liszkowski, J. 1992. *Detailed Geological Map of Poland. Arkusz Żarki.* Sosnowiec: PGI.

Janik et al. 2024 – Janik, K., Ślósarczyk, K. and Sitek, S. 2024. Study of Riverbank Filtration Effectiveness in the Kępa Bogumiłowicka Well Field, Southern Poland. *Journal of Hydrology: Regional Studies* 53, https://doi.org/10.1016/j.ejrh.2024.101834.

Juntunen et al. 2017 – Juntunen, J., Meriläinen, P. and Simola, A. 2017. Public Health and Economic Risk Assessment of Waterborne Contaminants and Pathogens in Finland. *Science of the Total Environment* 599–600, pp. 873–882, https://doi.org/10.1016/j.scitotenv.2017.05.007.

Karkocha, R. 2021. Assessment of Changes in the Quality of Groundwater in the Region of the Municipal Landfill in Wojkowice. *Acta Scientiarum Polonorum-Formatio Circumiectus* 20(1), pp. 43–54, https://doi.org/10.15576/ASP.FC/2021.20.1.43.

Katz et al. 2011 – Katz, B., Eberts, S. and Kauffman, L. 2011. Using Cl/Br Ratios and Other Indicators to Assess Potential Impacts on Groundwater Quality from Septic Systems: A Review and Examples from Principal Aquifers in the United States. *Journal of Hydrology* 397(3–4), pp. 151–166, https://doi.org/10.1016/j.jhydrol.2010.11.017.

Kayastha, S. 2015. Geochemical Parameters of Water Quality of Karra River, Hetauda Industrial Area, Central Nepal. *Journal of Institute of Science and Technology* 20(2), pp. 31–36, https://doi.org/10.3126/jist.v20i2.13945.

Kumar et al. 2017 – Kumar, M., Ramanathan, A., Tripathi, R., Farswan, S., Kumar, D. and Bhattacharya, P. 2017. Study of Trace Element Contamination Using Multivariate Statistical Techniques and Health Risk Assessment in Groundwater of Chhaprola Industrial Area, Gautam Buddha Nagar, Uttar Pradesh, India. *Chemosphere* 166, pp. 135–145, https://doi.org/10.1016/j.chemosphere.2016.09.086.

Kumar et al. 2023 – Kumar, M., Singh, S., Dwivedi, S., Trivedi, A., Dubey, I. and Trivedi, S.P. 2023. Copper-Induced Genotoxicity, Oxidative Stress, and Alteration in Transcriptional Level of Autophagy-Associated Genes in Snakehead Fish Channa Punctatus. *Biological Trace Element Research* 201, pp. 2022–2035, https://doi.org/10.1007/s12011-022-03301-8.

Lahr, J. and Kooistra, L. 2010. Environmental risk mapping of pollutants: State of the art and communication aspects. *Science of the Total Environment* 408(18), pp. 3899–3907, https://doi.org/10.1016/j.scitotenv.2009.10.045.

Li et al. 2023 – Li, Q., Han, Z., Tian, Y., Xiao, H. and Yang, M. 2023. Risk Assessment of Heavy Metal in Farmlands and Crops Near Pb–Zn Mine Tailing Ponds in Niujiaotang, China. *Toxics* 11(2), https://doi.org/10.3390/toxics11020106.

Łukasik, M. and Dąbrowska, D. 2022. Groundwater Quality Testing in the Area of Municipal Waste Landfill Sites in Dąbrowa Górnicza (Southern Poland). *Environmental and Socio-economic Studies* 10, pp. 13–21, https://doi.org/10.2478/environ-2022-0002.

Matyszkiewicz et al. 2006 – Matyszkiewicz, J., Krajewski, M. and Żaba, J. 2006. Structural Control on the Distribution of Upper Jurassic Carbonate Buildups in the Kraków–Wieluń Upland (South Poland). *Neues Jahrbuch für Geologie und Paläontologie* 3, pp. 182–192, https://doi.org/10.1127/njgpm/2006/2006/182.

Meng et al. 2016 – Meng, Q., Zhang, J., Zhang, Z. and Wu, T. 2016. Geochemistry of Dissolved Trace Elements and Heavy Metals in the Dan River Drainage (China): Distribution, Sources, and Water Quality Assessment. *Environmental Science and Pollution Research* 23, pp. 8091–8103, https://doi.org/10.1007/s11356-016-6074-x.

Nielsen, D. 2006. Practical Handbook of Environmental Site Characterization and Ground-Water Monitoring, Second Edition, 2nd ed., Ed.; CRC Press: Boca Raton, FL.

Oke et al. 2016 – Oke, S., Vermeulen, D. and Gomo, M. 2016. Aquifer vulnerability assessment of the Dahomey Basin usingthe RTt method. *Environmental Earth Sciences* 75, https://doi.org/10.1007/s12665-016-5792-1.

Okoń et al. 2020 – Okoń, D., Błońska, A., Różkowski, J. and Wojtal, A. 2020. Natural and Anthropogenic Factors Controlling the Calcareous Springs Biodiversity (Cracow-Częstochowa Upland, Poland). *Ecohydrology and Hydrobiology* 20(4), pp. 644–659, https://doi.org/10.1016/j.ecohyd.2020.06.007.

Paikaray, S. and Mahajan, T. 2023. Hydrogeochemical Processes, Mobilization Controls, Soil-Water-Plant-Rock Fractionation and Origin of Fluoride around a Hot Spring Affected Tropical Monsoonal Belt of Eastern Odisha, India. *Applied Geochemistry*, 148, 105521, https://doi.org/10.1016/j.apgeochem.2022.105521.

Qin et al. 2017 – Qin, G., Han, Z., Tan, Y., Xiao, H. and Yang, M. 2017. Chemical characteristics and quality evaluation of shallow groundwater in a typical karst plateau basin of Guizhou province: A case study of Houzhai river in Puding country. *Environmental Chemistry* 36, pp. 858–866.

Quan et al. 2023 – Quan, B., Tang, J., Niu, X., Su, P., Zhang, Z. and Yang, Y. 2023. Elaborating the Occurrence and Distribution of Per- and Polyfluoro-alkyl Substances in Rivers and Sediment around a Typical Aging Landfill in China. *Toxics* 11(10), https://doi.org/10.3390/toxics11100852.

Różkowski et al. 1997 – Różkowski, A., Siemiński, A., Pacholewski, A. and Zembal, M. 1997. *Explanations for the hydrogeological map of Poland on a scale of 1:50,000. Żarki sheet.* Warszawa: PGI.

Ruman, M. and Dąbrowska, D. 2024. Evaluation of Water Quality from the Zimny Sztok Spring (Southern Poland) – Preliminary Results. *Sustainability* 16(12), https://doi.org/10.3390/su16124962.

Sari et al. 2022 – Sari, M.M., Andarani, P., Notodarmojo, S., Harryes, R., Nguyen, M., Yokota, K. and Inoue, T. 2022. Plastic Pollution in the Surface Water in Jakarta, Indonesia. *Marine Pollution Bulletin* 182, https://doi.org/10.1016/j.marpolbul.2022.114023.

Shukla, S. and Saxena, A. 2020. Sources and Leaching of Nitrate Contamination in Groundwater. *Current Science* 118, http://dx.doi.org/10.18520/cs/v118/i6/883-891.

Singh et al. 2015 – Singh, R., Venkatesh, A., Syed, T., Reddy, A., Kumar, M. and Kurakalva, R. 2015. Assessment of potentially toxic trace elements contamination in groundwater resources of the coal mining area of the Korba Coalfield, Central India. *Environmental Earth Sciences* 76, https://doi.org/10.1007/s12665-017-6899-8.

Siudek et al. 2016 – Siudek, P., Frankowski, M. and Siepak, J. 2016. Atmospheric Particulate Mercury at the Urban and Forest Sites in Central Poland. *Environmental Science and Pollution Research* 23, pp. 2341–2352, https://doi.org/10.1007/s11356-015-5476-5.

Szkleniarz, J. 2024. Application of Selected Groundwater Quality Indices in Anthropogenically Transformed Areas. *Prace Komisji Geografii Przemysłu Polskiego Towarzystwa Geograficznego* 38, https://doi.org/10.24917/20801653.381.3.

Talalaj, I. 2014. Assessment of groundwater quality near the landfill site using the modified water quality index. *Environmental Monitoring and Assessment* 186, pp. 3673–3683, https://doi.org/10.1007/s10661-014-3649-1.

Talalaj, I. and Biedka, P. 2016. Use of the Landfill Water Pollution Index (LWPI) for Groundwater Quality Assessment Near the Landfill Sites. *Environmental Science and Pollution Research* 23, pp. 24601–24613, https://doi.org/10.1007/s11356-016-7622-0.

Tamasi, G. and Cini, R. 2004. Heavy metals in drinking waters from Mount Amiata. Possible risks from arsenic for public health in the province of Siena. *Science of the Total Environment* 327(1–3), pp. 41–51, https://doi.org/10.1016/j.scitotenv.2003.10.011.

Thapa et al. 2020 – Thapa, B., Pant, R.R., Thakuri, S. and Pond, G. 2020. Assessment of spring water quality in Jhimruk River Watershed, Lesser Himalaya, Nepal. *Environmental Earth Sciences* 79, https://doi.org/10.1007/s12665-020-09252-4.

Troiano et al. 2009 – Troiano, J., Spurlock, F. and Marade, J. 2009. Update of the California Vulnerability Soil Analysis for Movement of Pesticides to Groundwater. *Department of Pesticide Regulation*.

Vesković et al. 2024 – Vesković, J., Lučić, M., Ristić, M., Perić-Grujić, A. and Onjia, A. 2024. Spatial Variability of Rare Earth Elements in Groundwater in the Vicinity of a Coal-Fired Power Plant and Associated Health Risk. *Toxics* 12(1), https://doi.org/10.3390/toxics12010062.

Ward et al. 2018 – Ward, M., Jones, R., Brender, J., de Kok, T., Weyer, P., Nolan, B., Villanueva, C. and van Breda, S. 2018. Drinking Water Nitrate and Human Health: An Updated Review. *International Journal of Environmental Research and Public Health* 15(7), https://doi.org/10.3390/ijerph15071557.

Weststrate et al. 2019 – Weststrate, J., Dijkstra, G., Eshuis, J., Gianoli, A. and Rusca, M. 2019. The Sustainable Development Goal on Water and Sanitation: Learning from the Millennium Development Goals. *Social Indicators Research* 143, pp. 795–810, https://doi.org/10.1007/s11205-018-1965-5.

Zhu et al. 2023 – Zhu, L., Husny, Z., Samsudin, N., Xu, H. and Han, C. 2023. Deep learning method for minimizing water pollution and air pollution in urban environment. *Urban Climate* 49, https://doi.org/10.1016/j.uclim.2023.101486.

TESTING THE QUALITY OF SPRING WATERS IN TOURIST AREA IN LEŚNIÓW (SOUTHERN POLAND)

Keywords

spring water quality, mercury contamination, coliform bacteria, water quality assessment, public health

Abstract

Springs are important to ecosystems because they are naturally occurring outflows of groundwater to the surface. Spring water quality is often overlooked in areas where the main source for the water supply is, for example, groundwater. Meanwhile, springs located in urban spaces or tourist areas are used as drinking water without any awareness of their chemical state or bacteriological composition. This situation applies not only to Poland, but to many European countries. An example of formations that are highly susceptible to pollution is karst systems. The majority of the parameters continue to be normal, according to the results of physicochemical analyses. The tested waters had relatively high nitrate levels, but they didn't exceed the allowable limits for drinking water.

Tests carried out in three measurement series at the spring in Leśniów (southern Poland) indicate episodic mercury contamination and the consistent existence of the bacterium coliform. This was confirmed by the values of the Nemerow Index (NPI), which ranged from approximately 3 to 35, while the number of coliform bacteria was in the range of 7–35 cfu/100 ml. Values of the Water Quality Index were also calculated. In two series, they were in the range of 50–100, suggesting good quality, and in the third series, they exceeded 100, which indicates poor water quality. The consumption of contaminated water can have detrimental impacts on one's health. As a result, it is critical to regularly monitor water contamination, locate pollution sources, and reduce the likelihood of pollutant migration.

BADANIE JAKOŚCI WÓD ŹRÓDLANYCH W REJONIE TURYSTYCZNYM LEŚNIOWA (POŁUDNIOWA POLSKA)

Słowa kluczowe

jakość wód źródlanych, zanieczyszczenie rtęcią, bakterie coli, ocena jakości wód, ryzyko zdrowotne

Streszczenie

Źródła są ważne dla ekosystemów, ponieważ są naturalnie występującymi wypływami wód podziemnych na powierzchnię. Jakość wody źródlanej jest często pomijana na obszarach, gdzie głównym źródłem zaopatrzenia w wodę jest na przykład woda gruntowa. Tymczasem źródła zlokalizowane w przestrzeniach miejskich lub obszarach turystycznych są wykorzystywane jako woda pitna bez świadomości ich stanu chemicznego lub składu bakteriologicznego. Taka sytuacja nie dotyczy jedynie Polski, lecz także innych krajów europejskich. Przykładem formacji, które są bardzo podatne na zanieczyszczenia, są systemy krasowe. Większość badanych parametrów jest w normie, zgodnie z wynikami analiz fizykochemicznych. Badane wody miały stosunkowo wysokie poziomy azotanów, ale nie przekraczały one dopuszczalnych limitów dla wody pitnej. Testy przeprowadzone w trzech seriach pomiarowych przy źródle w Leśniowie (południowa Polska) wskazują na epizodyczne zanieczyszczenie rtęcią i stałą obecność bakterii coli. Potwierdziły to wartości indeksu Nemerowa (NPI), które wahały się od około 3 do 35, podczas gdy liczba bakterii coli mieściła się w zakresie 7–35 jtk/100 ml. Obliczono również wartości wskaźnika jakości wody. W dwóch seriach mieściły się one w zakresie 50–100, co sugeruje dobrą jakość, a w trzeciej serii przekraczały 100, co wskazuje na słabą jakość wody. Spożywanie zanieczyszczonej wody może mieć szkodliwy wpływ na zdrowie. W związku z tym niezwykle ważne jest regularne monitorowanie skażenia wody, lokalizowanie źródeł zanieczyszczeń i zmniejszanie prawdopodobieństwa migracji zanieczyszczeń.