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Access to Spring Quality Monitoring Data in Poland: Socio-economic Conditions

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Abstract

Monitoring of the quality of groundwater in Poland takes place at over 1,400 points that meet the requirements of the Water Framework Directive. Such points include, among others, wells, piezometers and springs. Access to good quality water is an important problem of the 21st century, which affects not only developing countries. It should be noted that many points from which drinking water is collected are located in urban spaces, where contamination often occurs. Anthropogenic activities may lead to an increase in the level of pollutants such as nitrates, chlorides and heavy metals or an increase in the number of bacteria. The most popular water is from the springs, which is taken by local residents and tourists. Research conducted in selected sources in the Silesian Voivodeship shows that the water consumed by people has increased concentrations of bacteria and some metals, such as iron and mercury. Unfortunately, for economic reasons, only 6 sources in the entire voivodeship are monitored. None of the analyzed points belong to this network.

Keywords: spring; groundwater monitoring; drinking water; health; Poland

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1. Introduction

It is assumed that the quality of life is influenced by health, which is determined by social, economic and environmental aspects (Barton and Grant 2006). All these aspects are also taken into account when preparing an appraisal report determining the market value of land ownership (Nawrocka 2016). The analyzes assess, among others, the location and surroundings, the purpose of the area, the features of the plot on which the property is located, the technical condition of the building, transport accessibility, the standard of the building, and the usable area of the building.

Environmental factors have a major impact on the spatial development of the immediate area, and the presence of pollution sources has a negative impact on real estate prices. Sources of environmental pollution have a negative impact on the quality of air, but also soil and water (Zimmermann and Davies, 2020). Access to good quality water is a significant challenge in the modern world. About 3% of water is in its natural state, and 90% of all wastewater still ends up in freshwater bodies (Owamah et al. 2013). Such statistics show what is causing water shortages and the risks to these resources (Al-Ghouti et al., 2021; Abubakar et al., 2022). Surface water resources are crucial for socio-economic development, protection of ecological systems and water supply for people, but there are also countries where groundwater resources are primarily used (Zhu et al., 2015). Poland is also one of such countries, where 70% of drinking water comes from groundwater intakes. The estimated available groundwater resources are approximately 34 million m^3/24h.

Springs are an intermediate element between surface and groundwater. Springs are natural outflows of groundwater, the occurrence of which depends on many factors, such as rock lithology, climatic conditions, but also hydrogeological conditions and anthropogenic pressure (Taloor et al., 2020; Stevens et al., 2021; Sari et al., 2022). The total number of springs in the world is unknown. In the article by Stevens et al. (2021) suggested that the number is around 2.5 million, although it is probably up to 3 times higher. The role of springs is invaluable in providing drinking water (Bender et al., 2001; Chełmicki et al., 2011; Fiorillo et al., 2020). Springs are one of the elements subject to monitoring of groundwater quality.

The most popular in providing water to the population are karst aquifers, which provide resources for approximately 20% of the population (Ford and Williams 2007). About 5% of Europe's territory is covered by exposures of carbonate rocks (Chen et al. 2017). These resources are among the most endangered due to the geological characteristics of aquifers, especially in areas with unregulated sewage management (Tufano et al. 2020). An additional aspect that threatens the quality of water in karst areas is the possibility of bacterial contamination (Prasad and Bose 2001; Muhammad et al. 2011). Bacterial contamination, if detected, causes negative economic consequences related to interruptions in water supply to residents. However, before restrictions on access to water are introduced, health problems may arise for people consuming such water. The threat of lowering the quality of water in springs also concerns the occurrence of, for example, increased concentration of nitrates of agricultural origin (Koit et al., 2011), heavy metals, the origin of which is related to the industry in the springs area. However, this is not the only aspect of the threat. In general, there is a decreasing trend in the number and efficiency of springs around the world, which is the result of reduced recharge of such waters from rainfall and increasing temperatures (Fiorillo et al., 2020).

Water in springs in Poland is often treated as better quality water and is taken for food purposes. This applies not only to karst springs, but also to springs located in urban space. Diagnostic and operational monitoring in Poland for such points is carried out in accordance with the Regulation of the Minister of Infrastructure of July 13, 2021 (Journal of Laws of 2021, item 1576) on the forms and methods of monitoring surface water bodies and groundwater bodies. The basic scope of diagnostic monitoring includes parameters such as pH, temperature, electrolytic conductivity, dissolved oxygen, total organic carbon and inorganic parameters such as ammonium ion, antimony, arsenic, nitrates, nitrites, boron, chlorides, chromium, cyanides, fluorides, phosphates , aluminum, cadmium, magnesium, manganese, copper, nickel, lead, potassium, mercury, selenium, sulfates, sodium, silver, calcium, bicarbonates, iron. Unfortunately, out of over 1,400 observation points, only a few dozen points are springs.

Water in springs is collected not only at points covered by the monitoring of Ground Water Bodies, but wherever there is easy availability, adequate efficiency and in places where it is assumed that the water has healing properties. As part of the research, water quality was assessed in six selected sources in the Silesian Voivodeship, from which water is regularly drawn by residents and tourists. However, none of these points belongs to the observation network of the State Environmental Monitoring. The research shows that in each of the tested points there are parameters exceeding the permissible standards for drinking water. The aim of the article is to indicate the need to monitor the quality of spring waters that are constantly used for drinking, which are not carried out due to the high costs of chemical analyses.

2. Methodology

Water quality tests in the springs were carried out in two measurement series in November 2023 and February 2024. Six springs located in the southern part of Poland were taken into account as test objects: the spring in Leśniów (Żarki commune), the Zygmunt spring (located in Złoty Potok), the Halszka spring (Niegowa commune), the Dobro Woda and Święta Woda springs (located in close proximity to the city of Żory) and the Zimny Sztok spring (Pilchowice commune).

The first three springs are located in karst areas, which are highly susceptible to pollution. These are areas of great tourist importance. Spring in Leśniów is located in the center of the town. It is completely built-in, and taps are installed at the outlet to facilitate water consumption. Spring is located on the premises of the Sanctuary of Our Lady of Leśniów, pilgrims and tourists draw water. Zygmunt's Spring is located next to road 793 leading from Złoty Potok to Żarki. It is worth mentioning that this is an area belonging to the Parkowe Reserve (https://www.slaskie.travel/poi/3888/powiedzat-parkowe-w-zlotym-potoku). The Halszka spring has been recognized as a monument of inanimate nature. It is located in the lowest part of the commune in the Halszka River valley. The three remaining springs are located in urban areas in the southwestern part of the Silesian Voivodeship. Dobro Woda and Święto Woda springs are located within the so-called Palowice Lake District located between the town of Żory and the town of Palowice. This region belongs to the "Cistercian Landscape Compositions of Rudy Wielkie" Landscape Park. The Zimny Sztok spring is located close to the road. Spring has a form of a small well built from the inside with clinker bricks. Local residents and tourists regularly collect drinking water from all these points without knowing the current quality status.

During field trips water samples were taken for physicochemical and bacteriological analyzes. Physicochemical and bacteriological analyzes were performed in an accredited laboratory. In terms of physicochemical parameters, the values of electrical conductivity, pH, Ca, Na, K, Mg, Fe, Al, Mn, Ni, Cu, Sr, S, Cl, SO_4, HCO_3, NO_3, NO_2, NH_4, PO_4, N, K, Total Organic Carbon, Pb, Cd, Cr, Hg, Zn, acidity and alkalinity were examined. In the bacteriological scope, the number of coliforms, the number of Escherichia coli, the number of Enterococci, the number of Clostridium perfringens, the total number of microorganisms at 22±2°C, the number of Pseudomonas aeruginosa and the total number of microorganisms at 36±2°C were measured.

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The results from both measurement series were compared with the permissible values of individual parameters specified in the Regulation of the Minister of Health of December 7, 2017 on the quality of water intended for human consumption (Journal of Laws of 2017, item 2294). Additionally, the results were compared with the values included in 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.

Due to the fact that the current article aims to draw attention to the need to perform regular and reliable monitoring of water quality in sources in order to reduce the negative health and economic effects related to the need for water treatment, only general results exceeding the permissible standards for individual research points are presented.

3. Results and discussion

Specific electrolytic conductivity is the basic parameter used to indirectly assess the mineralization of water. In shallow groundwater exposed to anthropogenic pollution, this value may exceed 1000 µS/cm, which indicates water pollution (Dąbrowska et al., 2016). First of all, it should be noted that the water of all springs has an electrolytic conductivity ranging from 150 to approximately 400 µS/cm, which is within the range permissible for first class water quality (up to 700 µS/cm) and for water intended for drinking (2500 µS/cm). Unfortunately, in the case of some another parameters increased values were observed (Table 1).

Table 1: Increased concentration of parameters in described springs in relation to regulations

Spring	Drinking water	I class of water quality
Leśniów	Hg, Coliform bacteria, Escherichia coli, Total number of microorganisms	HCO_3, NO_3
Zygmunt	Total number of microorganisms	NO_3
Halszka	-	NO_3, Ca
Dobro Woda	Ni, Coliform bacteria, Escherichia coli, Number of Enterococci, Total number of microorganisms	Ni, SO_4

Święto Woda	Fe, Al, Mn, Ni, Coliform bacteria, Escherichia coli, Total number of microorganisms	Fe, Al, Mn, Ni, TOC
Zimny Sztok	Total number of microorganisms	NO_3

The research results prove that the tested waters are characterized by increased concentrations of various parameters both in comparison to water intended for drinking and to the first class of water quality. In the case of springs located in karst areas, there is a problem with nitrate pollution. The origin of nitrates in water is primarily related to agricultural activities and the use of artificial fertilizers. Additionally, an increased number of microorganisms is noted, and in the case of the source in Leśniów, also coliforms and Escherichia coli. Attention should also be paid to the increased concentration of mercury in water, which could have migrated to water also with precipitation. In the case of springs located in such a way, it is also necessary to control the tightness of septic tanks, which may constitute a significant point source of pollution.

In the case of springs located in urban space, increased concentrations of iron, aluminum, manganese, nickel, and Coliform bacteria, Escherichia coli, Number of Enterococci and Total number of microorganisms were observed. The occurrence of increased metal concentrations in the analyzed research area is related to the operation of a steelworks in this area in the past (Palowickie Lake District). The problem of iron contamination of water is one of the important problems related to industrialization. Increased concentration of iron ions in water can cause diarrhea, lung damage and respiratory diseases. Other negative effects of consuming water enriched with high concentrations of iron is a change in the taste of food to a metallic one. Much better water quality can be observed for the Zimny Sztok spring, where the content was exceeded only in terms of nitrates and the total number of microorganisms. Pathogenic microorganisms occur wherever they have access to human waste. Microbiologically contaminated water becomes extremely dangerous to drink because it leads to problems with the digestive system, but in immunocompromised people it can lead to, among others, urosepsis, meningitis and peritonitis, with potentially serious consequences, including sepsis and death (Hernanzdez-Pastor et al., 2023). In this context, the costs of treating people consuming contaminated water should be taken into account.

Groundwater plays a strategic role in supplying people with drinking water. Monitoring of these waters is a fundamental element of their protection, both in quantitative and qualitative terms. Monitoring problems concern not only local monitoring of pollution hotspots, but also the national network, within which the parameters necessary for a reliable assessment of the quality of these waters should be measured. Reliable monitoring of the quality of groundwater, which will allow for the proper assessment of the quality of these waters, allows for rational water management in a given Groundwater Body and also allows for limiting the migration of pollutants (Singh et al. 2008; Jiang et al. 2014).

Due to the fact that the costs of monitoring all possible springs from which water is drawn are high, it is possible to introduce constant monitoring using sensors. Conducting such monitoring, on the one hand, provides a large amount of data that can be analyzed by artificial intelligence methods, and on the other hand, energy consumption is reduced due to the fact that current sensors use the Narrowband Internet of Things technology and cellular network modules (Xiao and Xie, 2021; Martin et al., 2023). This reduces the need to conduct field work, perform physicochemical analyses, analyze these data by people preparing reports, and the need to provide data to users of such waters. Sensors can monitor only selected parameters that require special attention and which pose the greatest threat to users' health. Additionally, analysis results can be sent to appropriate websites, e.g. of the municipalities where the springs are located.

4. Conclusions

Water tests in the springs show that water collected for drinking purposes is contaminated with inorganic substances or bacteriological contamination. Such waters may pose a potential health hazard to nearby residents and other users.

Access to good quality water also affects the overall assessment of the quality of life in a given commune and can be taken into account as a factor when estimating the market value of real estate. Hence, it is necessary to provide good quality water resources.

In order to maintain appropriate quantitative and qualitative resources of water intended for consumption in urban space, it is necessary not only to monitor individual parameters, but also to analyze the possible health and, indirectly, economic effects of consuming this water.

In this context, it is necessary to conduct reliable qualitative monitoring at all points from which water is collected for drinking purposes, and not only at points belonging to the national monitoring network. For economic reasons, such activities are not carried out, but a solution may be to install sensors operating within cellular networks, which could be installed by the authorities of the communes where the springs are located.

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