

GOOD WATERS STATUS AS ONE OF QUALITY FACTORS OF LIFE IN SMALL COMMUNES

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ABSTRACT

Enabling citizens to live in more sustainable cities that guarantee well-being and comfortable living conditions is a significant challenge of the 21st century. Factors affecting urban health have components relative to health issues, social, economic and environmental aspects. One of the factors in the last group is access to water with appropriate quality parameters. This is particularly important in small communes that are located in the area of karst aquifers which can be problematic because of unstable discharge regimes and high vulnerability to pollution. Research conducted for waters in the Halszka spring (Niegowa commune, southern Poland) indicate that the quality of these waters is very good, and the only health hazard can be the alkalinity (about 250 mgCaCO₃/l). Since there are many users of such water, it should be subject to constant quality monitoring and resource protection.

Keywords: spring, karst aquifer, hardness, microbiology, drinking water.

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INTRODUCTION

Health is a state of well-being, physically, mentally, and socially and is considered one of the important factors influencing the quality of life. Factors affecting urban health have components relative to health issues, social, economic and environmental aspects [1]. Additionally, the analysis of all factors can be used to prepare an appraisal report determining the market value of ownership of land real estate [2]. Market analysis aims to learn about the conditions influencing the development of real estate prices and their differences in market turnover. The main factors influencing real estate prices, and thus good living status, include location and surroundings, land use, attributes of the plot on which the property is located, technical condition of the building, transport accessibility, building standard, usable area of the building.

Land development and access to utilities also take into account environmental aspects. This is the largest group of factors influenced well-being. These factors include, among others: air and water pollution, sewage treatment, waste management, land use, sports and leisure facilities, transport system [3].

Water is crucial to the functioning of the global economy. It is assumed that 3% of water is in its natural state, and 90% of all wastewater still enters freshwater reservoirs untreated [4]. This is a significant problem that causes water shortages and increased pollution of the soil and water environment. As a result, it is necessary to conduct risk analysis for groundwater [5,6,7,8,9].

Karst aquifers play an important role in providing water to the population, being used by approximately 20% of the population [10]. In Europe, approximately 5.1% of the territory is covered by continuous exposures of carbonate rocks [11]. The quality of water in springs is influenced by geological and climatic conditions and land development [12,13]. The hydrogeological features of karst aquifers make them very vulnerable to the migration of contaminants [11,14,15]. The risk to water in karst layers may be increased in the area of small communes, with often unregulated sewage and domestic management, in the area of sewage treatment plants or in agricultural areas [16,17]. Agriculture is one of the main sources of wastewater

contamination from the pesticides and chemical fertilizers used in the cultivation of crops.

Karst springs are exposed to bacterial contamination, which may consequently lead to serious diseases [18,19,20]. If such water is contaminated, there are often interruptions in the exploitation of groundwater to supply cities [21].

Due to numerous problems related to the availability of good quality water, which negatively affects the standard of living, also in small communes, it is important to ensure the appropriate quality of water in sources and constant monitoring of selected physicochemical and bacteriological parameters. Numerous studies are being conducted around the world on determining the correlation between pollutants and other anthropogenic or environmental factors. Water discharge [22], turbidity [23], and organic carbon [24] are studied in springs. It should be noted that many of these studies confirm that advanced techniques for the treatment of these waters are necessary [25].

This is especially important in places where water is of good quality and parameters that may cause health problems can be removed using relatively simple treatment methods. The aim of the article is to emphasize the importance of taking care of the resources of karst springs and to draw attention to the fact that access to good quality water is an important factor for an adequate standard of living. Water research was performed in Halszka spring in the Niegowa commune (southern Poland), which is an example of good quality water with increased only hardness.

RESEARCH MATERIALS AND METHODS

The subject of the research is the quality of water in Halszka spring located in Sokolniki, Niegowa commune (southern Poland; Fig.1). In terms of physicogeography [26], the commune is located within the mesoregions of Wyżyna Częstochowska and Próg Lelowski. The Halszka spring is located within the first mesoregion. The spring is located at an altitude of 262 meters above sea level, i.e. in the lowest part of the commune in the Halszka River valley, and the ground elevation in the entire commune is approximately 162 meters. The highest areas are in the southwestern part (approx. 420 m above sea level).

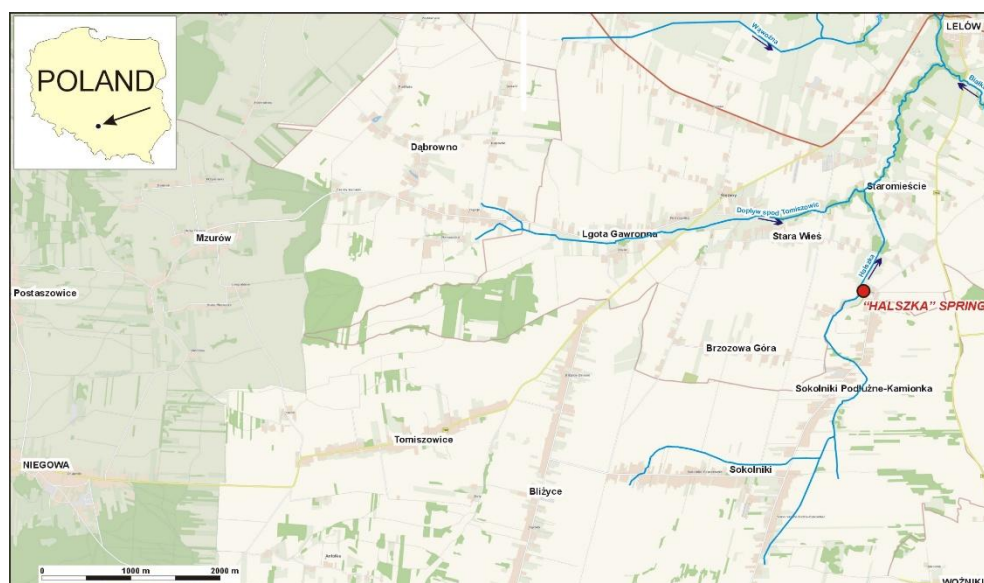


Fig. 1. Study area.

The economic factors influencing the quality of life in the described research area include a high average usable area per apartment (93.5 m²) and a well-developed communication network [27]. Two provincial roads run through the commune, and there are also a large number of unpaved roads connecting development areas and areas of field and forest cultivation. The heating and gas systems in this area are unfavorable. There is no central heating system in the commune. The commune is also an ungasified area.

The research area is located in the warm and transitional temperate climate zone. The average annual air temperature ranges from 7-8°C, and the annual amplitude is 21-23°C. The average annual rainfall ranges from 700-750 mm, depending on the topography and land cover. The maximum monthly rainfall falls in July and August, and the minimum in January and February. The highest value of relative air humidity is achieved in winter (up to 85%), and the lowest is approximately 70% and occurs in the summer months.

Due to the fact that the commune is located in karst areas, the surface water network is not well developed. In the north-eastern part of the commune there are the source sections of the Halszka River and its tributaries. The main watercourses include the Halszka River with its tributary from Zagaj, the spring area - a tributary from Tomiszowice and five water reservoirs.

The research area in the context of geology is located within the Silesian-Kraków monocline [28]. There are two complexes of geological layers here - the Variscan layer, made of Paleozoic rocks, and the Alpine layer, made of Mesozoic rocks (Fig. 2). Among the Paleozoic rocks, there are folded Cambrian, Silurian, Devonian and Lower Carboniferous formations. Triassic and Jurassic epicontinental formations lie on the erosionally cut Paleozoic formations, forming a fragment of the Silesian-Kraków monocline. The thickness of the Mesozoic deposits ranges from about 300 meters in the southwestern part to nearly 700 meters in the northeastern part. The Lower and Middle Triassic deposits represent sandstones and mudstones with gypsum and a complex of carbonate rocks. The Lower Jurassic formations include gravels, sands, clays, mudstones and sandstones, with a total thickness about 40 meters. The Upper Jurassic formations are

limestones whose thickness is over 500 meters. Tertiary formations occur locally in the commune - sands filling eroded karst forms of Jurassic limestone in the shape of funnels and wells. Quaternary deposits occur mainly in valleys and depressions. These are primarily sand and gravel deposits originating from fluvial glacial accumulations, sandy extraglacial sediments and alluvial fan deposits, as well as sands and silts of lacustrine accumulations, boulder clays and their sandy eluvia.

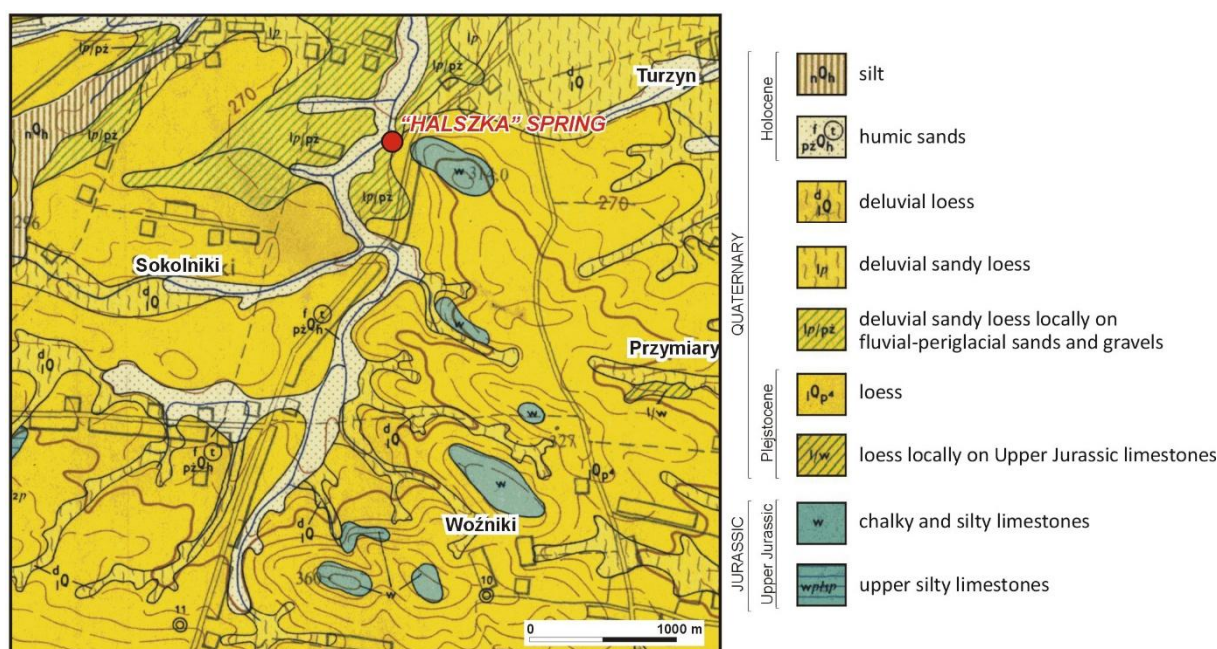


Fig. 2 Geological map of the study area Source: on the basis of Bednarek et al. 1985.

There are three water-bearing levels in the commune, i.e. Quaternary, Tertiary and Jurassic. The Quaternary aquifer is represented by debris deposits (variegated sands and gravels) originating mainly from aeolian and fluvioglacial accumulation. The thickness of these formations is up to several meters. Discharge of this aquifer is low, about 0.5 m³/h to 4.0 m³/h. This aquifer has no functional significance. The Tertiary aquifer is represented by crumbly deposits in the form of fine-grained sand, gravel and pebbles. The thickness of the aquifer is approximately 3 m. Water discharge is approximately 5 m³/h. The main aquifer here is the Jurassic one, in which waters occur in limestones of various lithological formations, up to 400 meters thick. These formations are strongly cracked, carved and karstified, which causes a high level of threat to these waters. The well flow rate for this aquifer is 30-50 m³/h [29].

One of the important environmental factors influencing the status of life in the commune is access to good quality water. The research was carried out in the Halszka spring which is classified as a karst fissure spring (Fig.1) in two measurement series - November 2023 and February 2024. It should be noted that the waters of this spring are used by residents. Field measurements included collecting water samples for physicochemical and bacteriological tests. Physicochemical and bacteriological analyzes were performed in an accredited laboratory. The electrolytic conductivity, water temperature, pH and flow rate were measured in the field. In the laboratory, the following physicochemical parameters were determined: Ca, Na, K, Mg, Fe, Al, Mn, Ni, Cu, Sr, S, Cl, SO₄, HCO₃, NO₃, NO₂, NH₄, PO₄, N, K, TOC, Pb, Cd, Cr, Hg, Zn, acidity and alkalinity. In terms of bacteriological risk, bacteria from the coliform group, enterococci, *P. aeruginosa* and *C. perfringens* were determined.

The research results were compared with the values contained in two regulations - 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 Regulation of the Minister of Health of December 7, 2017 on quality of water intended for human consumption.

RESEARCH RESULTS AND DISCUSSION

Water tests in the Halszka spring were carried out in two measurement series. The value of specific electrolytic conductivity was 416 μS/cm in the first measurement series, and 463 μS/cm in the second series. The electric conductivity values for this source are slightly increased compared to the average for other sources located in this area [30]. Previous studies conducted at springs in this area indicated that the EC value ranged from approximately 200 to approximately 700 μS/cm, with the average value being approximately 370 μS/cm.

The average water temperature was 10°C. The pH in the first measurement series was 6.8 and in the second 7.02. The results of field measurements classify these waters into the first quality class in accordance with 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 as well as the Regulation of the Minister of Health of December 7, 2017 in on the quality of water intended for human consumption.

In the case of other physicochemical parameters (Tab. 1), apart from nitrates and calcium, all obtained results are within the upper limit for the first class of water quality and meet the standards for water intended for drinking. The nitrate content, which was 13 mg/l in the first measurement series and 11 mg/l in the second series, slightly exceeds the values for the first class (10 mg/l). Disorderly water and sewage management in built-up areas causes increased concentrations of nitrogen compounds in this area [31]. It should be noted, however, that in the case of water from this source, there are no increased concentrations of chlorides and potassium, which would indicate contamination from domestic leachates.

Analyzes results.

Parameter	Unit	Value 1	Value 2
EC	$\mu\text{S}/\text{cm}$	416	463
Na	mg/l	3.9	4.8
K	mg/l	1.1	1.1
Ca	mg/l	96	99
Mg	mg/l	6.7	8.5
Fe	mg/l	0.002	0.043
Al	mg/l	0.005	0.005
Mn	mg/l	0.0005	0.005
Ni	mg/l	0.002	0.002
Cu	mg/l	0.002	0.007
Sr	mg/l	0.15	0.15
S	mg/l	3.3	4.3
Cl	mg/l	8	8
SO ₄	mg/l	12	12
HCO ₃	mg/l	307	303
NO ₃	mg/l	13	11
NO ₂	mg/l	0.033	0.033
NH ₄	mg/l	0.06	0.06
PO ₄	mg/l	0.096	0.092
N K	mg/l	2.5	2.5
TOC	mg/l	1	1
Pb	mg/l	0.002	0.002
Cd	mg/l	0.00025	0.00025
Cr	mg/l	0.0015	0.0015
Hg	mg/l	0.00005	0.00018
Zn	mg/l	0.0025	0.015
Acidity	mmol/l	0.71	1
Alkalinity	mg/l	252	248
	CaCO ₃		

Increased concentration values in relation to the first class of water quality were also observed in the case of calcium. The values from the first and second measurement series classify the water into class II. This parameter is not taken into account when assessing water intended for human consumption.

The only parameter that reduces the utility of water is its hardness. Water hardness is related to the concentration of calcium and magnesium ions in the water. These two metals combine with bicarbonates, sulphates or chlorides. Soft water occurs when the CaCO₃ equivalent content is less than 60 mg/l and hard water has a CaCO₃ equivalent content greater than 120 mg/l. Calcium carbonate in water acts as a pH buffer, while soft water is more susceptible to acidification due to its low buffering capacity. In contact with acid-forming compounds [32]. Hardness may be permanent or temporary. The first one is connected with the existence of dissolved bicarbonates of calcium, magnesium, and several other heavy metals. During boiling water the bicarbonates in it breakdown producing insoluble carbonates or hydroxides that settle at the bottom of the kettle. The second one is connected with the presence of mentioned substances in rocks. Boiling water does not remove permanent hardness [33]. The presence of increased concentrations of these ions may have a detrimental effect not only on the quality of life, but also on the condition of water and sewage systems

The results of chemical analyzes from both measurement series indicate that the general hardness of water is slightly over 100 mg CaCO₃/l. This is caused by high calcium concentrations. The human body generally controls calcium intake, but people with kidney disorders are at risk [35]. Although the hardness value does not exceed 120 mg CaCO₃/l, it is relatively close to this limit. In the tested waters, treatment could involve reducing water hardness, and such a process is not complicated.

Total alkalinity is also related to water hardness, which measures the water's capacity to buffer and resist pH changes. High total alkalinity value can lead to scaling or the formation of mineral deposits in pipes or water heaters. It can reduce water flow, decrease the efficiency of heat transfer in water heaters and boilers, and increase energy consumption [36]. Such phenomena may occur when the alkalinity value in water is higher than 150 mg CaCO₃/l, however, reducing water hardness will also affect the alkalinity value.

The results of bacteriological tests indicate that there is currently no bacteriological threat in the waters of the analyzed spring. The values of such parameters as the number of coliform bacteria, 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 0 in both

measurement series.

Numerous studies show how increased concentrations of various inorganic pollutants [37,38,39,40] in waters may affect human health, but also the state of sewage system. The negative health consequences include lung, kidney, gastrointestinal diseases and hypertension. Some of the pollutants are also carcinogenic. In this context, the obtained results of water tests in the Halszka spring indicate that access to good quality water is an important environmental factor for the good status of life in the commune.

CONCLUSIONS

Testing of the waters in the Halszka spring did not reveal any exceedances of the permissible values for water intended for drinking. Only the content of calcium ions and nitrates is higher than the permissible limit for the first class of water quality. High calcium content affects water hardness, which is an important parameter of water quality, but hardness removal is possible using numerous

methods. It should be noted that, compared to other pollutants, hardness does not cause health hazards such as high metal concentrations or high bacterial counts.

Access to good quality water affects the assessment of the quality of life in a given commune and may be taken into account as a factor in the estimation of the market value of real estate.

Despite the fact that the water in the analyzed spring is characterized by good chemical condition, it should be subject to control and monitoring to limit the possibility of migration of pollutants to this spring, which is related to the high vulnerability of water to pollution in karst aquifers.

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