

VARIABILITY OF SELECTED PHYSICOCHEMICAL PARAMETERS IN THE COASTAL ZONE OF THE MITRĘGA RESERVOIR

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ABSTRACT

Retention of clean water in river valleys is possible, among other things, thanks to the construction of water facilities and the adaptation of flat-bottomed river valleys to this by creating embankments. There are many such reservoirs in Upper Silesia (southern Poland). One example of such a reservoir is the Mitręga Reservoir, created at the mouth of the Mitręga River to the Czarna Przemsza. This reservoir also serves as a fishing and recreational area. In 2024, two measurement series were carried out, which included tests of temperature, pH, electrolytic conductivity and chloride concentration in the reservoir. The highest electrolytic conductivity values in the summer series were measured at the mouth of the Mitręga River to the Mitręga Pond (342 $\mu\text{S}/\text{cm}$), and the lowest equal to 293 $\mu\text{S}/\text{cm}$ at the outlet of water from the reservoir. In the winter series, the conductivity values were lower and reached 275 $\mu\text{S}/\text{cm}$. In the waters of the reservoir, a large variability of pH and chloride content was observed. The concentration of chlorides exceeded 250 mg/l in some measurement points.

Keywords: Mitręga, water quality, dam reservoirs, anthropogenic lake district.

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INTRODUCTION

Water pollution is currently one of the most important environmental problems of a global nature [1]. The hydrological regime, access to water and changes in water quality parameters are a negative effect of climate change [2,3]. The balance of aquatic ecosystems is disturbed by urbanization or increased waste production [4]. It should be noted that surface water pollution is spatial, not point-based, and should not be considered in the context of individual streams or reservoirs, but as an element of a larger ecosystem [5]. On the other hand, it is crucial to indicate factors causing increased pollution even in small reservoirs or rivers, because they are in contact with other aquatic ecosystems [6]. However, in the analysis of pollution sources, pollution within small water reservoirs is very often omitted [7]. River valleys have great possibilities for retaining clean water, which is related to the stability of the river flow of favorable quality [8,9]. Flat-bottomed river valleys can be adapted to capture water by building embankments. Such reservoirs are characterized by small variations in depth (approx. 1-1.5 m). Weir reservoirs, depending on their surface area, play a multi-faceted role in water management, environmental protection and support for anthropogenic activity. One of the applications of such reservoirs is water storage [10,11]. Construction of such reservoirs can play an important role in improving the living conditions of rural populations, what is more, managing such reservoirs requires relatively few problems in contrast to large dam reservoirs [12]. Water from such reservoirs can also be used for economic purposes - as technical reservoirs. Small weir reservoirs are also a habitat for many species of plants or animals. Weir reservoirs can also be used for recreational purposes (fishing, water sports) or tourist purposes (resting place, aesthetic landscape element) [13]. Studies indicate that the height of the dike has a significant effect on the sedimentation volume and the time to reach equilibrium in the reservoir [14]. However, their presence can affect changes in the river flow regime and the quality of fish habitats [15]. For example, in South Korea [16], as part of a project to renovate four major rivers, 16 multifunctional embankments were built to improve water resource management and flood protection. The quality of water in embankments is quite diverse and often depends on fishing activities.

Another factor causing quality changes is spatial development around the reservoir [17]. Sedimentation in water reservoirs is a serious problem due to the reduction of the original reservoir capacity, which adversely affects water supply, catchment management and even recreational activities [18,19].

Water quality and sediment tests in embankments are extremely important in the context of water resource protection and proper catchment management. However, such tests in small reservoirs are very often omitted and performed only as part of research monitoring. Water quality parameters such as pH or electrolytic conductivity are directly dependent on rainfall and temperature. Excessive runoff can increase water pollution [20]. Climate change leads to a decrease in the amount of dissolved oxygen in the water body and, consequently, an increase in temperature, which adversely affects the quality [21].

Smaller reservoirs are much more sensitive to

climate variability than larger ones. It is worth emphasizing, however, that this does not apply to negative anthropogenic impacts, which also pose a significant threat to small reservoirs. Water quality in terms of temperature, pH, specific electrolytic conductivity and chloride concentration was examined in two measurement series - summer and winter for the Mitrega dam reservoir located in southern Poland. The test results indicate a local increase in pH, conductivity and chloride concentration in water.

RESEARCH AREA

The Mitrega reservoir is located in the Mitrega river valley in the western part of the Łazy commune, southern Poland (Fig. 1). In terms of physiogeography, the analyzed reservoir is located in the Woźnicko-Wieluńska Upland Macroregion, Silesian-Kraków Upland subprovince [22]. The commune has a fairly large elevational diversity of the terrain. The elevations fluctuate quite between 320-400 m above sea level. The highest elevation of 434.8 m above sea level is on Stodółsko Mountain, and the lowest is around 300 m above sea level in the Mitrega Valley. The average annual air temperature is around 7.5°C, and the average annual precipitation in this region is 600-650 mm, with the minimum falling in January-March and the maximum in July.



Fig. 1 Study area.

The studied reservoir lies within the Silesian-Cracow monocline, composed of Mesozoic Triassic and Jurassic formations lying on Paleozoic Devonian, Upper Carboniferous and Permian formations. Quaternary formations are present on the surface [23]. Middle and Upper Devonian formations are mainly formed as carbonate formations: limestones, marly limestones and dolomites, which are locally interbedded with claystones occurring within Frasnian and Famennian layers. The thickness of these formations is at least several hundred meters. The Lower Carboniferous is formed in the carbonaceous limestone facies as limestones with subordinate dolomites and limestone breccias. In the upper part of the Lower Carboniferous, sandy or calcareous claystones appear in places. The Upper Carboniferous is represented by sandstones, shales, claystones, and locally conglomerates occur in the floor. The Permian formations are formed as red conglomerates composed of fragments of older Paleozoic and volcanic rocks with cement enriched in tuffs and tuffites. In this area, there are deposits of the Lower Triassic - Buntsandstein, the Middle Triassic - Muschelkalk and the Upper Triassic - Keuper. The Lower Triassic (Buntsandstein) is represented by the formations of the Lower and Middle Buntsandstein (Świerklaniec layers) and the Upper Buntsandstein - Röt. The Middle Triassic (Muschelkalk) is represented by the Gogolin, Góra, Terebratul, Karchowice layers, Diplopore and Tarnowice dolomites. The Gogolin layers are formed as wavy and plate limestones, as well as marly with a series of conglomerates and thin inserts of marly argillaceous shales. The Góra, Terebratul and Karchowice layers are composed of medium-bedded limestones. The Middle Triassic also contains diplopore dolomites, which are porous, cracked and partially weathered. The Tarnowice layers are formed as cracked and weathered pelitic limestones and dolomites. The Upper Triassic - Keuper is formed as clayey formations, with interbeddings of mudstones and clayey-limestone breccia. The Jurassic formations are formed by sandy-clayey sediments and rocky, plate and reef limestones. The Quaternary

sediments are formed by sands and gravels, clays and silts.

The groundwater in the area of the described Mitrega reservoir is connected with the Middle Jurassic formations. The aquifer does not meet the criteria of a utility level and is related to the occurrence of interbedding of fine-grained sandstones and sandy limestones within mudstones and locally claystones. Recharge occurs through infiltration of atmospheric precipitation. The depth of the aquifer ranges from below 5 to 20 m [24].

METHODOLOGY

Field tests of water in the Mitrega Reservoir (Fig. 3) included two measurement series, which were conducted in August and December 2024. During these tests, temperature, pH, specific electrolytic conductivity and chloride content were measured. Electrolytic conductivity measurements were carried out using a CC 411 conductometer from Elmetron, while pH was measured using a CP 411 pH meter from the same company. A CT2B-121 sensor equipped with a Pt-1000B resistor was used to measure temperature. Chloride content was determined using QuanTab strip tests from Hach, which are adapted to measure chlorides in the range of 30-600 mg/L. The measurements were carried out along the entire length of the reservoir's shoreline, each time taking a water sample from a distance of 50 cm from the shore. Within each measurement series, 50 measurements were made for each of the analyzed parameters. The results of these tests were visualized on maps created in the ArcGIS environment. To understand the relationships between key water quality parameters such as temperature, pH, electrical conductivity (EC) and chloride content, they were analyzed using univariate linear regression. For both measurement series, the linear regression equation and correlation coefficient (R) were established for each pair of parameters. Differences between individual measurement results in the summer

and winter series were also examined.

RESULTS AND DISCUSSION

However, earlier studies were conducted in the described reservoir [8], in which a broader chemical composition of the water was determined. The following results were obtained as part of the studies: pH 7.81, electrolytic conductivity 390 $\mu\text{S}/\text{cm}$, calcium 72 mg/l, magnesium 67.2 mg/l, sodium 8.2 mg/l, potassium 4.6 mg/l, chlorides 27.8 mg/l, sulphates 81.7 mg/l, nitrates 1 mg/l, phosphates 1.1 mg/l, bicarbonates 122 mg/l.

In order to assess the overall water quality in the Mitreža reservoir, this article focuses on several physicochemical parameters measured in the field, i.e. electrolytic conductivity, temperature, pH and chloride content.

Electrolytic conductivity (EC) is an important parameter used for the overall assessment and monitoring of water quality. It measures the ability of water to conduct electricity, which depends on the concentration of dissolved ions [25]. Electrical conductivity allows us to estimate the content of dissolved substances in water, and it also serves as an indicator of salinity in water bodies. Salinity mainly refers to the concentration of salts, especially sodium chloride, and high values of electrical conductivity suggest higher levels of salinity, which can negatively affect aquatic ecosystems and irrigation processes [26].

Changes in conductivity can also indicate the presence of pollutants in water. In the case of elevated conductivity levels, we may be dealing with the presence of dissolved substances such as heavy metals or sewage. Systematic monitoring of conductivity is helpful in identifying potential sources of pollution and in assessing the overall water quality [27]. It should be noted that the costs of measuring this parameter are negligible. Observing changes in this parameter allows for early detection of environmental problems, which in turn allows for the implementation of appropriate water management practices.

In the tested water reservoir, the maximum values in the summer series were 342 $\mu\text{S}/\text{cm}$, and in the winter series 275 $\mu\text{S}/\text{cm}$. The average values were 317 and 256 $\mu\text{S}/\text{cm}$, respectively, and the minimum values were 293 and 247 $\mu\text{S}/\text{cm}$. The obtained conductivity value is slightly higher than typical values for this type of reservoir. It is worth emphasizing that the reservoir is intensively used by anglers and tourists, which certainly affects the increased conductivity values, especially in the summer.

Another parameter is pH. Its value may depend on various factors, such as the presence of dissolved minerals, the amount of organic matter and the concentration of atmospheric gases. In the spring and summer period, pH values may be higher due to the increase in the photosynthesis process of aquatic plants and their absorption of large amounts of carbon dioxide. The values of this parameter measured in both series were characterized by great diversity. In the summer period, the maximum conductivity value was 8.64. The average pH values were 8.23, and the minimum value was 7.3. In the case of the winter series, the pH values were lower. The maximum value was 7.52, the lowest 5.31, and the average 6.64.

The highest water temperature measured in the summer series was 22.4°C, and in the winter 3.7°C. The lowest temperatures were 16.3 and 1°C, respectively. The

measurements show a fairly large temperature variation of the water in the Reservoir, depending on the place of measurement.

The chloride content in this type of reservoir can exceed even 400 mg/l [28]. In the case of measurements in the Mitreža Reservoir, such high values were not observed. The chloride content in the summer reached 275 mg/l, and in the winter up to 126 mg/l. The lowest recorded values were 80 and 50 mg/l, respectively. The average for the summer series was about 146 mg/l, and for the winter series about 100 mg/l. It should be noted, however, that these results are significantly higher than the archive data [8]. In comparison to the archive data, even the smallest values are twice as high.

Correlation analysis was also performed between various parameters separately for the summer and winter series and between identical parameters for both series. The calculations show that a statistically significant relationship in the summer series was obtained only for temperature and pH (Fig. 2).

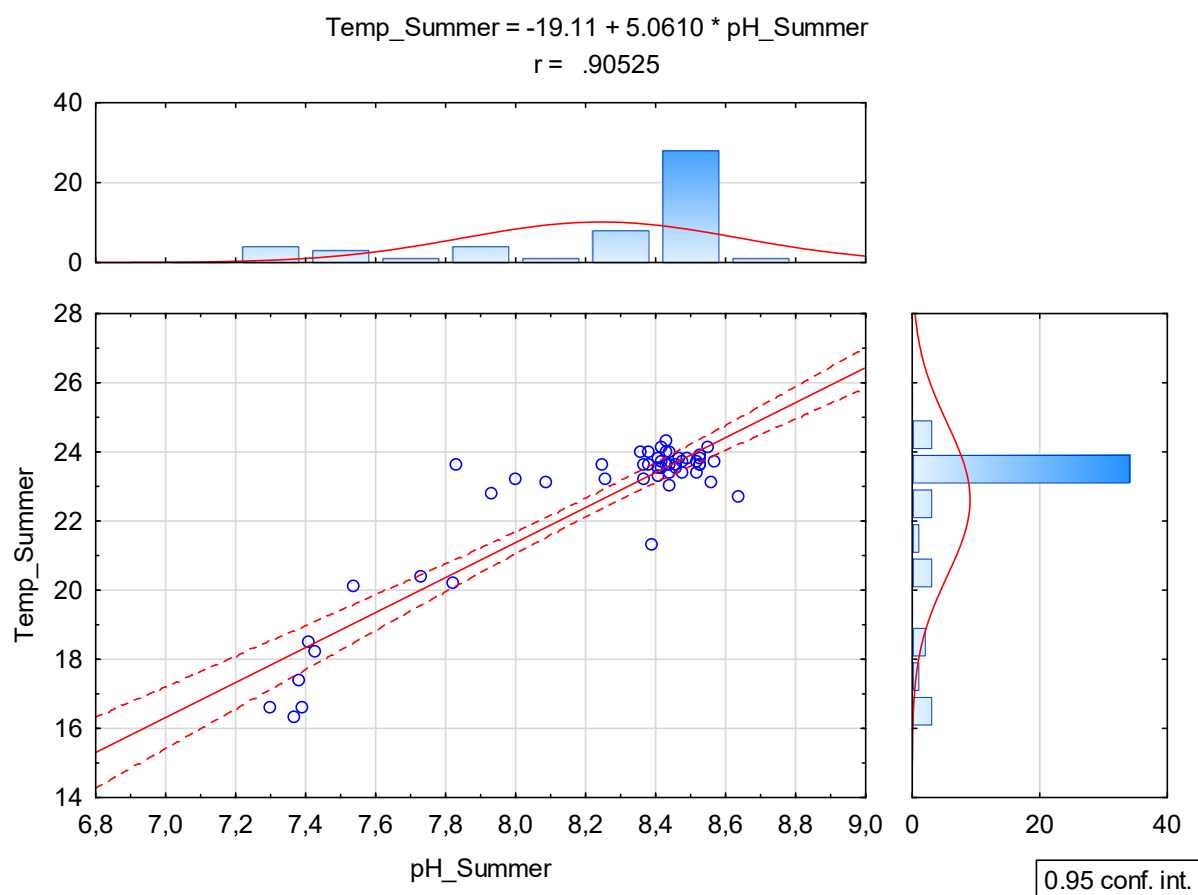


Fig. 2 Graph of the temperature dependence on pH in the summer series.

For these two parameters, the correlation coefficient was 0.91. For the winter series, statistically significant correlations were obtained for conductivity and chlorides. Surprisingly, however, the correlation coefficient for these parameters is negative and equal to -0.53 (Fig. 3).

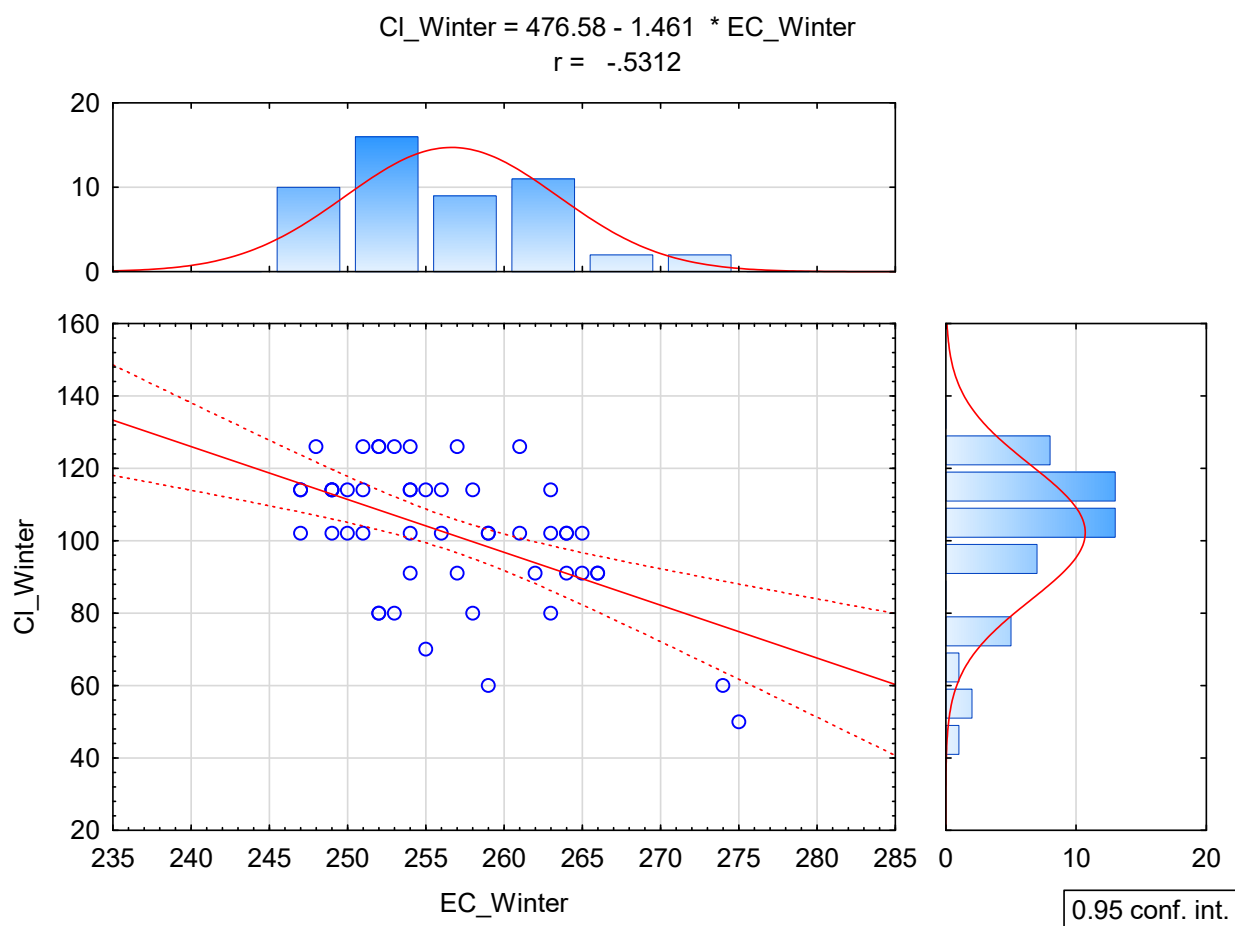


Fig. 3 Graph of the dependence of chloride content on conductivity in the winter series.

In the case of comparison of measurement series for the same parameters, a significant statistical correlation was obtained for pH – the correlation coefficient was 0.46 (Fig. 4) and for chlorides – the correlation coefficient was 0.30 (Fig. 5).

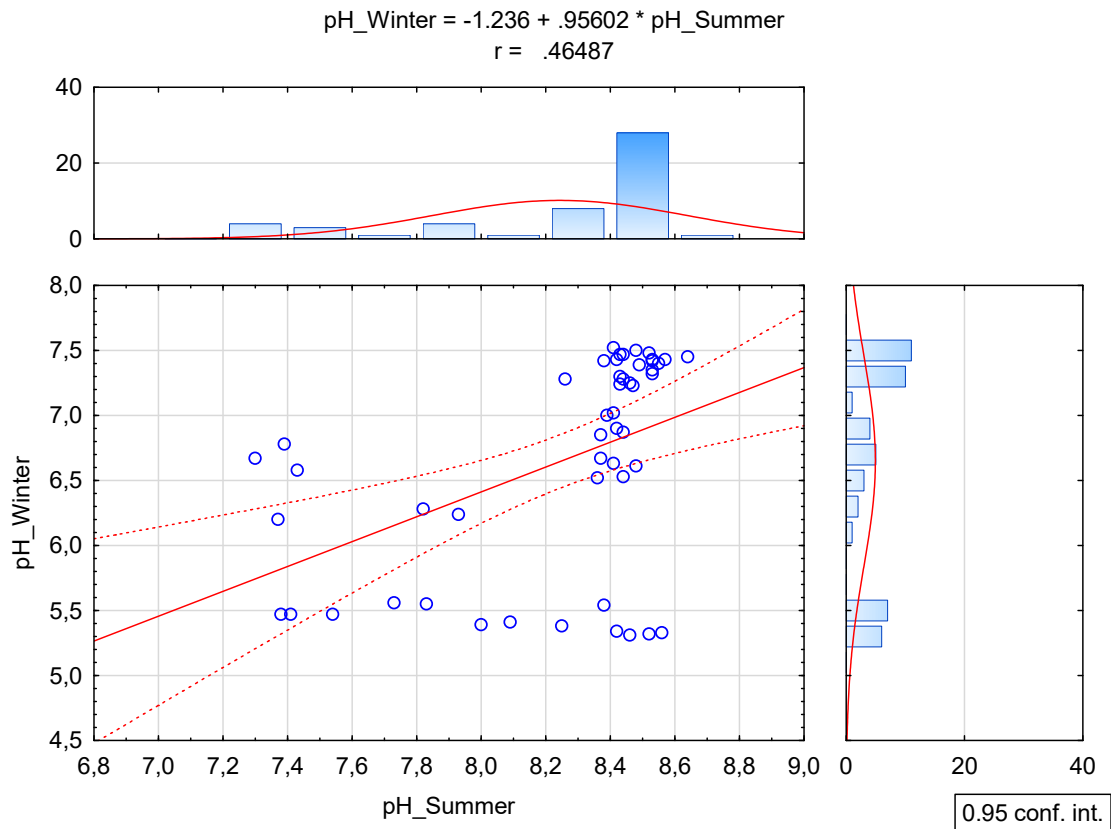


Fig. 4 Graph of pH dependence in both measurement series.

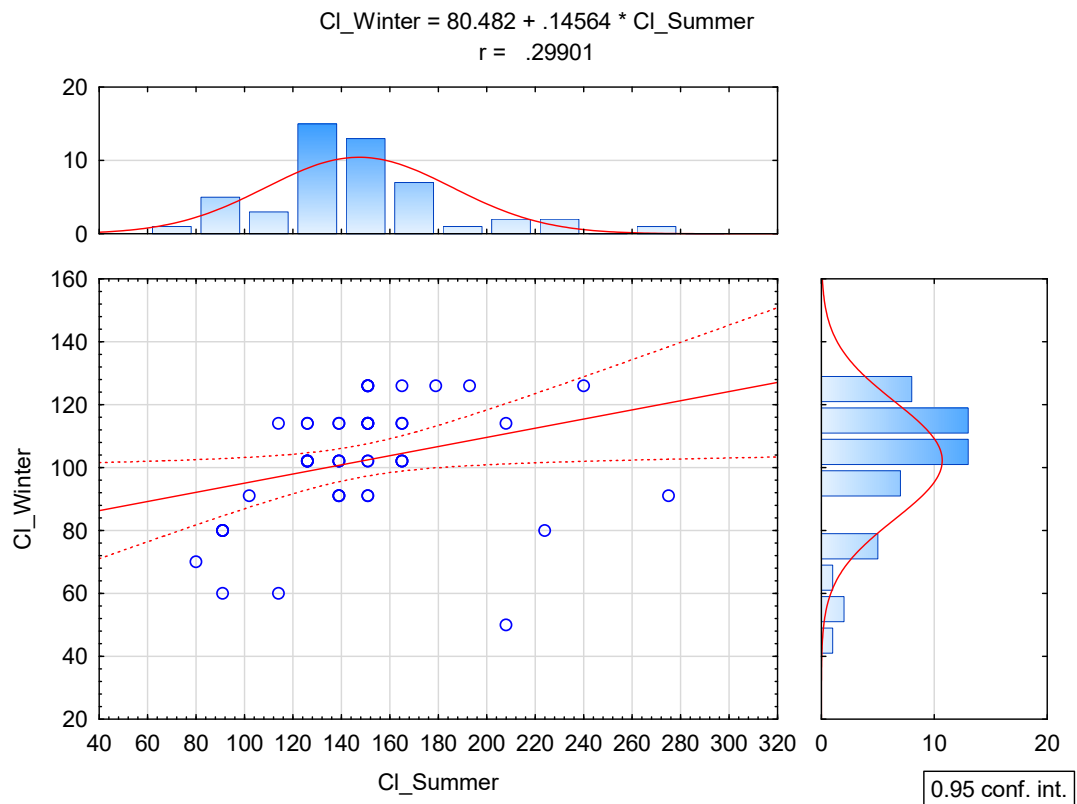


Fig. 5. Graph of the chloride content in both measurement series.

The interpolation results for conductivity in both measurement series differ significantly (Fig.6-7). In the case of the summer series, higher conductivity values can be observed only in the north-eastern and northern parts. The remaining part of the reservoir is covered by comparable values of this parameter. In the winter series, changes in conductivity values are noticeable in the west-east direction. The highest values were observed in the

southern part, and the lowest in the northern part of the reservoir. This is the opposite picture than for the summer series. The distribution of changes in the summer series may suggest greater mixing of waters during fishing or tourist use.

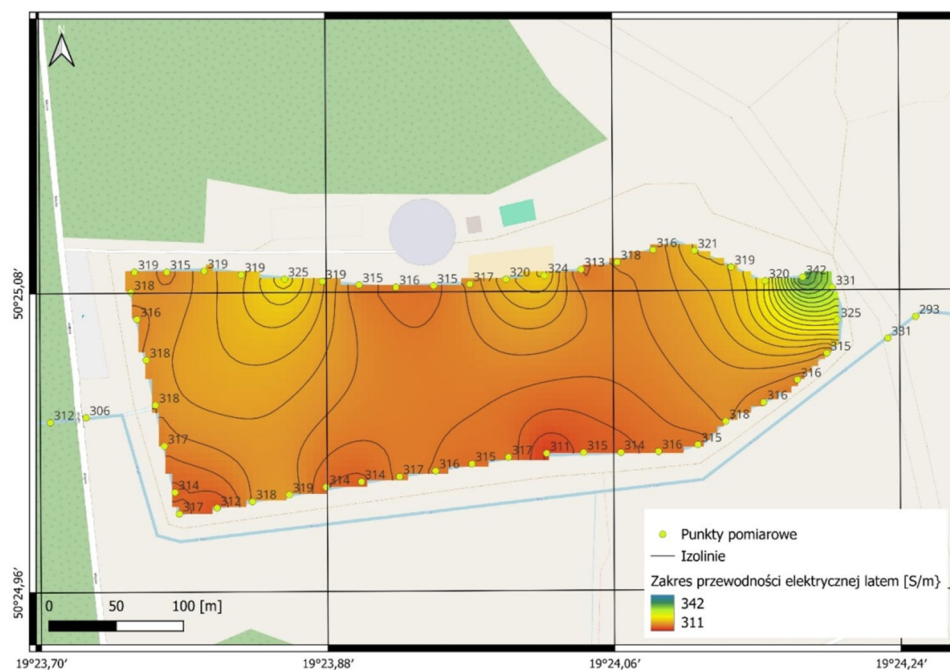


Fig. 6 The results of interpolation of EC values in the summer series.

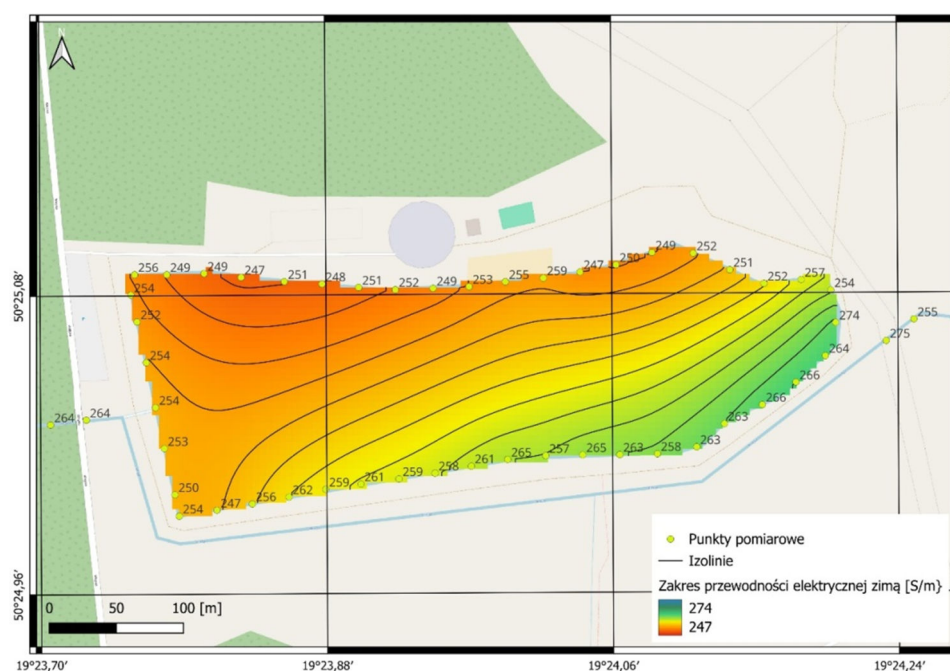


Fig. 7 The results of interpolation of EC values in the winter series.

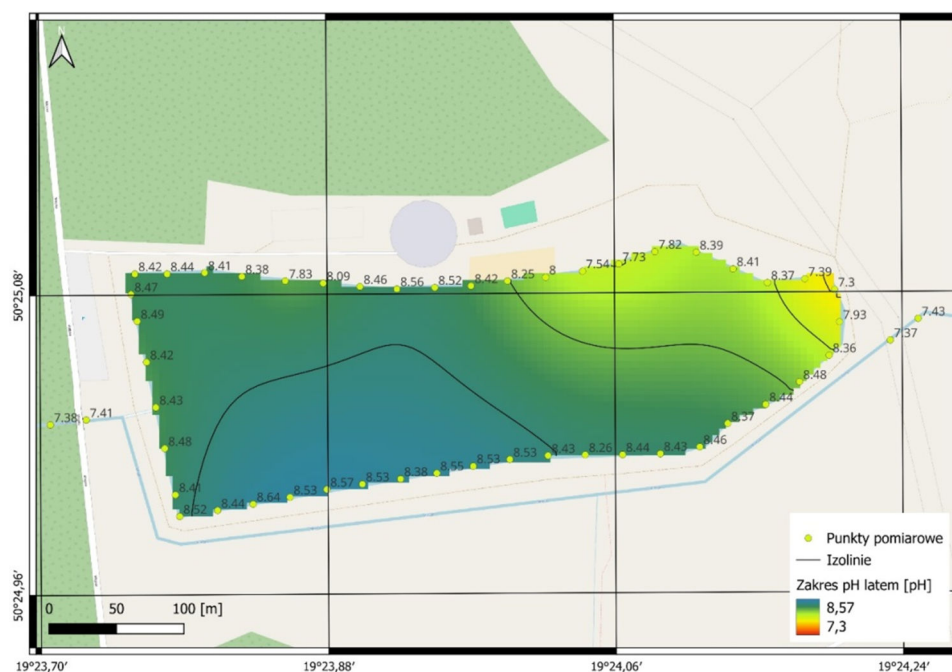


Fig. 8 The results of interpolation of pH values in the summer series.

In the summer series, higher pH values were obtained in the western and central parts of the reservoir, while in the winter series, pH values decreased towards the south (Fig. 8-9). Lower pH values were recorded in both series on the northern shore of the reservoir.

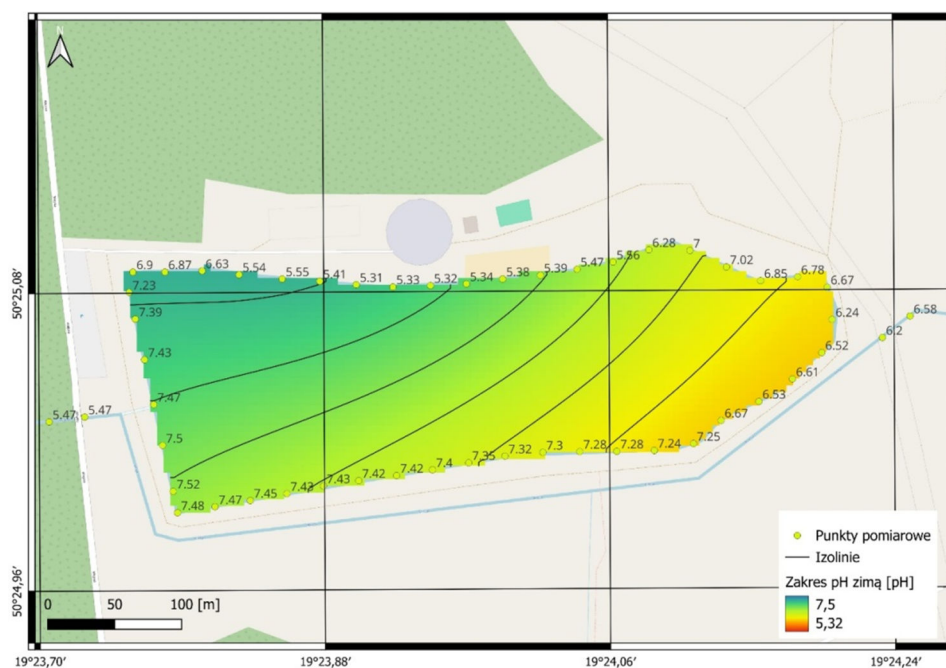


Fig. 9 The results of interpolation of pH values in the winter series.



The highest sodium chloride concentrations in the summer series (approx. 240 mg/L) are found in the western part of the study area (Fig. 12). Concentrations decrease towards the east, where values drop to about 91 mg/l. A strong gradient in the western part means

a sudden change in concentration, which may indicate a source point of contamination.



Fig. 12 The results of interpolation of chlorides values in the summer series.

NaCl concentrations in the entire area in winter are lower than in summer and range from 70 to 126 mg/l. The highest values are located in the eastern part of the reservoir (Fig. 13). The concentration of the isolines

indicates a local increase in concentration - perhaps related to the runoff from the road.



Fig. 13 The results of interpolation of chlorides values in the winter series.

SUMMARY

The Mitręga reservoir is an example of a weir reservoir that is used primarily for recreational and fishing purposes. The results of the studies conducted in 2024 indicate lower values of specific electrolytic conductivity in relation to the archived data. The highest conductivity values reach approximately 340 $\mu\text{S}/\text{cm}$. In the case of chloride content, however, the concentration is even 10 times higher than the data from 2008. The pH values indicate an alkaline reaction, especially in the summer. Statistically significant correlations between pH

and chloride content in the two measurement series indicate the lack of additional sources of pollution in the analyzed period of time. The differentiation of the values of individual parameters along the shoreline is related to the way the area around the reservoir is used (impact mainly in the winter months) and with angling and recreational activities (summer period). Due to the fact that it is planned to expand the sports offer at this facility, and thus to increase the use of water in this reservoir, it would be important to increase the frequency of water chemistry tests.

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