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# Analysis of the Status of Surface Waters in the Sącz Agglomeration Based on Physicochemical Parameter Studies

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**Abstract:** The analysis of the quality status of surface waters, carried out through two series of raw-water sampling at nine designated points during the astronomical summer and autumn, aims to assess the water quality of the rivers: Poprad, Kamienica, Dunajec, and the Łubinka stream. The study aims to determine the water purity class of the examined rivers in accordance with applicable legal standards. Raw water samples were analyzed in an accredited laboratory to determine selected physicochemical parameters. The analysis showed increased concentrations of both physical (e.g., suspended solids) and chemical (e.g., heavy metals) parameters. The study did not reveal analyzed pesticide levels high enough to be detected by laboratory instruments at nine sampling points marked as: P1, P2, K1, K2, Ł1, Ł2, D1, D2, D3. The most important factors influencing the quality of surface waters in the studied area are primarily the proximity. The most important factors influencing the quality of water in the Sądecki agglomeration include the proximity of watercourses to agricultural fields where fertilizers are used, as well as to wastewater treatment plants, landfills, and industrial facilities.

**Keywords:** surface water, physicochemical parameters, physicochemical analysis of water

## 1. Introduction

Physicochemical analysis of surface waters is a fundamental element in assessing water quality and the degree of water pollution, but it is limited by its availability on Earth. Their quality varies significantly by region. Surface waters include, above all, rivers, lakes, and streams, which serve as primary sources of drinking water and therefore create pressure to maintain their proper purity and ecological quality to minimize the adverse effects of pollution on human health and the balance of local ecosystems (Cheng et al., 2022; Papa et al., 2023). Surface waters are particularly susceptible to changes and contamination, as even slight deviations from standards translate into poorer drinking-water quality, which can facilitate the transmission of diseases (Mashala et al., 2023; Johnson et al., 2022). Special attention must be paid to pollution generated by human activity, which is increasingly discharged into surface waters (Hairom et al., 2021), including industrial and agricultural wastewater, which are considered the most common and most hazardous contaminants (Hammoumi et al., 2024; Ciuła et al., 2019).

Pollution of water bodies increasingly involves the ingress of agricultural pollutants, nutrients, pesticides, and heavy metals. The ingress of these pollutants through runoff causes eutrophication and contamination of water bodies. Agricultural activities also pollute water bodies with organic matter, nutrients, pesticides, and heavy metals. Their runoff leads to eutrophication and contamination. Pesticides and heavy metals contribute to environmental contamination and toxicity, posing risks to aquatic ecosystems and human health (Qu et al., 2024; Chyła et al., 2023). However, it is important to emphasize that high-quality water is essential for human activities, including agriculture, livestock production, and industry (Yan et al., 2022; Bai et al., 2022).

Insufficient access to clean water is particularly evident in the world's largest developing regions, such as Africa. It is estimated that about 55% of the global population faces difficulties in obtaining potable water (Jones et al., 2024). Attention should also be paid to changing climatic conditions and anthropogenic disturbances, which, through global warming, are altering Earth's ecosystems, contributing, among other things, to the degradation and destruction of surface waters and to the lack of sustainable water use (Lane et al., 2023). Research by Kazemi Garajeha et al. (2024) indicates that the main determinants of shrinking water resources are air temperature, actual evapotranspiration, and precipitation (Mats et al., 2025). The annual increase in air temperature reduces water surface area, underscoring its significant influence on regulating the extent of water bodies. The studies also show that over several decades, about 40% of water reservoirs remained permanent, while nearly 30% of those permanent bodies transformed into seasonal reservoirs, now accounting for almost 13% of the total (Kazemi Garajeha et al., 2024).

It is therefore crucial to maintain surface water at appropriate quality levels, reducing contamination and increasing its usability. Surface water pollution has a significant impact on human health and is defined as exceeding the self-purification capacity of a water body (Bai et al., 2022; Guan et al., 2024). Studies by Guan et al. (2024) show the influence of pollutants on the incidence of, among others, esophageal, stomach, colorectal, gallbladder, and pancreatic cancers. The control of surface water pollution has improved health outcomes, contributing to a −3.49% change in health impact over 7 years (Guan et al., 2024).

Surface-water pollution is an essential indicator of the negative impact of contaminated waters on the natural environment and represents a serious threat to the health of living organisms, including humans (Chmielewska et al., 2025; Syeed et al., 2023). Water quality is closely linked to human health and socioeconomic sustainability; thus, the more intense the anthropogenic activity, the greater the amount of pollutants and trace elements entering the water system, causing harm (Tong et al., 2021). To prevent the negative impacts of surface-water pollution on human health and life, continuous monitoring is essential. Physicochemical parameters constitute fundamental components of environmental monitoring, revealing the overall condition of a given ecosystem and identifying the sources and types of pressures affecting surface water.

## 2. Research Object and Methodology

This work aims to analyze the surface waters of the Dunajec, Poprad, Kamienica rivers, and the Łubinka stream during the astronomical summer and autumn. Water intake points are located within the Sądecka agglomeration. Raw water samples were taken at nine points for evaluation by an accredited laboratory. Designated sampling points, allowing for a complete assessment of surface water quality in the cities of Nowy Sącz, Stary Sącz, the Nawojowa commune, and the Chełmiec commune (Basta & Ciuła, 2024). The selected research results were analyzed in graphs using the Statistica program. This work involves collecting and analyzing surface water samples during the astronomical summer (July) and autumn (October) periods, and assessing water quality based on physicochemical parameters. A total of 332 parameters were analyzed in a single analytical series. The tests were performed in an accredited laboratory using reference methods based on ISO, PN-EN, and industry standards. The results were compared to the permissible values specified in the Regulation of the Minister of Infrastructure of June 25, 2021, on the classification of ecological status, ecological potential, and chemical status, and the method for classifying the status of surface water bodies (Journal of Laws, 2021, item 1475).

### 2.1. Research Object

The project aimed to analyze the physicochemical parameters of surface water samples collected from points located in Stary Sącz, Chełmiec, and Nowy Sącz, where the studied watercourses flow. The Poprad River and the Kamienica River are considered the main tributaries of the Dunajec River, which flows through Nowy Sącz. The research project aims to determine the quality of the following watercourses: the Dunajec, Poprad, Kamienica, and Łubinka.

The analyzed surface waters originate from mountainous areas, namely Nowy Sącz, Stary Sącz, and the municipalities of Chełmiec and Nawojowa. These regions are mountainous and include both industrial enterprises and agricultural fields. Such landscape characteristics promote contamination of surface waters, for example through the infiltration of pesticides contained in fertilizers and waste from industrial activity. The geographical setting of Nowy Sącz falls within the Outer Western Carpathians province, the Western Beskids subprovince, and the Sądecka Basin macroregion. These lands lie at the confluence of the Dunajec, Poprad, and Kamienica rivers. On the outskirts of the study area, the Łubinka stream flows.

Below (Fig. 1), on the overview map, surface water sampling points are marked in the analyzed area of the Sądecka agglomeration. Surface waters cover approximately 2.19 ha of the city area, and the largest of the rivers is the Dunajec, with an average annual discharge of about 63.5 $m^3/s$, followed by the Poprad with a discharge of around 24.5 $m^3/s$, and the Kamienica with a discharge of about 3.67 $m^3/s$. The rivers in this region are typical mountain watercourses—their levels rarely remain stable. High water stages, ranging from elevated to maximum levels, usually occur after spring snowmelt or intense summer storms. In winter, water levels are generally low and stable due to persistent snow cover, though they may decrease in autumn or summer. Within Nowy Sącz, the Dunajec is protected by embankments, while the remaining rivers and streams have mainly been regulated, and their banks partially reinforced with earth dikes (Gryczko-Gostyńska & Olędzka).

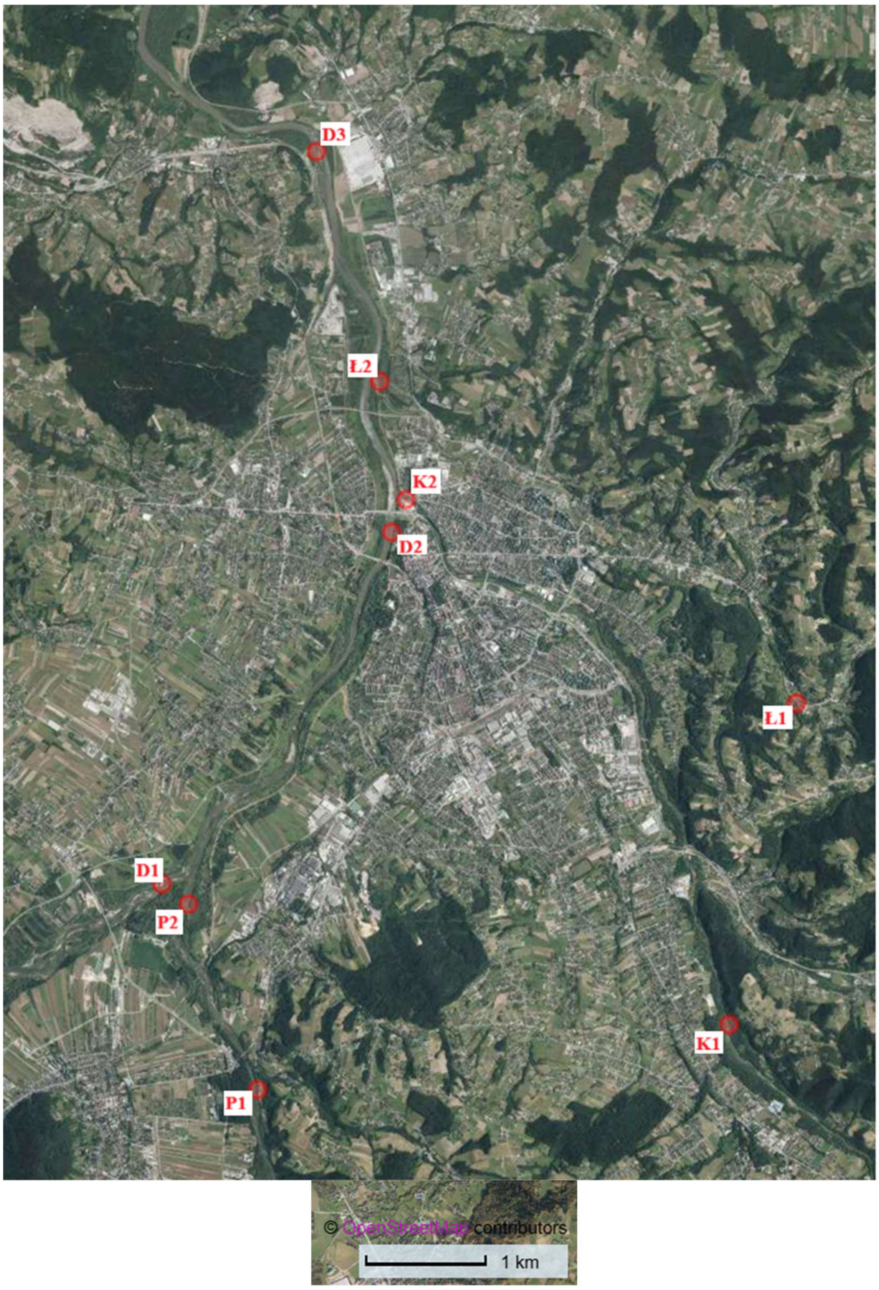


**Fig. 1.** Overview map of surface water collection points
Source: own study based on: https://polska.geoportal2.pl

Based on field observations and site visits, nine locations for surface water sampling were selected, as shown in Figure 1 (Basta & Ciuła, 2024). The exact location of the sampling points was defined using geographic coordinates in the 1992 coordinate system (EPSG 2180). To accurately interpret the results of the conducted research, it is important to note that the Poprad River is typologically classified as a medium eastern upland river (Journal of Laws, 2021, item 1475). Its total length is 169.8 km, with a catchment area of 2077.30 km². Part of the Poprad flows through both Poland and Slovakia. On the Polish side, it covers a section of 62.1 km with a catchment of 482.8 km². Its tributaries include smaller mountain streams and creeks (Radecki-Pawlik et al., 2019). The Poprad River originates in the High Tatras on the Slovak side, at the confluence of the Hińczowy Stream with the Krupa Stream, and flows into the Dunajec River near Stary Sącz. Water quality tests were conducted at points P1 and P2 to analyze the surface waters of this stream.

In the study, raw-water samples were collected at three sampling points on the Dunajec River (D1, D2, D3) and at points located on its tributaries: the Kamienica (K1, K2) and the Łubinka (Ł1, Ł2). The Dunajec, which constitutes the main hydrological axis of the Sądecka agglomeration, is classified as a medium eastern upland river (Czerniawski & Bilski, 2019; Basta & Ciuła, 2024). Its tributaries, the Kamienica and the Łubinka, are classified as surface waters of the flysch-stream type (Policht-Latawiec et al., 2014). The Kamienica River originates on the northern slopes of the Jaworzyna Krynicka massif. Its waters flow through a valley toward the northwest, forming the natural boundary between the Low Beskid and the Sądecki Beskid, and after more than 33 km, they flow into the Dunajec in Nowy Sącz. The Kamienica catchment covers an area of 237.83 km² and is composed mainly of Carpathian flysch formations—sandstones, shales, and conglomerates. Land use in this area is closely linked to soil and climatic conditions. Forests dominate (58.7%), followed by built-up areas (11.8%), wasteland (15.6%), grasslands (7.4%), and arable land (6.5%). Due to its mountainous character, the highest runoff occurs in March and April from snowmelt, whereas floods are rapid and short-lived, typically lasting around 2 days (Wałęga et al., 2016; Jones et al., 2023). The second Dunajec tributary analyzed in the study is the Łubinka stream. It is a 15-kilometer stream originating in the village of Mogilno, with a catchment located at the intersection of three mesoregions. Although most of it lies within the Low Beskid, its headwater tributaries also flow from the Rożnów Foothills, and its lower course is already situated in the Sądecka Basin. Several smaller streams, including Krasówka, Łękówka, Naściszówka, and Wsiówka, feed it. The Łubinka joins the Dunajec from the right, carrying pollutants from agricultural and industrial areas, as well as from nearby waste storage sites and wastewater treatment plants (Kajetanowicz & Osuch, 1962).

Each of the analyzed watercourses ultimately flows into the Dunajec River, the second-largest tributary of the Vistula River in the Carpathians (247 km). Its extensive catchment (6813 km², including 1028 km² outside Poland) is characterized by a highly complex geological structure. The Dunajec originates in Nowy Targ from the confluence of the Biały and Czarny Dunajec rivers. It flows along the northern edge of the forested Nowy Targ Basin, cuts through the erosional basin of Krościenko, and from Jazowsko descends into the Sądecka Basin through a wide funnel-shaped depression. Further downstream, it is fed by waters from the Gorce Mountains (carried by the Ochotnica and the previously mentioned Kamienica). Within the Sądecka Basin, it receives a major tributary from the High Tatras—the Poprad River. The geological substrate of the Dunajec catchment is a mosaic: from the crystalline and sedimentary rocks of the Tatras (Triassic, Jurassic, Cretaceous), through the Podhale flysch, to the formations of the Magura and Menilite series. The floor of the Sądecka Basin is underlain by Miocene deposits (Pasternak, 1968), further enhancing the geological diversity of this area.

### 2.2. Research Methodology

The study was carried out using research materials consisting of surface-water samples collected at nine sampling points identified in Figure 1. The samples used in this article are raw-water samples collected during the astronomical summer and autumn. The research schedule included two series of surface-water sampling campaigns conducted in July and October at the nine designated points. The samples were subjected to a series of laboratory tests of raw water for 16 non-metal inorganic parameters, including total phosphorus (P), Kjeldahl nitrogen (TKN), total nitrogen (N), nitrates ($NO_3$), nitrites ($NO_2$), chlorides ($Cl^-$), CODCr, phosphate phosphorus, sulfates ($SO_4^{2-}$), the sum of $NNO_2$ + $NNO_3$, oxidizability (CODMn), nitrate nitrogen ($NNO_3$), nitrite nitrogen ($NNO_2$), $BOD_5$, orthophosphates ($PO_4$), and total suspended solids. Analyses were also performed for physical parameters, dissolved metals—including major cations—and 239 pesticides (herbicides, insecticides, fungicides, and general-use pesticides, including plant-growth regulators). The analyzed pesticides are mainly applied in autumn to protect crops of spring and winter cereals, as well as apples, maize, potatoes, and rapeseed. Additionally, 45 organochlorine pesticides were analyzed, resulting in approximately 332 parameters tested in a single series of analyses.

The tests were conducted in accordance with PN-EN1899-2:2002, ISO5815-2, SM5210B (biochemical oxygen demand after five days - $BOD_5$), ISO 15923-1:2013(E) (determination of parameters such as ammonium ion, nitrates, nitrites, chlorides, orthophosphates, sulfates), and NR – Dz.U. 2019, item 1747 (determination of silica using the photometric method). The permanganate index was measured using the permanganate method, and chemical oxygen demand was determined using the dichromate method (CODCr), including spectrophotometric analysis. In accordance with PN-ISO 15705:2005, the sealed-tube method was used to determine the chemical oxygen demand index (SP-COD). In accordance with PN-EN 27888:1999, specific electrical conductivity was determined (with temperature compensation at 25°C). Mercury content was measured by fluorescence spectrometry (filtration through a 0.45 μm microfilter and addition of nitric acid prior to analysis, according to CSN EN ISO 17852). Element concentrations were determined by inductively coupled plasma atomic emission spectrometry, followed by stoichiometric calculation of compound concentrations, including overall mineralization and Ca + Mg. Samples were filtered through a 0.45 μm microfilter and acidified with nitric acid before analysis (CSN EN ISO 11885). Kjeldahl nitrogen was determined spectrophotometrically (CSN ISO 7150-1). In accordance with ISO 15923-1:2013(E), selected parameters were determined via discrete analysis (ammonium ion, nitrates, nitrites, chlorides, orthophosphates, sulfates). Additionally, total nitrogen concentration was calculated from component results. Organochlorine pesticides and other halogenated compounds were determined by gas and liquid chromatography with ECD detection, and their sums were calculated from the measured values (CSN EN ISO 6468). Using liquid chromatography with MS/MS detection, pesticide residues, pesticide metabolites, pharmaceutical residues, and other contaminants were determined, and their total concentrations calculated from the measured values. According to PN-EN ISO 10523:2012, water pH was determined with temperature compensation (20°C), and turbidity was measured using an optical turbidimeter. In accordance with ISO 15923-1:2013(E), selected water-quality parameters (ammonium ion, nitrates, nitrites, chlorides, orthophosphates, sulfates, and silica using the photometric method) were determined via discrete W-F-IC analysis. According to PN-EN ISO 6878:2006, phosphorus was determined using the ammonium molybdate spectrophotometric method. Suspended solids were determined according to PN-EN 872:2007 + A1:2007 using filtration through glass-fiber filters (CSN EN ISO 7027-1).

The obtained results were compared with permissible parameters specified in the current legal act concerning surface-water quality which is the Regulation of the Minister of Infrastructure of 25 June 2021 on the classification of ecological status, ecological potential, and chemical status, as well as on the method for classifying the status of surface-water bodies and the environmental quality standards for priority substances (Journal of Laws, 2021, item 1475; https://isap.sejm.gov.pl).

## 3. Research Results

Tables 1, 2, 3, and 4 present the results of analyses for selected surface water parameters for the following watercourses: the Poprad River, the Kamienica River, the Łubinka Stream, and the Dunajec River, respectively. The assessment of surface water quality and its classification were carried out in accordance with the Regulation of the Minister of Infrastructure (Journal of Laws, 2021, item 1475), which defines five classes of surface water quality. In the assessment of physicochemical parameters, the analysis is divided into two classes: Class I represents a very good status, Class II a good status, and failure to meet Class II requirements indicates a status below good, defined as moderate.

For all analysed water courses, laboratory analysis of water samples showed concentrations of individual pesticides and chloro-organic pesticides below the limit of quantification (Tables 1, 2, 3, 4). The quality class for these indicators is not specified in the Regulation (Journal of Laws, 2021, item 1475). Considering their low concentrations, it is concluded that the waters of the Poprad River, the Kamienica River, and the Łubinka Stream are not contaminated with pesticides.

Elevated concentrations of the analysed indicators at sampling points P1 and P2 (Table 1), observed in both sampling series, are likely due to the Poprad River being a mountain river originating in Slovakia. It flows through areas characterized by the tanning industry, which influences elevated levels of, among others, cadmium and chromium in watercourses (Wiśniowska-Węglarz, 2008). Upstream of point P2, the Poprad River flows through urbanized areas, agricultural fields, and in the vicinity of a landfill. This landscape creates a risk of leachate infiltration into surface waters (Basta & Szewczyk, 2024; Fork et al., 2021). During raw water sampling from the Poprad River in July, the river stage was approximately 147 cm, and the flow ranged from 20 to 25 $m^3/s$. In October, the flow was 17 $m^3/s$, and the water level was 129 cm (hydro.imgw.pl).

At Class I (very good), the ecological status and quality of the Poprad River water were determined based on total phosphorus (P) concentrations, which ranged from 0.082 to 0.120 mg/L. The highest concentration of this parameter was recorded in July at points P1 and P2 (0.082 mg/L). Additional parameters classified as very good included: magnesium (Mg) (9.2-10.1 mg/L), pH (7.7-8.3), electrolytic conductivity (SEC) (331-360 µS/cm), oxidizability (3.04-3.19 mg/L), sulphates ($SO_4^{2-}$) (20.02-22.1 mg/L), CODCr (<10.0-15.1 mg/L), and $BOD_5$ (0.90-1.2 mg/L). Class II (good status) was determined by total nitrogen concentrations (N) (<1.00-3.13 mg/L), chlorides ($Cl^-$) (11.4-12.7 mg/L), and calcium (Ca) (39.6-44.1 mg/L). Parameters exceeding the Class II thresholds included Kjeldahl nitrogen (TKN) (<0.50-2.13 mg/L), nitrite nitrogen ($NNO_2$) (<0.00300-0.956 mg/L), orthophosphates ($PO_4$) (0.179-0.255 mg/L) (exceeding Class II limits), and total suspended solids (TSS) (6.8-67.4 mg/L, with 65.3 mg/L exceeding Class II limits). These values are classified as moderate water quality.

The primary sources of nitrogen pollution in the natural environment include the discharge of large amounts of industrial and domestic wastewater. It should be emphasized that nitrates commonly occur in groundwater, as they dissolve easily and may infiltrate groundwater through surface runoff and leaching. However, long-term exposure to high nitrate concentrations poses varying degrees of health risk. Therefore, nitrate pollution must be monitored and characterized to assess potential risks to human health, especially in surface and drinking water (Liu et al., 2021). Studies by Grabowski et al. (2023) also demonstrated high concentrations of ammonium, nitrates, nitrites, manganese, iron, chlorides, and total hardness in rainwater runoff from roofs contaminated with bird droppings. Kochanek et al. (2025) also note that in the environment, concentrations of microplastics are increasingly detected in air, water, and soil. Occasionally, values exceeding the limits specified for surface water quality in the Regulation (Journal of Laws, 2021, item 1475) were observed, which disqualify the water for drinking purposes without prior filtration and treatment. However, it does not exclude its use for non-potable purposes. Excessive nitrogen and phosphorus levels lead to algal blooms, eutrophication, and even fish kills in water bodies. Therefore, systematic and thorough monitoring of reservoirs and watercourses is crucial (Varol, 2020). Parameters not classified in the Regulation (Journal of Laws, 2021, item 1475) include the sum of $NNO_2$ + $NNO_3$, pesticides such as imidacloprid and imazalil, lithium, manganese, potassium, sodium, and iron. According to laboratory data, the limit of quantification for the sum of $NNO_2$ + $NNO_3$ is 0.050 mg/L. At point P2 during the July sampling, this value was nearly 20 times higher than the allowable limit of quantification indicated by the accredited laboratory. Similarly, other values fall outside the classification thresholds for surface water quality established in the Regulation (Journal of Laws, 2021, item 1475) (Table 1).

**Table 1.** Water Quality Indicators in the Poprad River

| Parameters | Unit | P1 | | P2 | | Surface water quality class |
|---|---|---|---|---|---|---|
| | | Draft 3 (July) | Draft 4 (October) | Draft 3 (July) | Draft 4 (October) | |
| P | mg/l | 0.082 | 0.053 | 0.081 | <0.120 | I |
| TKN | mg/l | 2.13 | <0.50 | 0.9 | <0.50 | below II |
| N | mg/l | 3.13 | <1.00 | 1.89 | <1.00 | II |
| $BOD_5$ | mg/l | 1.2 | 1.1 | 1.2 | 0.90 | I |
| $Cl^-$ | mg/l | 11.4 | 12.7 | 11.8 | 12.08 | II |
| CODCr | mg/l | 15.1 | <10.0 | 13.7 | <10.0 | I |
| $SO_4^{2-}$ | mg/l | 20.9 | 22.1 | 20.2 | 22.02 | I |
| Sum of $NNO_2$+$NNO_3$ | mg/l | 1.0 | 0.827 | 0.992 | 0.927 | unclassified |
| CODMn | mg/l | 3.04 | 3.13 | 3.14 | 3.19 | I |
| $NNO_2$ | mg/l | 0.956 | <0.00300 | 0.944 | 0.00312 | below II |
| $PO_4$ | mg/l | 0.266 | 0.18 | 0.255 | 0.179 | below II |
| TSS | mg/l | 130.0 | 6.8 | 130.0 | 11.0 | below II |
| SEC | µS/cm | 331.0 | 360.0 | 332.0 | 360.0 | I |
| pH value | - | 7.7 | 8.3 | 7.9 | 8.3 | I |
| imidacloprid | µg/l | <0.050 | <0.050 | <0.050 | <0.050 | unclassified |
| imazalil | µg/l | <0.050 | <0.050 | <0.050 | <0.050 | unclassified |
| Li | mg/l | 0.0078 | 0.0101 | 0.0078 | 0.0101 | unclassified |
| Mg | mg/l | 9.36 | 10.0 | 9.2 | 10.1 | I |
| Mn | mg/l | 0.00123 | 0.00067 | 0.00133 | 0.00067 | unclassified |
| K | mg/l | 3.33 | 2.79 | 3.46 | 2.82 | unclassified |
| $Na^+$ | mg/l | 10.1 | 10.7 | 10.2 | 10.8 | unclassified |
| Ca | mg/l | 40.2 | 44.0 | 39.6 | 44.1 | I |
| Fe | mg/l | 0.0146 | 0.0149 | 0.0221 | 0.0151 | unclassified |

The water studies on the Poprad River, covering July and October, reveal a Mied classification of individual physicochemical parameters. High nitrogen concentrations in surface waters may indicate elevated concentrations of anthropogenic pollutants, such as those from agricultural sources, municipal and industrial wastewater, urban areas, and air pollution (Bijay-Singh & Craswell, 2021; Schulte-Uebbing et al., 2022).

Eutrophication of the Poprad River surface water is also indicated by Total suspended solids values ranging from 6.8 to 130mg/l, reached in July at both points P1 and P2, and water turbidity ranging from 7.2 ZFn (NTU) in October 2025 at point P2 to 32.3 ZFn (NTU) at point P1 in July 2025. The electrolytic conductivity of the water at points P1 and P2 in October was also 360 µS/cm, indicating high levels of chlorides, sulfates, magnesium, sodium, and potassium, among other elements, and may also suggest water contamination from municipal/industrial pollutants and field runoff. During surface water sampling at point K1 in July, the highest level was recorded at 133 cm, exceeding the upper limit of the average levels. The operating flow on the Kamienica River ranged from approximately 6 to 13.2 m²/s. At point K2, the highest River level was 177 cm, with a maximum flow of 49 m²/s. In October, the water level at point K1 was 68 cm, with a maximum operating flow of 1.12 m²/s. At point K2, the water level was 89 cm, with a maximum operating flow of 1.8 m²/s (https://hydro.imgw.pl/#/). During the analysis of the test results on the Kamienica River, only one parameter was assessed at level I (very good): $BOD_5$, which ranged from 1.0 to 2.3 mg/l. The following parameters were determined to be at a good level: sulphates (15.2-20.3 mg/l), nitrite-nitrogen ($NNO_2$) (0.0353-0.12 mg/l), and magnesium (4.94-10.7 mg/l). The parameters whose results did not fall within the values for class II according to the Regulations (Journal of Laws, 2021, item 1475) were classified as moderate class. Theseare: total phosphorus (0.276 mg/l), Kjeldahl nitrogen (1.18 mg/l), total nitrogen (1.0-4.72 mg/l), chlorides (5.3-13.2 mg/l), CODCr (10.0-37.0 mg/l), oxidizability (1.98-8.22 mg/l), orthophosphates (0.030-0.095 mg/l), Total suspended solids (5.0-360 mg/l), electrolytic conductivity SEC (223-429 µS/cm), pH value (7.5-8.5 mg/l), calcium (27.1-57.0 mg/l). Values not classified in the Regulation (Journal of Laws, 2021, item 1475) are the sum of $NNO_2$ + $NNO_3$, pesticides, including imidacloprid and imazali, lithium, manganese, potassium, sodium, and iron.

The analysis of physicochemical parameters of raw water collected from the Kamienica River indicates good or moderate quality classes of surface waters. Attention should be paid to the concentrations of $BOD_5$ and CODCr. $BOD_5$ reflects the biochemical oxygen demand, which measures the amount of biologically degradable substances. In the Kamienica River, this indicator is at a very good level. However, CODCr ranks above Class II, indicating a moderate quality class of the analysed surface water. The CODCr index ranges from values below the permissible limit of quantification (<10.0 mg/L) in October at both sites K1 and K2, to 37.0 mg/L in July at site K2. Its higher concentration suggests the presence of toxic or poorly degradable chemical compounds, which may originate from industrial or agricultural wastewater pollution and may lead to fish kills, ecosystem degradation, and eutrophication of the water body (Zhang et al., 2024; Wang et al., 2021) (Table 2).

**Table 2.** Water quality indicators in the Kamienica River

| Parameters | Unit | K1 | | K2 | | Surface water quality class |
|---|---|---|---|---|---|---|
| | | Draft 3 (July) | Draft 4 (October) | Draft 3 (July) | Draft 4 (October) | |
| P | mg/l | <0.050 | <0.050 | 0.276 | 0.097 | below II |
| TKN | mg/l | 1.04 | <0.050 | 1.18 | <0.050 | below II |
| N | mg/l | 2.05 | <1.0 | 2.95 | 4.72 | below II |
| $BOD_5$ | mg/l | 1.2 | 1.9 | 2.3 | 1.0 | I |
| $Cl^-$ | mg/l | 5.3 | 11.0 | 5.9 | 13.2 | below II |
| CODCr | mg/l | 20.2 | <10.0 | 37.0 | <10.0 | below II |
| $SO_4^{2-}$ | mg/l | 16.3 | 19.7 | 15.2 | 20.3 | II |
| Sum of $NNO_2$+$NNO_3$ | mg/l | 1.01 | 0.513 | 1.77 | 4.72 | unclassified |
| CODMn | mg/l | 7.09 | 2.50 | 8.22 | 1.98 | below II |
| $NNO_2$ | mg/l | 0.04 | 0.00353 | 0.012 | 0.00434 | II |
| $PO_4$ | mg/l | 0.083 | <0.030 | 0.095 | <0.030 | below II |
| TSS | mg/l | 57.0 | 55.0 | 360.0 | <5.0 | below II |
| SEC | µS/cm | 224.0 | 408.0 | 223.0 | 429.0 | below II |
| pH value | - | 7.5 | 8.5 | 7.5 | 8.4 | II/ below II |

**Table 2.** cont.

| Parameters | Unit | K1 | | K2 | | Surface water quality class |
|---|---|---|---|---|---|---|
| | | Draft 3 (July) | Draft 4 (October) | Draft 3 (July) | Draft 4 (October) | |
| imidacloprid | µg/l | <0.050 | <0.050 | <0.050 | <0.050 | unclassified |
| imazalil | µg/l | <0.050 | <0.050 | <0.050 | <0.050 | unclassified |
| Li | mg/l | 0.0023 | 0.0056 | 0.0023 | 0.0055 | unclassified |
| Mg | mg/l | 4.97 | 10.6 | 4.94 | 10.7 | II |
| Mn | mg/l | 0.00153 | <0.00050 | 0.00133 | 0.00057 | unclassified |
| K | mg/l | 2.46 | 3.21 | 2.8 | 3.2 | unclassified |
| $Na^+$ | mg/l | 5.11 | 11.5 | 5.14 | 12.5 | unclassified |
| Ca | mg/l | 27.1 | 54.3 | 29.0 | 57.0 | below II |
| Fe | mg/l | 0.056 | 0.0050 | 0.0638 | 0.0047 | unclassified |

The highest water level of the Łubinka stream was recorded in July at 247 cm, with operational flow on that day ranging from approximately 4 to 6.99 $m^3/s$. During the October raw water sampling from the Łubinka stream, the water level was 215 cm with a maximum operational flow of 1.28 $m^3/s$ (hydro.imgw.pl). Parameters classified as Class I (very good) for the Łubinka stream include $BOD_5$, ranging from 1.0 to 2.1 mg/L, and pH values between 7.4 and 7.9. No parameters were classified as Class II (good). Parameters that did not meet Class II requirements were assigned to the moderate quality class of surface waters, including: total phosphorus from 0.068 to 0.462 mg/L, Kjeldahl nitrogen <0.50 to 1.31 mg/L, total nitrogen from 1.68 to 5.49 mg/L, chlorides from 18.8 to 29.07 mg/L, CODCr from <0.10 to 23.7 mg/L, sulphates from 28.2 to 31.4 mg/L, oxidizability 2.38 to 6.78 mg/L, nitrite nitrogen from 0.00835 to 0.092 mg/L, orthophosphates from 0.161 to 0.372 mg/L, total suspended solids from 6.9 to 290.0 mg/L, electrolytic conductivity from 346.0 to 544.0 µS/cm, magnesium from 7.36 to 12.9 mg/L, and calcium from 33.7 to 64.2 mg/L. Values not classified in the Regulation (Journal of Laws, 2021, item 1475) include the sum of $NNO_2 + NNO_3$, pesticides including imidacloprid and imazalil, lithium, manganese, potassium, sodium, and iron (Table 3).

**Table 3.** Water quality indicators in the Łubinka Stream

| Parameters | Unit | Ł1 | | Ł2 | | Surface water qualityclass |
|---|---|---|---|---|---|---|
| | | Draft 3 (July) | Draft 4 (October) | Draft 3 (July) | Draft 4 (October) | |
| P | mg/l | 0.093 | 0.097 | 0.462 | 0.068 | below II |
| TKN | mg/l | 1.31 | <0.50 | 1.05 | 0.51 | below II |
| N | mg/l | 3.61 | 5.49 | 2.81 | 1.68 | below II |
| $BOD_5$ | mg/l | 2.1 | 1.0 | 1.6 | 1.40 | verygood |
| $Cl^-$ | mg/l | 19 | 25.0 | 18.8 | 29.07 | below II |
| CODCr | mg/l | 23.7 | <10.0 | 19.4 | <10.0 | below II |
| $SO_4^{2-}$ | mg/l | 28.6 | 29.6 | 28.2 | 31.4 | below II |
| Sum of $NNO_2$+$NNO_3$ | mg/l | 2.3 | 5.49 | 1.76 | 1.17 | unclassified |
| CODMn | mg/l | 6.78 | 3.19 | 7.5 | 2.38 | below II |
| $NNO_2$ | mg/l | 0.092 | 0.00835 | 0.027 | 0.0133 | below II /II |
| $PO_4$ | mg/l | 0.289 | 0.372 | 0.209 | 0.161 | below II |
| TSS | mg/l | 210.0 | 6.9 | 290.0 | 39.0 | below II |
| SEC | µS/cm | 393.0 | 513.0 | 346.0 | 544.0 | below II |

**Table 3.** cont.

| Parameters | Unit | Ł1 | | Ł2 | | Surface water qualityclass |
|---|---|---|---|---|---|---|
| | | Draft 3 (July) | Draft 4 (October) | Draft 3 (July) | Draft 4 (October) | |
| pH value | - | 7.4 | 7.6 | 7.6 | 7.9 | II |
| imidacloprid | µg/l | <0.050 | <0.050 | <0.050 | <0.050 | unclassified |
| imazalil | µg/l | <0.050 | <0.050 | <0.050 | <0.050 | unclassified |
| Li | mg/l | 0.0042 | 0.0055 | 0.0027 | 0.0059 | unclassified |
| Mg | mg/l | 9.32 | 12.5 | 7.36 | 12.9 | below II |
| Mn | mg/l | 0.00093 | 0.00167 | 0.00093 | <0.00050 | unclassified |
| K | mg/l | 4.88 | 4.09 | 5.17 | 4.1 | unclassified |
| $Na^+$ | mg/l | 18.0 | 21.6 | 15.0 | 22.0 | unclassified |
| Ca | mg/l | 40.6 | 58.6 | 33.7 | 64.2 | below II |
| Fe | mg/l | 0.0347 | 0.0093 | 0.0273 | 0.0036 | unclassified |

On the day of raw water sampling from the Dunajec River in July, the surface water level at point D2 ranged from 74 cm to 91 cm on average, indicating a decreasing trend. The highest water level recorded that day was 116 cm, slightly exceeding the lower boundary of the average water level range. The operational flow of the Dunajec River fluctuated between 40 and 121 $m^3/s$. At point D1, the surface water level ranged from 160 cm to 176 cm, with the highest recorded level of 212 cm, exceeding the upper boundary of the average water level. The operational flow at this point varied from approximately 40 to 107 $m^3/s$. In October, the water level at point D2 was 72 cm, with a maximum operational flow of 31.6 $m^3/s$. At point D1, the October water level was 147 cm, with a maximum operational flow of 19.7 $m^3/s$ (hydro.imgw.pl).

Analysis of surface water samples from the Dunajec River indicates that in both summer and autumn, water quality is generally good or moderate; none of the tested parameters met the criteria for very good quality. Parameters classified as good include: total phosphorus, with values ranging from <0.050 to 0.286 mg/L, pH values from 7.2 to 8.4, and magnesium from 6.34 to 9.82 mg/L. The remaining analysed parameters that met the classification criteria were assigned to the moderate-quality class of surface waters. These include: Kjeldahl nitrogen (<0.05 to 1.09 mg/L), total nitrogen (<1.0 to 4.43 mg/L), $BOD_5$ (0.9 to 4.6 mg/L), chlorides (9.9 to 124.0 mg/L), CODCr (<0.10 to 28.2 mg/L), sulphates (17.9 to 44.9 mg/L), oxidizability (1.73 to 6.22 mg/L), nitrite nitrogen (0.00322 to 0.0529 mg/L), orthophosphates (<0.030 to 0.145 mg/L), total suspended solids (<5.0 to 300 mg/L), electrolytic conductivity EC (292 to 953 µS/cm), and calcium (36.4 to 68.1 mg/L). Values not classified in the Regulation (Journal of Laws, 2021, item 1475) include the sum of $N–NO_2$ + $N–NO_3$, pesticides including imidacloprid and imazalil, lithium, manganese, potassium, sodium, and iron (Table 4).

**Table 4.** Water quality indicators in the Dunajec river

| Parameters | Unit | D1 | | D2 | | D3 | | Surface water quality class |
|---|---|---|---|---|---|---|---|---|
| | | Draft 3 (July) | Draft 4 (October) | Draft 3 (July) | Draft 4 (October) | Draft 3 (July) | Draft 4 (October) | |
| P | mg/l | <0.050 | <0.050 | 0.056 | <0.050 | 0.051 | 0.286 | II |
| TKN | mg/l | 0.71 | <0.50 | 1.09 | 0.58 | 0.87 | 2.75 | below II |
| N | mg/l | 4.04 | <1.0 | 1.91 | 1.21 | 2.32 | 4.43 | below II |
| $BOD_5$ | mg/l | 1.7 | 1.0 | 1.3 | 0.9 | 2.2 | 4.6 | below II |
| $Cl^-$ | mg/l | 10 | 11.1 | 11.2 | 12.2 | 9.9 | 124.0 | below II |
| CODCr | mg/l | 28.2 | <0.10 | 14.5 | <0.10 | 23.0 | 22.2 | below II |
| $SO_4^{2-}$ | mg/l | 20.0 | 18.1 | 17.9 | 20.4 | 17.7 | 44.9 | below II |

**Table 4.** cont.

| Parameters | Unit | D1 | | D2 | | D3 | | Surface water quality class |
|---|---|---|---|---|---|---|---|---|
| | | Draft 3 (July) | Draft 4 (October) | Draft 3 (July) | Draft 4 (October) | Draft 3 (July) | Draft 4 (October) | |
| Sum of $NNO_2$+$NNO_3$ | mg/l | 3.32 | 0.574 | 0.821 | 0.634 | 1.45 | 1.68 | unclassified |
| CODMn | mg/l | 3.09 | 1.73 | 3.69 | 3.25 | 6.03 | 6.22 | below II |
| $NNO_2$ | mg/l | 0.032 | 0.00322 | 0.027 | 0.00325 | 0.017 | 0.0529 | II/ below II |
| $PO_4$ | mg/l | <0.030 | <0.030 | 0.126 | 0.089 | 0.073 | 0.145 | below II |
| TSS | mg/l | 300.0 | <5.0 | 150.0 | <5.0 | 290.0 | 5.0 | below II |
| SEC | µS/cm | 298.0 | 321.0 | 299.0 | 338.0 | 292.0 | 953.0 | below II |
| pH value | - | 7.2 | 8.4 | 7.5 | 8.4 | 7.4 | 7.5 | II |
| imidacloprid | µg/l | <0.050 | <0.050 | <0.050 | <0.050 | <0.050 | <0.050 | unclassified |
| imazalil | µg/l | <0.050 | <0.050 | <0.050 | <0.050 | <0.050 | <0.050 | unclassified |
| Li | mg/l | 0.0046 | 0.0057 | 0.0051 | 0.0076 | 0.0034 | 21.0 | unclassified |
| Mg | mg/l | 7.11 | 8.30 | 7.41 | 9.24 | 6.34 | 9.82 | II |
| Mn | mg/l | 0.00073 | <0.00050 | 0.00073 | 0.00057 | 0.00093 | 0.00807 | unclassified |
| K | mg/l | 2.42 | 2.16 | 2.38 | 2.55 | 3.02 | 20.0 | unclassified |
| $Na^+$ | mg/l | 8.47 | 9.38 | 9.19 | 10.3 | 8.28 | 97.5 | unclassified |
| Ca | mg/l | 36.4 | 39.7 | 37.4 | 43.0 | 32.2 | 68.1 | below II |
| Fe | mg/l | 0.0162 | 0.0032 | 0.0145 | 0.0100 | 0.035 | 0.0768 | unclassified |

The Poprad and Kamienica rivers, as well as the Łubinka stream, flow into the Dunajec River at various points along its course through the entire Sądecka agglomeration. Such an extensive surface water catchment area, spanning diverse land types, poses a risk of contamination from municipal and industrial wastewater, as well as agricultural runoff.

Similarily to the physicochemical analyses carried out in this study for the Dunajec, Poprad, Kamienica rivers and the Łubinka stream, the physicochemical parameters that exceeded the surface water quality class limits defined in the Regulation (Journal of Laws, 2021, item 1475) – including electrolytic conductivity, chloride ion concentrations, alkalinity, $BOD_5$, and CODCr – were also reported in the research conducted by Rahman et al. (2021). The values of the analysed parameters in the Turag River in Bangladesh changed with the seasons and rainfall levels. During the highest pollution periods, the water was unsuitable for drinking, irrigation, recreational use, or aquatic life in most seasons. This contamination resulted from improper management of domestic and industrial waste (Rahman et al., 2021; Przydatek & Basta, 2020). The proximity of watercourses to agricultural fields may lead to pesticides entering surface waters through field runoff. Herbicides are particularly dangerous because they can cause environmental problems, such as algal blooms, by altering phytoplankton composition and stimulating toxin production (Xing et al., 2023; Martínez-Dalmau et al., 2021).

## 4. Discussion

The analyses of surface water samples collected in July and October from the Poprad, Dunajec, Kamienica rivers, and the Łubinka stream indicate chloride concentrations (0.10 mg/L) that exceed the values defined for Class I in the Regulation (Journal of Laws, 2021, item 1475). At the sampling points on the Poprad River, chloride concentrations at point P1 were 11.4 mg/L in July, increasing to 12.4 mg/L in October, while at point P2 they were 11.8 mg/L in July and 12.8 mg/L in October. These values correspond to Class II, which is defined as "good" in the Regulation (Journal of Laws, 2021, item 1475).

In the Dunajec River, the measured chloride concentrations were generally lower. At point D1, concentrations were approximately 10.0 mg/L in July and 11.1 mg/L in October, at D2, 11.2 mg/L in July and 12.2 mg/L in October, and at D3, 9.9 mg/L in July and a remarkably high 124 mg/L in October—about six times higher than the Class II limit specified in the Regulation (Journal of Laws, 2021, item 1475). For the Kamienica

River, chloride concentrations were as follows: point K1 – 5.3 mg/L in July and 11 mg/L in October, point K2 – 5.9 mg/L in July and 13.2 mg/L in October. The highest surface water chloride concentrations were recorded in the Łubinka stream at points Ł1 and Ł2: 19.0 mg/L and 18.8 mg/L in July, and 25.0 mg/L and 29.07 mg/L in October, respectively (Fig. 2).

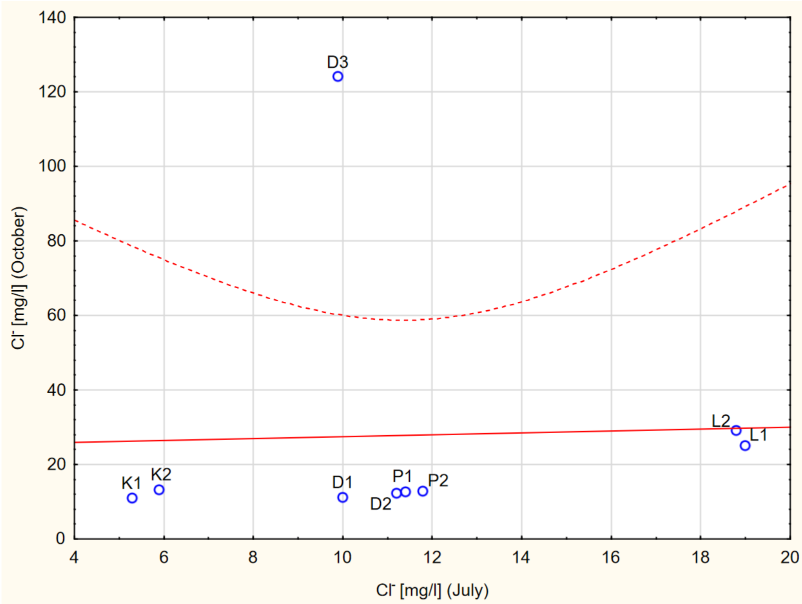


**Fig. 2.** Chlorides concentration in surface waters

The analyses of surface water samples collected in July and October from the Poprad, Dunajec, Kamienica rivers, and the Łubinka stream indicate the highest sodium concentrations at point D3 in October, where the sodium value reached 97.5 mg/L, and the highest chloride concentration ($Cl^-$) was 124 mg/L, also at point D3 in October.

At the sampling points on the Poprad River, sodium concentrations were as follows: at point P1, 10.1 mg/L in July and 10.7 mg/L in October, at point P2, 10.2 mg/L in July and 10.8 mg/L in October. In the Dunajec River, sodium concentrations were slightly lower during the summer: at points D1 (8.47 mg/L), D2 (9.19 mg/L), and D3 (8.28 mg/L). In the autumn, sodium increased at point D1 by 0.91 mg/L, at D3 by 89.22 mg/L, and decreased at point D2 by 1.11 mg/L. On the Kamienica River, sodium concentrations were 5.11 mg/L at point K1 in July and 11.5 mg/L in October, and 5.14 mg/L at point K2 in July and 12.5 mg/L in October. Sodium concentrations in the Łubinka stream also increased from summer to autumn: at point Ł1, from 18 to 21.6 mg/L, and at point Ł2, from 15 to 22 mg/L (Fig. 3). These two elements ($Na^+$ and $Cl^-$) most often occur together as so-called road salt (mainly NaCl), which is commonly applied in winter to ensure road safety. It should be noted that, despite the benefits of using NaCl, its long-term use has a negative impact on the soil and water environments. Road salt is often considered a primary reason for the excessive presence of chloride and sodium in surface waters, particularly near bridges and high-traffic roads (Cooper et al., 2014; Granato et al., 2015). However, this source is primarily relevant during the winter season (Granato et al., 2015). Prolonged application of NaCl to the environment increases annual average $Cl^-$ concentrations in rivers and lakes due to its infiltration into groundwater. $Cl^-$ is known to promote the growth of phytoplankton, especially cyanobacteria, thereby reducing natural water self-purification, denitrification, and organic matter decomposition (Szklarek et al., 2022; Xuan et al., 2025).

Chlorides naturally occur in most surface waters; however, many anthropogenic sources increase chloride concentrations in numerous water bodies. Chlorides are also present in terrestrial environments, serving as indicators of water flow and contaminant transport, organochlorine pollution, $Cl^-$ cycling, radioactive waste, and plant sciences (Svensson et al., 2021). Other anthropogenic sources of chlorides include wastewater, fertilizers, animal excreta, irrigation, aquaculture, energy production waste, and leachate from landfills (Granato et al., 2015; Ciuła et al., 2024). These sources may contribute toxic, carcinogenic, or mutagenic pollution that disrupts local water management and must be mitigated (Granato et al., 2015).

High concentrations of chlorides and sodium are considered to be influenced by natural and anthropogenic sources in surface waters. Quantitative fluctuations in parameters such as sodium and chloride are influenced by rainfall and agricultural runoff (Hammoumi et al., 2024).

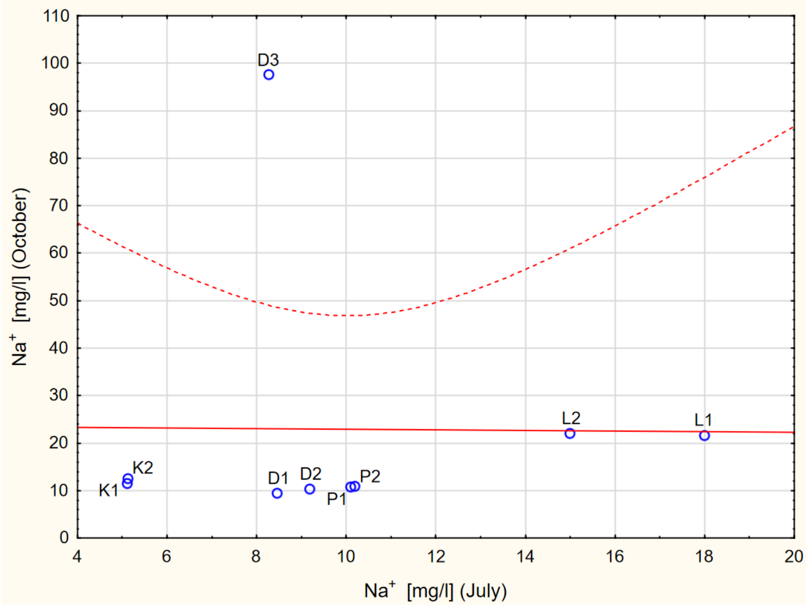


**Fig. 3.** Sodium concentration in surface waters

Based on the results of water samples collected in July and October, variability in specific electrical conductivity is evident (Fig. 4). High concentrations of sodium and chloride are also associated with higher electrical conductivity at each sampling point. Figure 4 presents the electrical conductivity measurements at the individual points during summer and autumn.

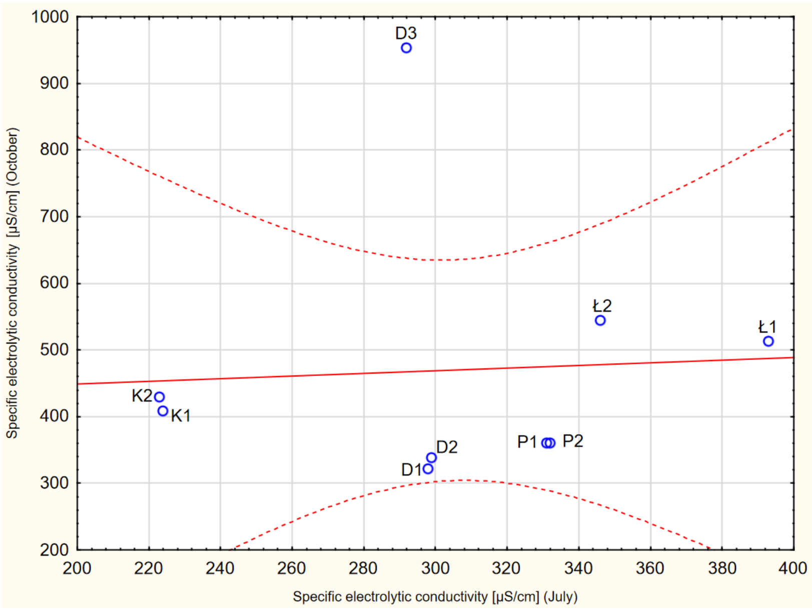


**Fig. 4.** Specification electrocity conductivity in surface water

The results of surface water studies in July indicate similar electrical conductivity values. The analysis of raw water samples collected from the Poprad River shows specific electrical conductivity (SEC) values of 331 µS/cm at P1 and 332 µS/cm at P2. In the Dunajec River, the measured values did not exceed 300 µS/cm, with 298 µS/cm at D1, 299 µS/cm at D2, and 292 µS/cm at D3. The Kamienica River exhibited the lowest electrical conductivity results, with 224 µS/cm at K1 and 223 µS/cm at K2. The Łubinka Stream recorded the highest conductivity values in summer, reaching 393 µS/cm at Ł1 and 346 µS/cm at Ł2. Significant discrepancies in electrical conductivity measurements are observed in October between the Poprad, Dunajec, Kamienica Rivers, and the Łubinka Stream. The Poprad River shows conductivity values of 360 µS/cm at both P1 and P2, while in the Dunajec River, the values trend upwards, with 321 µS/cm at D1, 338 µS/cm at D2, and as high as 953 µS/cm at D3. In the Kamienica River, conductivity reached 408 µS/cm at K1 and 429 µS/cm at K2. The Łubinka Stream also showed high conductivity, with 513 µS/cm at Ł1 and 544 µS/cm at Ł2. Electrical conductivity measures the water's ability to conduct an electric current. The presence of dissolved ions in surface waters, including salts and other conductive substances, and elevated conductivity levels can indicate the presence of pollutants or dissolved solids (Mathur, 2016; Aluwong et al., 2024).

## 5. Conclusions

Analysis of surface water status in the Sądecka agglomeration, based on physicochemical parameters, enabled an assessment of the quality of surface waters in the region. The results for the Poprad River indicate a mixed classification of surface waters. Eight parameters were classified as very good (total phosphorus, magnesium, pH, electrical conductivity, oxidizability, sulfates, CODCr, $BOD_5$). Three parameters were classified as class II, good status (total nitrogen, chlorides, calcium), while six parameters exceeded class II limits (Kjeldahl nitrogen, nitrite nitrogen ($NNO_2$), orthophosphates, total suspended solids).

The Kamienica River, during the July–October period, showed very good results only for $BOD_5$. Parameters classified as good were sulfates, nitrite nitrogen ($NNO_2$), and magnesium, while the following were classified as moderate: total phosphorus, Kjeldahl nitrogen, total nitrogen, chlorides, CODCr, oxidizability, orthophosphates, total suspended solids, electrical conductivity, pH, and calcium.

For the Łubinka Stream, similar to the Kamienica River, $BOD_5$ and pH were classified as very good, and no parameters were classified as good (class II). Parameters that did not meet class II requirements were classified as moderate, including total phosphorus, Kjeldahl nitrogen, total nitrogen, chlorides, CODCr, sulfates, oxidizability, nitrite nitrogen, orthophosphates, total suspended solids, electrical conductivity, magnesium, and calcium.

For the main watercourse, into which the Poprad River, Kamienica River, and Łubinka Stream flow, surface water was sampled at three points. Studies of surface water samples from the Dunajec River indicate that, in the summer and autumn seasons, water quality is generally good to moderate. It is worth noting that none of the measured parameters indicated very good water quality. Parameters classified as good included total phosphorus, pH, and magnesium. The remaining parameters were classified as moderate: Kjeldahl nitrogen, total nitrogen, $BOD_5$, chlorides, CODCr, sulfates, oxidizability, nitrite nitrogen, orthophosphates, total suspended solids, electrical conductivity (SEC), and calcium.

The highest average concentrations of physicochemical parameters are characteristic of the Dunajec River, which accumulates the surface waters of the Poprad, Kamienica, and Łubinka Rivers. These watercourses have a mountainous character. The Poprad and Dunajec Rivers are the main hydrological axes of the Sądecka region. Particularly in the Sądecka Basin, fertile, intensively cultivated agricultural areas are typical. These rivers also flow through heavily urbanized centers, in proximity to urban and industrial infrastructure. Other watercourses, the Kamienica River and Łubinka Stream, strongly influence urban areas. The Kamienica River, flowing from Nawojowa, passes through densely populated areas characterized by compact housing and industrial activity. The Łubinka Stream, joining the Dunajec, flows through agricultural, orchard, and cultivated fields, as well as light industrial zones (warehouses and small production facilities). The study indicates that high concentrations of physicochemical parameters are likely due to runoff from rainwater into the analyzed watercourses, discharges from wastewater treatment plants, and waters flowing from the mountains. Surface water sampling in both July and October occurred during rainfall events; therefore, it is important to consider so-called surface runoff, during which there is an increase in suspended solids, concentrations of biogenic compounds, heavy metals, and pesticides, as well as fluctuations in pH and electrical conductivity. The multi-parameter analysis showed differences in water quality at the tested points, with particular emphasis on exceedances of organic pollutant and nutrient concentrations, confirming the influence of the catchment area's specificity and nearby pollution sources on the individualization of the monitoring strategy for individual watercourses in the Sącz area.

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